

PROJECT MANUAL

DOVER HIGH SCHOOL & CAREER TECHNICAL CENTER

Dover, New Hampshire

These specifications are a compilation of the original August 12, 2016 100% Construction Documents and published Addenda, including other specific changes communicated by PC Construction during the bidding period. These compiled specifications were prepared for convenience. The completeness and/or accuracy of the information is not guaranteed; any inconsistencies with the 100% Construction Documents and the published addenda and specific changes communicated by PC Construction during bidding period do not alter the requirements of the Contract Documents

HMFH Architects, Inc.

130 Bishop Allen Drive

Cambridge, MA 02139

617 492 2200

***100% Conformed Set
For Construction
VOLUME 2 OF 2***



SET# _____

September 12, 2016

DOCUMENT 000105
LIST OF CONSULTANTS

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Landscape Architect:	Halvorson Design Partnership, Inc. 25 Kingston Street Boston, MA 02111
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Hazardous Materials:	Universal Environmental Consultants 12 Brewster Road Framingham, MA 01702
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END OF DOCUMENT

DOCUMENT 000107
PROFESSIONAL SEALS

SPECIFICATIONS FOR
Dover High School & Career Technical Center

Designer
Architects

Structural Engineers

Landscape Architects

Civil Engineers

Fire Protection Engineers

HMFH PROJECT NO. 403114
September 12, 2016

Dover High School & Career Technical Center
Dover, NH

HVAC Engineers

Plumbing Engineers

Electrical Engineers

END OF DOCUMENT

PROFESSIONAL SEALS
000107-2

TABLE OF CONTENTS

GENERAL DOCUMENTS

Document:
000105 List of Consultants
000107 Professional Seals
000110 Table of Contents

VOLUME 1 OF 2

DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS

PROCUREMENT REQUIREMENTS

Document:
Not Issued

CONTRACTING REQUIREMENTS

Document:
Not Issued

SPECIFICATIONS

DIVISION 01 - GENERAL REQUIREMENTS

Section:
011100 Summary of Work
011400 Work Restrictions
011401 Electronic Release Form
012200 Unit Prices
012201 Unit Price Proposal Sheet
012300 Alternates
012400 Schedule of Values
013100 Project Management and Coordination
013119 Project Meetings
013200 Construction Progress Documentation
013300 Submittal Procedures
013301 Substitution / Or Equal Request Form
013302 Submittal Review Transmittal
013543 Environmental Procedures – To be issued as an addendum.
014000 Quality Requirements
015000 Temporary Facilities and Controls
015639 Temporary Tree and Plant Material Protection
017329 Cutting and Patching
017400 Cleaning and Waste Management
017700 Closeout Procedures
017839 Project Record Documents
018119 Indoor Air Quality Requirements
019112 Commissioning of Building Enclosure
019113 Commissioning Requirements

DIVISION 02 - EXISTING CONDITIONS

Section:

022820 Asbestos Remediation – To be issued as an addendum.
024119 Demolition
024119 Selective Demolition - Site

DIVISION 03 - CONCRETE

Section:

033000 Cast-In-Place Concrete
033060 Site Architectural Concrete
033300 Architectural Concrete
033650 Concrete Finishes
034500 Precast Architectural Concrete
034500 Site Precast Architectural Concrete

DIVISION 04 - MASONRY

Section:

042000 Unit Masonry
044000 Site Stone

DIVISION 05 - METALS

Section:

051200 Structural Steel Framing
051226 Shear Connectors
052100 Steel Joist Framing
053100 Steel Decking
054000 Cold-Formed Metal Framing
055000 Metal Fabrications
057300 Decorative Glass Railings
057500 Decorative Formed Metal

DIVISION 06 - WOOD, PLASTICS AND COMPOSITES

Section:

061000 Rough Carpentry
061600 Sheathing
064020 Interior Architectural Woodwork
066400 FRP Paneling

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

Section:

071100 Bituminous Dampproofing
071300 Fluid Applied Waterproofing
071400 Self-Adhering Sheet Waterproofing
071600 Polymer Modified Cement Waterproofing
071800 Pavement Markings
072100 Thermal Insulation
072500 Air Barriers
074210 Metal Rooftop Panels
074220 Solid Phenolic Wall Panels
075300 EPDM Roofing

076200	Sheet Metal Roofing, Siding, Flashing and Trim
077200	Roof Accessories
078100	Applied Fireproofing
078400	Firestopping
079200	Joint Sealants
079500	Expansion Control

DIVISION 08 - OPENINGS

Section:

081110	Hollow Metal Doors and Frames
081400	Flush Wood Doors
083100	Access Doors and Frames
083300	Overhead Coiling Doors
083320	Overhead Coiling Grilles
083436	Darkroom Doors
083470	Sound Control Door Assemblies
083513	Folding Doors
083610	Sectional Doors
083620	Bi-Fold Doors
084410	Glazed Aluminum Curtain Walls
085110	Aluminum Windows
086200	Unit Skylights
087100	Door Hardware (Not Issued)
088000	Glazing
089000	Louvers and Vents

DIVISION 09 - FINISHES

Section:

090160	Vapor Mitigation at Slabs
092710	Glass-Fiber-Reinforced Gypsum (GFRG)
092900	Gypsum Board Assemblies
093000	Tiling
095100	Acoustical Panel Ceilings
096400	Stage Flooring
096466	Wood Athletic Flooring
096500	Resilient Flooring
096566	Resilient Athletic Flooring
096820	Carpeting
097200	Wall Coverings
098400	Acoustic Room Components
099000	Painting and Coating
099646	Intumescent Painting

DIVISION 10 - SPECIALTIES

Section:

101100	Visual Display Surfaces
101400	Signage
102100	Toilet Compartments and Cubicles
102210	Wire Mesh Partitions
102800	Toilet Accessories
104400	Fire Protection Specialties
105100	Metal Lockers

DIVISION 11 - EQUIPMENT

Section:

- 110610 Stage Rigging and Curtains
- 110640 Theatrical Lighting Control and Fixtures
- 111300 Loading Dock Equipment
- 111320 Projection Screens
- 114000 Food Service Equipment
- 116620 Athletic Equipment

DIVISION 12 - FURNISHINGS

Section:

- 122110 Horizontal Louver Miniblinds
- 122400 Window Shades
- 123000 Manufactured Casework
- 124810 Entrance Floor Mats and Frames
- 126100 Fixed Audience Seating
- 126600 Telescoping Stands
- 129300 Site Furnishings

DIVISION 13 – SPECIAL CONSTRUCTION

Section:

- 133420 Pre-Engineered Building Systems

DIVISION 14 - CONVEYING EQUIPMENT

Section:

- 142400 Hydraulic Elevators

VOLUME 2 OF 2

DIVISION 21 - FIRE SUPPRESSION

Section:

- 210000 Fire Protection
- 210800 Commissioning of Fire Suppression

DIVISION 22 - PLUMBING

Section:

- 220000 Plumbing
- 220800 Commissioning of Plumbing
- 221113 Facility Water Distribution Piping
- 221313 Facility Sanitary Sewers

DIVISION 23 - HEATING VENTILATING AND AIR CONDITIONING

Section:

- 230000 Heating, Ventilating and Air-Conditioning
- 230548 Vibration Control and Seismic Restraint
- 230800 Commissioning of HVAC Systems
- 231123 Facility Natural-Gas Piping

DIVISION 26 - ELECTRICAL

Section:
260000 Electrical
260543 Underground Ducts and Raceways for Electrical Systems
260800 Commissioning of Electrical

DIVISION 27 – COMMUNICATIONS

Section:
270000 Technology
274116 Integrated Audiovisual Systems And Equipment

DIVISION 28 – ELECTRONIC SAFETY AND SECURITY

Section:
280000 Integrated Electronic Security System

DIVISION 31 - EARTHWORK

Section:
311000 Site Clearing
311300 Selective Tree and Plant Material Removal
312000 Earth Moving
312001 Building Earthwork
312219 Fine Grading
312319 Dewatering
312500 Storm Water Pollution Prevention Plan
315000 Excavation Support and Protection
316630 Aggregate Piers

DIVISION 32 - EXTERIOR IMPROVEMENTS

Section:
321216 Asphalt Paving
321293 Artificial Grass Fieldturf, Fieldturf Monofilament FTRV360-1: Revolution 360
321313 Portland Cement Concrete Paving
321316 Integrally Colored Concrete Pavement
321640 Granite Curbing
321829 Synthetic Running Track Surface
323113 Chain Link Fences
323223.13 Segmental Retaining Wall System
328400 Irrigation System Alternate
329000 Planting
329100 Planting Soils
329200 Lawns
329353 Planting Maintenance

DIVISION 33 - UTILITIES

Section:
334100 Storm Utility Drainage Piping
334600 Subdrainage

Add A
Item
027

END OF TABLE OF CONTENTS

SECTION 210000

FIRE PROTECTION

PART 1 - GENERAL..... 1

1.1 GENERAL PROVISIONS..... 1

1.2 DESCRIPTION OF WORK..... 1

1.3 RELATED WORK..... 2

1.4 CODES, ORDINANCES, AND PERMITS..... 2

1.5 RECORD DRAWINGS..... 3

1.6 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS..... 3

1.7 SHOP DRAWINGS AND MATERIAL SCHEDULES..... 4

1.8 COORDINATION DRAWINGS..... 4

1.9 GUARANTEE..... 4

1.10 DRAWINGS..... 5

1.11 SYSTEM DESCRIPTION..... 5

1.12 ALARM FACILITIES..... 5

1.13 PIPE MARKER IDENTIFICATION SYSTEM..... 6

1.14 VALVE TAGS..... 6

1.15 IDENTIFICATION SIGNS..... 6

1.16 WATER SUPPLY TEST DATA..... 6

1.17 COMMISSIONING..... 6

1.18 BREAKDOWN..... 7

1.19 VISIT TO SITE..... 7

PART 2 - PRODUCTS..... 7

2.1 GENERAL..... 7

2.2 PIPE AND FITTINGS..... 7

2.3 JOINTS..... 8

2.4 VALVES..... 8

2.5 SPRINKLERS..... 9

2.6 FIRE DEPARTMENT CONNECTION..... 10

2.7 FIRE DEPARTMENT OUTLET HYDRANT CONNECTION..... 10

2.8 SUPPLEMENTARY STEEL, CHANNEL, AND SUPPORTS..... 10

2.9 HANGERS AND SEISMIC RESTRAINTS..... 11

2.10 ALARM DEVICES..... 11

2.11 DOUBLE CHECK VALVE ASSEMBLY..... 11

2.12 ACCESS DOORS..... 12

2.13 AIR COMPRESSOR..... 12

2.14 **FIRE STANDPIPE EQUIPMENT**..... 12

PART 3 - EXECUTION..... 13

3.1 WORKMANSHIP AND INSTALLATION METHODS..... 13

3.2 WORK COORDINATION AND JOB OPERATIONS..... 13

3.3 CUTTING AND CORE DRILLING..... 14

3.4 CLEANING AND PROTECTION..... 14

3.5 SLEEVES, INSERTS, AND ESCUTCHEONS..... 14

3.6 TESTING..... 15

END OF INDEX

SECTION 210000
FIRE PROTECTION

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 DESCRIPTION OF WORK

- A. Provide all labor, materials, equipment, services and accessories necessary to Design, Furnish and Install the work of this Section, complete and functional, as indicated in the Contract Documents and as specified herein. The Design shall conform to the documents and shall be subject to approval by the Architect.
- B. Without limiting the generality thereof, the work to be performed under this Section includes:
 - 1. Fire Service to 10' outside buildings and/or as shown on the drawings.
 - 2. A hydraulically designed combination automatic sprinkler system to provide 100% protection for the new buildings as noted on the Drawings. Refer to Fire Protection Criteria on the Drawings. Prepare Working Drawings for approval of the Architect, the local authority having jurisdiction, and the owner's insurance company under stamp of an independent New Hampshire Registered Professional Fire Protection Engineer.
 - 3. Backflow Control Device
 - 4. Fire Department Connections.
 - 5. Pipe and Fittings
 - 6. Valves
 - 7. Hangers
 - 8. Sprinkler Heads
 - 9. New hydrant flow test.
 - 10. Single interlock preaction system complete with general air riser mounted compressor and photoelectric smoke detectors to protect MDF room.
 - 11. A dry system complete with dry valve and trim, riser mounted compressor and exposed galvanized sprinkler piping and upright sprinkler heads serving loading dock.
 - 12. Kidde IND dry chemical system for vehicle spray booth. Dry chemical system shall be complete with XV control system, IND agent storage container, Fenwal Detect-A-Fire/rapid response thermo-bulb links, dry chemical discharge nozzles, manual remote release, control panel, Kidde dry chemical agent, & actuation delay.
 - 13. Furnishing and installation of Supervisory Switches and Controls
 - 14. Systems Identification
 - 15. Flushing and Testing of the interior system as provided herein. Coordinate, witness, and certify the flushing and testing of the exterior system and submit certificates. The exterior installation is provided in Division 32 – EXTERIOR IMPROVEMENTS.

16. Drilling, Coring, Cutting & Patching of holes and openings (where the largest dimension thereof does not exceed 12 inches), for Fire Protection Piping and Equipment. All such holes require sleeves.
17. Scaffolding, Rigging, and Staging required for all Fire Protection Work. Comply with Division 01 requirements.
18. Provide Seismic Restraints for all Fire Protection Systems conforming to the requirements of Section 230548 which Section is herein incorporated by reference as work of the Fire Protection Sub Contractor.
19. Furnishing of Access Panels
20. Smoke and Firestopping Seals and sealing of all wall penetrations as detailed on the drawings. Refer to Section 078400 which defines the firestopping materials and methods.
21. When open-flame or spark producing tools such as blower torches, welding equipment, and the like are required in the process of executing the work, the General Contractor shall be notified not less than twenty four hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant non-working fire watch through the Local Fire Department where work is being performed and until it is completed.
22. It shall be the responsibility of this division 210000 to provide all personnel as required to fully coordinate with the commissioning agent. The hours of training and instruction outlined in this division 210000 and the Testing requirements shall be in addition to those tests and requirements outlined in section 019113 and section 210800 and required to fulfill section 019113 and section 210800 commissioning obligations.

1.3 RELATED WORK

- A. The following items of work related to the Fire Protection Work are included under other Sections of the Specifications:
 1. Fire Service up to 10 feet outside foundation wall: DIVISION 33 – SITE UTILITIES.
 2. Cutting & Patching beyond 1.2B.16 above: SECTION 017329 - CUTTING AND PATCHING.
 3. Installation of Access Panels: Respective finish section.
 4. Excavation and Backfill: DIVISION 31 – EARTHWORK.
 5. Finish Painting: SECTION 099000: PAINTING AND COATING.
 6. Wiring for Supervisory Switches, Electrical Alarm, and Flow Switches, and Power Wiring: SECTION 260000 – ELECTRICAL.
 7. Temporary Facilities: SECTION 015000 - TEMPORARY FACILITIES AND CONTROLS.
 8. Installation of Hood Suppression System – SECTION 114000 - FOOD SERVICE EQUIPMENT.

1.4 CODES, ORDINANCES, AND PERMITS

- A. Perform all work in accordance with the following Codes:
 1. The State Building Code.
 2. New Hampshire Fire Code.
 3. NFPA-13-2013, NFPA-14-2013, and Owner's insurance company requirements.
 4. NFPA 24- 2013, NFPA 25 2013, NFPA 17, 33, & 34 (2013)
 5. All applicable Local, State, and Federal Codes, Statutes, or Regulations.
 6. City of Dover Fire Department.
 7. City of Dover Building Department.

- B. Obtain all permits, inspections, and approvals, from the governing authorities and pay all fees and include cost in the bid, including approvals for the cross connection control device. Provide the Owner with the cross connection permit for the device in the Owner's name.

1.5 RECORD DRAWINGS

- A. General: Refer to DIVISION 01 - GENERAL REQUIREMENTS for general requirements for maintaining as-built drawings and submitting final reproducible record documents.
- B. The General Contractor will provide two sets of black or blue line on white Drawings to the Fire Protection Subcontractor, one set of which shall be maintained at the site and which shall, at all times, be accurate, clear, and complete, showing the actual locations of all equipment and piping as it is being installed. The Record Drawings shall be available to the Architect/Engineer's field representative at all times.
- C. Provide electronic AutoCAD drawings to indicate revisions to piping size and location both exterior and interior; including locations of valves and other equipment requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; concealed equipment, dimensioned to column line; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located.
- D. Include in the Record Drawings any addenda, sketches, and supplementary Drawings issued during the course of construction.
- E. Non-availability of Record Drawings or inaccuracies therein will postpone the final inspection until they are available.
- F. All valves shown on these Drawings shall be numbered with numbers corresponding to those on the valve charts.
- G. All costs related to the foregoing requirements shall be paid by the Fire Protection Subcontractor.

1.6 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. Provide operating instructions to the owner's designated representative with respect to operation functions and maintenance procedures for all equipment and systems installed. At the completion of the project, turn over to the Architect four (4) complete manuals in three-ring, loose-leaf binders, containing the following:
 - 1. Complete Shop Drawings of all equipment.
 - 2. Operation description of all systems.
 - 3. Names, addresses, and telephone numbers of all suppliers of the system.
 - 4. Preventive maintenance instructions for all systems.
 - 5. Spare parts list of all system components.
- B. Contractor shall provide a computerized preventative maintenance management system in format compatible with School Dude (excel or other similar program) for Fire Protection equipment.

1.7 SHOP DRAWINGS AND MATERIAL SCHEDULES

- A. Refer to SECTION 013300 – SUBMITTAL PROCEDURES for substitution of equipment and submittal of Shop Drawings. If apparatus or materials are substituted for those specified, and such substitution necessitates changes in or additional connections, piping, supports or construction, same shall be provided as the responsibility, and at the expense, of the Fire Protection Subcontractor.
- B. Fabrication of any material or performing of any work prior to the final approval of the Submittals will be entirely at the risk of the Subcontractor. The Subcontractor is responsible for furnishing and installing materials called for in the Contract Documents, even though these materials may have been omitted from approved Submittals.
- C. Submit Shop Drawings for the following materials and equipment.
 - 1. Coordinated Working Drawings and hydraulic calculations for each building, including size, type, length, temperature rating of sprinkler heads, piping and the like. Indicate flow test results, design criteria, hydraulic reference points, diffuser and light locations.
 - 2. Access Panels and Covers
 - 3. Sprinkler Heads
 - 4. Hangers and Seismic Restraints
 - 5. Pipe, Fittings, and Appurtenances
 - 6. Systems Identification
 - 7. Valves
 - 8. Fire Department Connection
 - 9. Cross Connection Devices

1.8 COORDINATION DRAWINGS

- A. Before materials are purchased or Work is begun, prepare and submit to the Architect, Coordination Drawings showing the size and location of all equipment and piping lines relevant to the complete system. Ensure that these Drawings are compatible and correctly annotated and cross-referenced at their interfaces.
- B. Coordination Drawings are for the Contractor's and the Architect's use during Construction and shall not be construed as replacing any Shop or Record Drawings required elsewhere in these Contract Documents.
- C. Detailed procedures for Coordination Drawings are contained in Division 01 of these Contract Documents.

1.9 GUARANTEE

- A. Guarantee all work under this Section free from defects in workmanship or materials for a period of one (1) year from the date of final acceptance of the building, as set forth in the Contract.
- B. Replace any such defective work developing during this period, unless such defects are clearly the result of bad usage of equipment by others. Where such defective work results in damage to work of other Sections of the Specifications, restore such work to its original condition by mechanics skilled in the affected trade.

1.10 DRAWINGS

- A. All work shown on the Drawings is intended to be approximately correct to scale but shall be taken in a sense as diagrammatic. Sizes of pipes and general method of running them are shown, but it is not intended to show every offset and fitting. To carry out the true intent and purpose of the plans, furnish all necessary parts to make a complete working system ready for use.
- B. The Drawings and Specifications are intended to supplement each other so that any details shown on the Drawings and not mentioned in the Specifications, or vice-versa, shall be executed the same as if mentioned in the Specifications and shown on the Drawings.
- C. Refer to the Architectural, Structural, and Other Mechanical and Electrical Drawings which indicate the construction in which this work shall be installed. Locations shown on the plans shall be checked against the general and detailed drawings of the construction proper. All measurements must be taken at the building.

1.11 SYSTEM DESCRIPTION

- A. The new building is to be 100% sprinklered with an automatic sprinkler system. The system shall be designed in accordance with NFPA-13-2013 and NFPA-14-2013.
- B. Building is to be 100% sprinklered including all closets, Electric rooms, and Electrical closets. The Emergency Electric Closets shall be constructed and occupied to meet the exceptions listed under NFPA-13-2013 paragraph 8.15.11 and are not sprinklered. These spaces have automatic detectors.
- C. Refer to Fire Protection Criteria on the Drawings. Conform to the zoning shown on the plans.
- D. Locations of sprinkler heads are shown in some of the areas to be sprinklered only to establish the patterns and design intent. Major equipment and runs of piping may also be shown. Refer to reflected ceiling plan for location of all sprinkler heads. All sprinkler heads are to be installed dead center of tile.
- E. The documents require that the building be covered 100%. This includes all closets, combustible concealed spaces, and other areas as required under NFPA-13-2013. These areas are to be included in the Sub-contractor's bid whether or not the heads are shown on the sprinkler plans.

1.12 ALARM FACILITIES

- A. Furnish and install all Supervisory Switches, Flow Switches, Pressure Switches, and other Alarm Devices. Install all such devices on the piping and coordinate with the Electrical Subcontractor who shall wire all such devices to the Fire Alarm System. Every shutoff valve installed on this project shall have a supervisory trouble switch wired to the Fire Alarm Panel.

1.13 PIPE MARKER IDENTIFICATION SYSTEM

- A. Mark all fire mains installed under this Section with a marking system in basic colors conforming to those specified in ANSI/ASME A-13.1. Markings shall indicate pipe content and direction of flow. Apply markers every 20 feet on center on piping which is exposed in mechanical or storage areas and above suspended accessible ceilings. Also, apply at all access panels, valves, tee joints, alarms, and/or controls.
- B. Adhesive system may be used throughout except at the mechanical rooms in which case markings shall be painted on.

1.14 VALVE TAGS

- A. All valves installed in the Fire Protection Contract shall be tagged. Tags shall be secured to valves with chain link and shall be marked with 3/4 inch high letters as to function. All valve tags shall indicate the Fire Zone.

1.15 IDENTIFICATION SIGNS

- A. All equipment and systems shall be identified with signs furnished and attached in accordance with NFPA 13.

1.16 WATER SUPPLY TEST DATA

- A. The following water supply data is included as information available to bidders.
- B. A hydrant flow test was performed on February 26, 2016, by Dover School District at Durham Road, Dover, NH and will be used for preliminary design. A new hydrant flow test shall be submitted with shop drawings.
- C. Flow Test Results:
 - 1. Static Pressure = 89 PSI
 - 2. Residual Pressure = 66 PSI
 - 3. Flow = 1177 GPM

1.17 COMMISSIONING

- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 019113 – General Commissioning Requirements and Section 210800 – Fire Protection Commissioning Systems.
- B. Complete installation and startup checks and functional tests according to Section 019113 – General Commissioning Requirements and Section 210800 – Fire Protection Commissioning Systems and manufacturers written instructions.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start-up procedure.

- D. Verify that equipment is installed and commissioned as per requirements of section 019113 and section 210800 and manufacturers written instructions/requirements.

1.18 BREAKDOWN

- A. Submit a breakdown of the contract price to aid the Architect in determining the value of the work installed as the job progresses.
- B. No requisition will be approved until the breakdown is delivered to the Architect.

1.19 VISIT TO SITE

- A. Prior to submitting a bid, visit the site of work and become familiar with existing conditions at the site of the work. Any assumptions made are at this Subcontractor's expense.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials and equipment furnished under this Section shall be new, unused, first quality of a manufacturer of established reputation and shall be U.L./F.M. approved. Each valve, fitting, section of pipe, and piece of equipment shall have cast or indelibly stamped thereon the manufacturer's name and pressure rating where applicable. All threads for fire department connection shall conform to the standards of the Local Fire Department.

2.2 PIPE AND FITTINGS

- A. Pipe and fittings shall conform to the latest A.S.A., A.S.T.M., C.A., and F.S. Standards. All grooved products shall be of one manufacturer to conform to NFPA Standards.
- B. All piping installed under this Section shall be in accordance with the following:

Service

Materials

Trim piping around alarm valves, sprinkler piping 1-1/2 inch and smaller

ASTM A-53, Schedule 40 steel pipe, black for wet system, galvanized for dry and pre-action systems

Sprinkler and standpipe piping 2 inch to 6 inch

Schedule 10, ASTM A-135 U.L./F.M. steel black for wet system, galvanized for dry and pre-action systems

Underground service

CL 52 ductile iron pipe

- C. Fittings on fire line piping, 2 inch and larger, shall be Victaulic Fire Lock Ductile Iron Fittings conforming to ASTM A-536 with integral grooved shoulder and back stop lugs and grooved ends for use with Style 009-EZ or Style 005 couplings.

- D. Fittings for standpipes and risers, 2-1/2 inch and larger, and where ever required to conform to Seismic Requirements shall be Victaulic Vic-Flex Style 75 or 77 with Fire Lock Gasket.
- E. Branch line fittings shall be welded or shall be Victaulic 920/920N Mechanical Tees.
- F. Schedule 10 pipe shall be roll grooved. Schedule 40 pipe where used with mechanical couplings shall be rolled groove and shall be threaded where used with screwed fittings.
- G. Fittings for threaded piping shall be malleable iron screwed sprinkler fittings.
- H. All pipe and fittings shall be U.L./F.M. approved for sprinkler and standpipe service. All pipe and fittings shall be galvanized for dry or pre-action system and black for wet system.
- I. Fittings on underground fire service piping shall be 250 psi gray iron fittings with mechanical joint ends. Coordinate with site contractor to assure all joints are properly thrust blocked.
- J. Grooved fittings shall be manufactured by Victaulic, Grinnell, Anvil, or equal.

2.3 JOINTS

- A. Threaded pipe joints shall have an approved thread compound applied on male threads only. Teflon tape shall be used for threads on sprinkler heads.
- B. Joints on piping, 2 inch and larger, shall be made up with Victaulic, or equal, Fire Lock Style 005, rigid coupling of ductile iron and pressure responsive gasket system for wet or dry sprinkler system as recommended by manufacturer. Couplings on dry systems shall be galvanized. Cutting, roll grooving, lubrication, and assembly of all joints shall be made strictly in accordance with manufacturer's recommendations. Exercise particular caution in the use of lubricant to avoid "squeeze out" of lubricant when system is in service.
- C. Grooved joints and fittings shall be manufactured by Victaulic, Grinnell, Anvil, or equal.
- D. Furnish and install where piping crosses building expansion joints furnish and install listed expansion joints and anchors per NFPA-13 2013. Expansion joints shall be Victaulic 155, Metraflex "Fireloop", or manufactured by Flexonic Company or Hyspan, or equal. Expansion joints shall be UL approved for use for fire sprinkler systems.
- E. All joints on Fire Service under slab shall be restrained up to the service stub flange connection above slab.

2.4 VALVES

- A. All shutoff and control valves shall be U.L./F.M. approved, indicating type valves equipped with a supervised trouble switch wired to the fire alarm system. Shutoffs and zone valves may be either OS&Y indicating gates or butterfly valves.
- B. Gate valves shall be outside screw and yoke indicating type, 175 psi W.P. and U.L./F.M. listed, Jenkins or equal. All such valves shall have supervised trouble switch.
- C. Butterfly valves shall be Victaulic Series 705-W for 2-1/2 inch and larger, and Milwaukee indicating type U.L./F.M. butterfly for threaded service. Coordinate with Electrical Sub-contractor to have factory installed monitor switches compatible with the remainder of the Fire Alarm System.

- D. Check valves shall be iron body bronze mounted U.L./F.M., 175# W.P. or U.L./F.M. wafer checks. Grooved end valves shall be Victaulic Style 717 Fire Lock Check Valve.
- E. Pressure relief valves shall be located on wet systems pressure regulating valves and downstream of check valves per NFPA-13-2013. Pressure relieve valves shall be listed and not less than 1/2 in. in size and shall be by AGF, Watts, Cla-Val or equal.
- F. Ball drips shall be Potter Roemer #5682, 3/4 inch straight design ball drip valve, or by Victaulic, Viking, or equal.
- G. Drains shall be provided in the systems as may be required by field conditions. Provide drains at all low points and wherever necessary to insure that all portions of the sprinkler piping may be completely drained. Test connections shall be provided as required to test all portions of the system. Pipe low point drains and test connections to suitable receptor as determined in field or shown on Drawings.
- H. Install an inspector's test connection at the furthest point of each sprinkler zone. Run discharge back to a suitable receptor. Exterior wall penetration is permitted with test drain but only as approved by the Architect.
- I. Valves shall be manufactured by Victaulic, Nibco, Viking, or equal. Inspector's test stations shall be manufactured by AFG, Tyco, Victaulic, or equal.

2.5 SPRINKLERS

- A. All sprinklers to be used on this project shall be Quick Response type and shall be stamped with date of manufacture and temperature rating. Temperature ratings shall be determined by the location of the heads per NFPA 13-2013, section 8.3.2.5, and shall be minimum 155 degrees F. throughout except in special areas around heat producing equipment, skylights, and attics in which case use temperature rating to conform with hazard as specified in NFPA 13-2013. Orifice diameter and K factor shall be appropriate to meet the hydraulic design criteria, the available water supply, and NFPA Standards.
- B. Furnish spare heads of each type installed located in a cabinet along with special sprinkler wrenches. The number of spares and location of cabinet shall be in complete accord with NFPA 13-2013.
- C. Sprinklers shall be manufactured by Tyco, Victaulic, Viking, or equal.
- D. Upright sprinkler heads in areas with no ceilings shall be Tyco Model "TY-FRB" Quick Response, upright natural brass finish heads. Include heavy duty sprinkler guards in all mechanical and storage rooms, gymnasium outdoor activity, aerobics, wrestling, auto shops and general shop. In pool area, all heads shall have a corrosive resistant lead coating.
- E. Sidewall heads shall be Tyco Model "TY-FRB" Quick Response with white polyester head and escutcheon.
- F. Pendent wet sprinkler heads shall be Tyco Model "TY-FRB" Quick Response recessed adjustable escutcheon, white polyester finish.
- G. Concealed heads shall be Tyco Model "RFII" Quick Response concealed type, 1-1/2 inch adjustment white cover plate. In special areas, as may be noted on the Drawings, provide alternate cover plate finishes.
- H. Pendent dry sprinkler heads shall be Tyco Model "DS-1" Quick Response dry type, white polyester finish and escutcheon.

- I. Dry sidewall heads shall be Tyco Model "DS-1" dry horizontal sidewall heads, white polyester finish.
- J. Window sprinkler heads shall be Tyco Model "WS" pendent vertical sidewall heads, white polyester finish.
- K. Sprinkler heads located in concealed combustible spaces shall be Tyco Model "CC2" upright sprinkler head, natural brass finish.
- L. Upright sprinkler heads in automotive shall be designed to provide an ordinary hazard 0.2 density.

2.6 FIRE DEPARTMENT CONNECTION

- A. Fire Department Inlet Connection shall be Croker #6350 Series; 4 inch Storz inlet x 4 inch outlet, 30 degree elbow, brass plate, and stamped "Sprinkler-Standpipe". Install 1/2" ball drip valve and chrome plated trim wall fitting on bottom of inlet fitting body. Provide access panel for servicing the ball drip.
- B. Fire Department Connection shall be manufactured by Croker, Potter Roemer, Elkhart, or equal.

2.7 FIRE DEPARTMENT OUTLET HYDRANT CONNECTION

- A. Fire Department outlet hydrant connection on roof shall be Potter Roemer #5826 polished brass flush 2 way fire department outlet connection assembly – 2-1/2"x2-1/2"x6". Hydrant valve control assembly shall be Potter Roemer #5852-DH polished brass hydrant valve control assembly.
- B. Fire Department outlet connection shall be manufactured by Croker, Potter Roemer, Elkhart, or equal.

2.8 SUPPLEMENTARY STEEL, CHANNEL, AND SUPPORTS

- A. Furnish and install All Supplementary Steel, Channels, and Supports required for the proper installation, mounting, and support of all equipment.
- B. Supplementary Steel and Channels shall be firmly connected to building construction in a manner approved by the Architect.
- C. The type and size of the Supporting Channels and Supplementary Steel shall be determined by the Fire Protection Subcontractor and shall be sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for loading.
- D. All Supplementary Steel and Channel shall be installed in a neat and workmanlike manner parallel to the walls, floor, and ceiling construction. All turns shall be made with 90 degree fittings, as required to suit the construction and installation conditions.

2.9 HANGERS AND SEISMIC RESTRAINTS

- A. Hangers shall be furnished, installed, and supported from the building structure in accordance with NFPA - 13, Section 230548 and Drawing VS.1.
- B. All piping shall be seismic restrained.

2.10 ALARM DEVICES

- A. Flow switches shall be vane type water flow detectors with 0-70 Sec. Adjustable non-accumulative retard device and (2) single pole double throw contacts, Notifier Series WFD Potter, VSR.F or equal.
- B. Pressure switches shall be adjustable Potter Model PS10A or equal.
- C. High/Low pressure switches shall be adjustable Potter Model PS40A or equal.
- D. Supervisory switches on all O.S. & Y. gate valves shall be Notifier NGV complete with mounting bracket.
- E. The wet system alarm device shall be Reliable Model 'E' alarm valve with "E1" trimmings. Package to include electric bell.
- F. Dry valve shall be Reliable Model "A" or "B" as dictated by Hydraulic Calculations complete with Water Motor Alarm and Electric Trim Package.
- G. Preaction valve shall be Victaulic Firelock NXT actuated valve with pre-action trim, pressure switch, & general air riser mounted compressor.
- H. Refer to Drawings for additional devices. Co-ordinate, prior to ordering devices, with the Electrical Sub-Contractor to assure device compatibility with the Fire Alarm System.
- I. Alarm valves shall be as manufactured by Reliable, Victaulic, Tyco, or equal. Flow, pressure and supervisory switches shall be manufactured by Potter, Notifier, System Sensor, or equal.

2.11 DOUBLE CHECK VALVE ASSEMBLY

- A. Double check valve assembly shall be State approved, U.L./F.M. approved, with iron body bronze mounted construction complete with supervised OS & Y gate valves and test cocks. Furnish two spare sets of gaskets and repair kits.
- B. Double check valve assembly shall be of one of the following:
 - 1. Watts Series 757-OSY
 - 2. Wilkins 350A-OSY
 - 3. Conbraco Series 4S-100
 - 4. Or equal.
- C. In the name of the owner pay for, file for, and obtain required permits from D.E.P. and/or local authority whichever has jurisdiction prior to installation.

2.12 ACCESS DOORS

- A. Furnish Access Doors for access to all concealed control valves, drains, inspector's tests, supervisory devices, and to all other concealed parts of the system that require accessibility for the proper operation and maintenance of the system. These doors shall be installed under the appropriate Section of the Specifications for the surface upon which the panels are mounted.
- B. All Access Doors shall be located in a workmanlike manner in closets, storage rooms, and/or non-public areas, positioned so that the valve or part can be easily reached, and the size shall be sufficient for this purpose (minimum size 12 inch x 16 inch). When access doors are required in corridors, lobbies, or other habitable areas, they shall be located as directed by the Architect.
- C. Access Doors shall be prime painted and be complete with cylinder lock and two keys as manufactured by Acudor, Inland Steel Products Company "Milcor", or Walsh-Hannon-Gladwin, Inc., "Way Lector". Type shall be as follows:
- | | |
|-------------------------|----------------|
| Acoustical Tile Ceiling | Acudor AT-5020 |
| W.B. Surfaces | Acudor DW-5040 |
| Masonry Construction | Acudor UF-5000 |
| Fire Rated Construction | Acudor FB-5060 |
- D. Access Doors Shop Drawings shall be submitted to the Architect for approval.

2.13 AIR COMPRESSOR

- A. Furnish and install a general UL listed air riser mounted compressor wired for 120V, single phase power sized for the volume of the dry and pre-action system.

2.14 FIRE STANDPIPE EQUIPMENT

- A. **Fire Department Valves shall be Croker Series 5015 Fire Department Valves fitted with 2-1/2 inch x 1-1/2 inch reducer, caps and chains all conforming to Local Fire Department thread standard. Valves shall be polished chrome plated and shall be mounted in a recessed cabinet as indicated on Drawings.**
- B. **Cabinets for the Fire Department Valves located in Stage area shall be Croker model 1750 - 20 inch x 27 inch x modified 10 inch deep cabinet. Cabinet shall be fully recessed with solid steel door prime painted. Include graphic and door catch.**
- C. **Cabinets shall be fitted with pull handles. Cylinder locks are not allowed.**
- D. **Cabinets and valves shall be manufactured by Croker, Potter Roemer, Elkhart, or equal.**

PART 3 - EXECUTION

3.1 WORKMANSHIP AND INSTALLATION METHODS

- A. All work shall be installed in a first-class manner consistent with the best current trade practices. All materials shall be securely installed plumb and/or level, and all flush mounted equipment shall have front edge flush with finished wall surface.
- B. Protect all concealed heads. Coordinate and advise finishing trades so as to prevent painting of sprinkler heads or inadvertent filling with paint or jointing compound of required air spaces in the case of the concealed type sprinkler heads.

3.2 WORK COORDINATION AND JOB OPERATIONS

- A. The equipment shall not be installed in congested and possible problem areas without first coordinating the installation of same.
- B. Before materials are purchased or work is begun, prepare and submit to the Architect, Coordination Drawings showing the size and location of all equipment and piping lines relevant to the complete system. Ensure that these Drawings are compatible and correctly annotated and cross-referenced at their interfaces.
- C. Coordination Drawings are for the Contractor's and the Architect's use during construction and shall not be construed as replacing any Shop or Record Drawings required elsewhere in these Contract Documents.
- D. Detailed procedures for Coordination Drawings are contained in DIVISION 01 - GENERAL REQUIREMENTS of these Contract Documents.
- E. Particular attention shall be directed to the coordination of piping and other equipment installed in the ceiling areas. Coordinate the elevations of all piping in hung ceiling areas to insure adequate space for the installation of recessed lighting fixtures before other mechanical equipment is installed.
- F. Furnish to the General Contractor, and all other Subcontractors, all information relative to the portion of the Fire Protection installation that will affect them, sufficiently in advance so that they may plan their work and installation accordingly.
- G. In case of failure to give proper information as indicated above, sufficiently in advance, pay for all back-charges for the modification, renovation, and relocation of any portion of the work already performed.
- H. Obtain from the other trades, all information relative to the Fire Protection Work to be executed in conjunction with the installation of their respective equipment.

3.3 CUTTING AND CORE DRILLING

- A. Perform all cutting and core drilling operations that are outlined in Part 1 of this SECTION. Throughout the performance of the cutting and coring work, ensure that the structural integrity of the walls, floors, overhead structure, and other structural components is maintained until permanent work is installed. Prior to any coring or cutting, verify all locations of same with the General Contractor. All cutting and coring is to be performed in accordance with approved Coordination Drawings.
- B. Cut all masonry and concrete with an approved diamond blade concrete saw in a neat straight direction, perpendicular to the plane of the wall or floor.
- C. Use a core drilling process which produces clean, sharp edges and the minimum hole size which will accommodate the size of pipe sleeve specified.
- D. Patch all holes up to the sizes indicated in this Section with material and methods as are specified in the Section of the Specifications for the finish trade involved. Holes which are improperly done due to poor materials or method, shall be patched to the satisfaction of the Architect by the finish trade and back-charged to this Subcontractor.

3.4 CLEANING AND PROTECTION

- A. Protect all materials and equipment during shipment and installation and properly handle and store at the job site so as to prevent damage. Assume full responsibility for protection of work until its completion and final acceptance.
- B. Keep the premises reasonable clean at all times and remove rubbish caused by the Fire Protection work as directed by the Architect.
- C. Upon completion of this work, clean all sprinklers, and equipment and replace damaged parts. Failure to fulfill this obligation will result in back-charges for correction of the defective work by others.

3.5 SLEEVES, INSERTS, AND ESCUTCHEONS

- A. All piping passing through slabs, floors, walls, and partitions shall be sleeved and all such sleeves shall be furnished and installed by the Fire Protection Subcontractor as detailed on the Drawings and herein specified. Fire Protection Contractor, shall do his core drilling as approved by the Architect and the cored opening shall have a sleeve caulked and leaded in place. Set sleeves in concrete floors and walls as soon as forms set and before concrete is poured.
- B. All pipes passing through floor, whether slab-on grade or above grade levels shall be sleeved with sleeve extending 1 inch above floor. This includes all piping in toilet room pipe space, stairwells, closets, and partitions. In mechanical penthouses, pipe sleeves shall extend 4 inches above floor.
- C. All sleeves shall be Schedule 40 galvanized steel pipe and shall be reamed. There shall be annular space between the sleeve and pipe per NFPA requirements. Sleeves on drywall, masonry, or concrete walls and partitions shall be flush with wall on both sides.

- D. The space between sleeve and pipe, in all cases, shall be filled with U.L./F.M. approved caulking compound. This includes pipes concealed in chases and/or partitions.
- E. Inserts, where required, shall be furnished and set by the Fire Protection Subcontractor and, where necessary, may be drilled or power driven and shall be sized such that the insert will not exceed a depth of penetration of 1 inch into concrete.
- F. Escutcheons: All exposed pipe, uncovered, passing through walls, or floors, or ceilings, shall be fitted with C.P. brass spun or split type escutcheons with approved clamping device for holding in position. Floor escutcheons shall be deep enough to fit over sleeves, fastened to pipe, and extend down to floor.

3.6 TESTING

- A. Flush the system and test all work in the presence of the Architect and/or Engineer and as required by NFPA and the Insurance Company. The flushing and testing procedures to be followed are specified herein. At the completion of the testing, submit fully executed copies of Contractor's Material and Test Certificate for both above ground and underground piping as contained in NFPA-13.
 - 1. Water Supply:
 - a. Flushing: Underground/exterior service entrance shall be flushed at a minimum velocity of 10 fps in accordance with NFPA Standards 13, 14, and 24. The Fire Protection sub-contractor shall coordinate with Division 33 and shall notify the Water and Fire Departments prior to testing of the entire exterior system.
 - 2. Sprinkler System:
 - a. Hydrostatic Testing: The interior system shall be hydrostatically tested at 200 psi for 2 hours in accordance with NFPA 13 paragraph 25.2.1.
 - b. Operational Testing: Water flow switches and associated alarm systems shall be tested by water flow through the inspector's test assemblies in accordance with NFPA 13, 25.2.3.
 - c. Main Drain Test: A flow test shall be performed on the main drain valve and recorded on the Contractor's test certificate in conformance with NFPA 13, 25.2.3.4.
 - d. Backflow Preventor Flow Test: The double check valve assembly shall be flow tested in conformance with NFPA 13, 25.2.5.
 - 3. Bulk Fire Main:
 - a. Flushing: The fire department connection piping shall be flushed at a minimum velocity of 10 fps in conformance with NFPA 13, and NFPA 14.
 - b. Hydrostatic Testing: All piping shall be pressure tested at 200 psi for 2 hours in conformance with NFPA 14.
 - c. Flow Tests: The system shall be flow tested at the hydraulically most remote hose connection in conformance with NFPA 14.
 - d. Valve and Supervisory Switch Test: All valves and tamper switches will be tested by opening and closing valves in conformance with NFPA 14.

END OF SECTION

SECTION 21 08 00 - COMMISSIONING OF FIRE SUPPRESSION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.

1.2 SUMMARY

- A. This section includes commissioning process requirements for Fire Suppression systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
- C. Certificates of readiness
- D. Certificates of completion of installation, prestart, and startup activities.
- E. O&M manuals
- F. Test reports

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired

resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the contractor for the equipment being tested. For example, the fire protection contractor of Division 21 shall ultimately be responsible for all standard testing equipment for the plumbing system in Division 21.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for applicable commissioned components, equipment, and systems.
- B. Red-lined Drawings: The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. Operation and Maintenance Data: Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and

systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the contractor.

- D. Demonstration and Training: Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior to the training session.

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Perform tests that are specified in the Division 21.
- B. Attend construction phase coordination meetings.
- C. Participate in Fire Suppression systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- D. Provide information requested by the CxA for final commissioning documentation.
- E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- F. Prepare preliminary schedule for Fire Suppression system orientations and inspections, operation and maintenance manual submissions, training sessions, flushing and cleaning, equipment start-up, and task completion for owner. Distribute preliminary schedule to commissioning team members.
- G. Update schedule as required throughout the construction period.
- H. Assist the CxA in all verification and functional performance tests.
- I. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- J. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.
- K. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- L. Participate in, and schedule vendors and contractors to participate in the training sessions.
- M. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 - 1. Life Safety/Fire Suppression equipment including pumps, piping, and all other equipment furnished under this Division.
 - 2. Automatic sprinkler and standpipe systems.
 - 3. Fire stopping in fire rated construction, including caulking, gasketing and sealing of smoke barriers.
- N. The equipment supplier shall document the performance of his equipment.

- O. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- P. Equipment Suppliers
 - 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 - 2. Assist in equipment testing per agreements with contractors.
 - 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- Q. Refer to Division 01 Section “General Commissioning Requirements” for additional contractor responsibilities.

3.3 CxA'S RESPONSIBILITIES

- A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

3.4 TESTING PREPARATION

- A. Certify in writing to the CxA that Life Safety/Fire Suppression systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that Life Safety/Fire Suppression instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- D. Inspect and verify the position of each device and interlock identified on checklists.
- E. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- F. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.5 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of Life Safety/Fire Protection testing shall include entire Fire Suppression installation. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions.
- D. The CxA along with the Fire Suppression contractor may prepare detailed testing plans, procedures, and checklists for Fire Suppression systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.

- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the Fire Suppression system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.6 FIRE SUPPRESSION SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 21 sections. Provide submittals, test data, inspector record, and certifications to the CxA.
- B. Fire Suppression Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of sprinkler distribution systems.
- C. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

- 1. Fire protection and suppression systems and fire pump systems,

3.7 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.8 APPROVAL

- A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.9 DEFERRED TESTING

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.10 OPERATION AND MAINTENANCE MANUALS

- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.

- B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.11 TRAINING OF OWNER PERSONNEL

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

END OF SECTION 21 08 00

SECTION 220000

PLUMBING

PART 1 - GENERAL.....	1
1.1 GENERAL PROVISIONS.....	1
1.2 DESCRIPTION OF WORK.....	1
1.3 RELATED WORK.....	2
1.4 CODES, ORDINANCES, AND PERMITS.....	3
1.5 SHOP DRAWING AND MATERIAL SCHEDULES.....	3
1.6 COORDINATION DRAWINGS.....	4
1.7 RECORD DRAWINGS.....	4
1.8 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS.....	5
1.9 GUARANTEE.....	5
1.10 DRAWINGS.....	5
1.11 VALVE TAGS, NAMEPLATES, AND CHARTS.....	6
1.12 PIPE MARKER IDENTIFICATION SYSTEM.....	6
1.13 SANITARY, WASTE, VENT, KITCHEN GREASE WASTE AND VENT, GARAGE WASTE AND VENT, AND STORM SYSTEMS.....	7
1.14 DOMESTIC WATER SYSTEMS (POTABLE & NON-POTABLE).....	7
1.15 COMPRESSED AIR SYSTEM.....	8
1.16 EMERGENCY TEMPERED WATER SUPPLY.....	8
1.17 FUEL GAS SYSTEM.....	8
1.18 SPECIAL WASTE AND VENT SYSTEM.....	9
1.19 EQUIPMENT FURNISHED BY OTHERS.....	10
1.20 PAINTING.....	11
1.21 HOISTING EQUIPMENT AND MACHINERY.....	11
1.22 STAGING AND SCAFFOLDING.....	11
1.23 COMMISSIONING.....	11
1.24 BREAKDOWN.....	12
1.25 ENERGY REBATE PROGRAM.....	12
1.26 TRADE RESPONSIBILITY FOR INTERCONNECTIONS MATRIX.....	12
PART 2 - PRODUCTS.....	14
2.1 GENERAL.....	14
2.2 PIPE AND FITTINGS.....	14
2.3 JOINTS.....	16
2.4 VALVES.....	16
2.5 INSULATION.....	17
2.6 TRAPS.....	18
2.7 DRAIN VALVES.....	18
2.8 SHOCK ABSORBERS.....	18
2.9 PIPING ACCESSORIES.....	18
2.10 HYDRANTS AND HOSE BIBB.....	19
2.11 CLEANOUTS.....	19
2.12 ACCESS DOORS.....	20
2.13 SUPPLEMENTARY STEEL, CHANNEL, AND SUPPORTS.....	20
2.14 HANGERS, ANCHORS, GUIDES, AND PIERS.....	21
2.15 DRAINS.....	22
2.16 PLUMBING FIXTURES.....	22
2.17 BACKFLOW PREVENTERS.....	28
2.18 UNION AND NIPPLES.....	28
2.19 POTABLE WATER HEATER (WH-1 & WH-2).....	29
2.20 ELECTRIC NON-POTABLE WATER HEATER (WH-3).....	31

2.21	TEMPERING VALVES	31
2.22	RECIRCULATING HOT WATER PUMPS.....	31
2.23	CONDENSATE NEUTRALIZING TUBES	31
2.24	NATURAL GAS SUB-METER	31
2.25	WATER METER	32
2.26	DOMESTIC WATER SUB-METER	32
2.27	GAS SOLENOID VALVE.....	32
2.28	COMPRESSED AIR REGULATORS	32
2.29	FIRESTOP SYSTEMS	32
2.30	SCAFFOLDS AND STAGING	32
2.31	HOISTING MACHINERY AND EQUIPMENT	33
2.32	ACID NEUTRALIZATION SYSTEM (NT-1).....	33
2.33	AIR COMPRESSOR (AC-1)	34
2.34	TRENCH DRAIN	34
2.35	MANHOLE AND PRECAST CONCRETE OIL/GAS SEPARATOR STRUCTURE.....	34
PART 3 - EXECUTION		35
3.1	WORKMANSHIP AND INSTALLATION METHODS.....	35
3.2	WORK COORDINATION AND JOB OPERATIONS	35
3.3	CUTTING AND CORE DRILLING	36
3.4	CLEANING AND PROTECTION.....	36
3.5	SLEEVES, INSERTS, AND ESCUTCHEONS	36
3.6	TESTING	37
3.7	CHLORINATION	38
3.8	INSTALLATION OF FIRESTOP SYSTEMS.....	38

END OF INDEX

SECTION 220000

PLUMBING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 DESCRIPTION OF WORK

- A. Provide all labor, materials, equipment, services and accessories necessary to furnish and install the work of this Section, complete and functional, as indicated in the Contract Documents and as specified herein.
- B. The work covered by this Section of the Specifications includes the furnishing of all labor and materials and in performing all operations in connection with the installation of the Plumbing Work.
- C. Without limiting the generality thereof, the work to be performed under this Section includes:
 - 1. Domestic water service to 10 ft. outside building and/or as shown on the Drawings.
 - 2. Complete Sanitary, Waste & Vent System to 10 ft. outside building and/or as shown on the drawings.
 - 3. Storm drainage system including Roof Drains, Rain Leaders, and horizontal drains to 10 ft. outside foundation wall.
 - 4. Special Waste and Vent System (Acid Waste) including neutralizer and pH monitoring system to tie into Sanitary System at least 10 ft. after neutralization.
 - 5. Kitchen Grease Waste and vent system including waste piping within the exterior grease trap provided under Division 33 – UTILITIES.
 - 6. Garage waste and vent system including precast concrete oil/gas separator structure and access manhole.
 - 7. Coordinate all drainage with subsoil drainage system by others.
 - 8. Potable Cold, Hot, and Hot Water Re-circulation System.
 - 9. Non-Potable Cold, Hot, and Hot Water Re-circulation System.
 - 10. Natural Gas System including elevated pressure gas manifold and pressure regulators for all gas systems.
 - 11. Shop compressed Air System including Air Compressor.
 - 12. Insulation.
 - 13. Potable & Non-Potable Water Heating Equipment.
 - 14. Science Classroom and Kitchen Emergency Gas Solenoid Valves
 - 15. Fixtures and Equipment
 - 16. Connection to Equipment Furnished by Others

17. Flushing, Sterilization, and Tests
18. Furnishing of Access Panels
19. Drilling, Coring and Cutting & Patching of holes and openings where the largest dimension thereof does not exceed 12 inches for Plumbing Piping and Equipment.
20. Provide and maintain temporary water service as directed by General Contractor. General Contractor to pay for all water use.
21. Scaffolding, Rigging, and Staging required for all Plumbing Work. Comply with Division 01 requirements.
22. Provide Seismic Restraints for all Plumbing Systems conforming to the requirements of Section 230548 which Section is herein incorporated by reference. Seismic restraints are required on all new systems.
23. Preparation of Co-ordination Drawings.
24. Smoke and Firestopping Seals and sealing of all wall penetrations as detailed on the drawings. Refer to Section 078400 which defines the firestopping materials and methods.
25. At Project close out the Plumbing Sub-Contractor shall provide the services of an outside firm who shall run an underground video camera, locating all drainage system lines including depth, preparing a video and identifying & correcting any problem areas. The Plumbing Sub-Contractor shall rod-out and power wash all underground drainage systems. Turn over 4 copies of the video and written report to the owner. Videos are required for the underground sanitary, storm drainage, garage waste, and special waste systems.
26. It shall be the responsibility of this division ~~220000~~ **230000** to provide all personnel as required to fully coordinate with the commissioning agent. The hours of training and instruction outlined in this division ~~220000~~ **230000** and the Testing requirements shall be in addition to those tests and requirements outlined in section 019113 and section 220800 and required to fulfill section 019113 and section 220800 commissioning obligations.
27. When open-flame or spark producing tools such as blower torches, welding equipment, and the like are required in the process of executing the work, the General Contractor shall be notified not less than twenty four hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant non-working fire watch, paying all fees, where work is being performed and until it is completed. Fee for fire watch shall be included in the bid.

1.3 RELATED WORK

A. The following Related Work will be performed under the designated Sections:

1. Domestic Water Service to 10 ft. outside – DIVISION 33 – UTILITIES.
2. Cutting and Patching beyond 1.2C.19 above: SECTION 017329 - CUTTING AND PATCHING.
3. Installation Of Roof Drains, Flashing for vents through roof: SECTION 076200 – SHEET METAL ROOFING, SIDING, FLASHING AND TRIM.
4. Electric Power Wiring: SECTION 260000 – ELECTRICAL.
5. HVAC Equipment: SECTION 230000 – HVAC.
6. Excavation and Backfill: DIVISION 31 – EARTHWORK.
7. Sanitary Sewer and storm drains to 10 feet outside the foundation wall: DIVISION 33 – UTILITIES.
8. Finish Painting: SECTION 099000 – PAINTING AND COATING.
9. Installation of Access Panels: SECTION describing material in which panel is installed.
10. Toilet Room Accessories: SECTION 102800 - TOILET ACCESSORIES.

11. Temporary Facilities: SECTION 015000 - TEMPORARY FACILITIES AND CONTROLS.
12. Food Service Equipment: SECTION 114000 - FOOD SERVICE EQUIPMENT.
13. Laboratory Casework and Sinks: DIVISION 12 – FURNISHINGS.

1.4 CODES, ORDINANCES, AND PERMITS

- A. Perform all work in accordance with the requirements of the City of Dover Building Department, International Plumbing and Fuel Gas Codes, including New Hampshire Amendments, D.E.P., A.D.A., NFPA, The Architectural Barrier Code, and applicable State and Federal Laws. Give all requisite notices, file all requisite plans, and obtain all permits required to perform all Plumbing Work. Where the Contract Documents indicate more stringent requirements than the above Codes and Ordinances, the Contract Documents shall take precedence.
- B. Obtain all permits, inspections, and approvals, from the governing authorities and pay all fees and include cost in the bid, including approvals for the cross connection control device. Provide the Owner with the cross connection permit for the device in the Owner's name.
- C. Owner will pay all related Gas Utility Company back charges.

1.5 SHOP DRAWING AND MATERIAL SCHEDULES

- A. Refer to SECTION 013300 – SUBMITTAL PROCEDURES for submittal of Shop Drawings. If apparatus or materials are substituted for those specified, and such substitution necessitates changes in or additional connections, piping, supports or construction, same shall be provided as the responsibility, and at the expense, of the Plumbing Subcontractor.
- B. Fabrication of any material or performing of any work prior to the final approval of the Submittals will be entirely at the risk of the Subcontractor. The Subcontractor is responsible for furnishing and installing materials called for in the Contract Documents, even though these materials may have been omitted from approved Submittals.
- C. Submit Shop Drawings for the following materials and equipment.
 1. Valves, Piping, couplings and Fittings
 2. Fixtures, Drains and Equipment including Supports
 3. Backflow Preventers
 4. Access Panels and Covers
 5. Insulation
 6. Drains, and Hydro Mechanical Specialties
 7. Hose Bibs, Wall Hydrants, Roof Hydrants
 8. Hangers, Anchors, Guides, and Supports including Seismic Restraints
 9. Cleanouts
 10. Piping Identification System
 11. Water Heating Equipment
 12. Hair and plaster traps
 13. Acid Neutralizer tank and monitoring equipment
 14. Air Compressor
 15. Natural gas sub meters
 16. Domestic water sub meter
 17. Precast concrete oil/gas separator and access manhole

1.6 COORDINATION DRAWINGS

- A. Before materials are purchased or Work is begun, prepare and submit to the Architect, Coordination Drawings showing the size and location of all equipment and piping lines relevant to the complete system. Ensure that these Drawings are compatible and correctly annotated and cross-referenced at their interfaces (match lines).
- B. Coordination Drawings are for the Contractor's and the Architect's use during Construction and shall not be construed as replacing any Shop or Record Drawings required elsewhere in these Contract Documents.
- C. Detailed procedures for Coordination Drawings are contained in DIVISION 01 - GENERAL REQUIREMENTS of these Contract Documents.

1.7 RECORD DRAWINGS

- A. General: Refer to DIVISION 01 - GENERAL REQUIREMENTS for general requirements for maintaining as-built drawings and submitting final reproducible record documents.
- B. The Construction Manager will provide two sets of Drawings to the Plumbing Subcontractor, one set of which shall be maintained at the site and which shall, at all times, be accurate, clear, and complete, showing the actual locations of all equipment and piping as it is being installed. The Record Drawings shall be available to the Architect/Engineer's field representative at all times.
- C. Provide electronic AutoCAD drawings to indicate revisions to piping size and location both exterior and interior; including locations of valves and other equipment requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; concealed equipment, dimensioned to column line; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located.
- D. Include in the Record Drawings any addenda, sketches, and supplementary Drawings issued during the course of construction.
- E. Non-availability of Record Drawings or inaccuracies therein will postpone the final inspection until they are available.
- F. All valves shown on these Drawings shall be numbered with numbers corresponding to those on the valve charts.
- G. All costs related to the foregoing requirements shall be paid by the Plumbing Subcontractor.

1.8 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. Provide operating instructions to the Owner's designated representative with respect to operation functions and maintenance procedures for all equipment and systems installed. At the completion of the project, turn over to the Architect four (4) complete manuals, in three-ring, loose-leaf binders, containing the following:
1. Complete Shop Drawings of all equipment.
 2. Operation description for all systems.
 3. Names, addresses, and telephone numbers of all suppliers of the system.
 4. Preventative maintenance instructions for all systems.
 5. Spare parts lists of all system components.
 6. Four copies of video of new piping.
 7. Valve tag chart.
- B. Contractor shall provide a computerized maintenance management system in format compatible with School Dude (excel or other similar program) for Plumbing equipment.

1.9 GUARANTEE

- A. Refer to Division 01 of the Contract. Guarantee all work under this Section free from defects in workmanship and materials for a period of one (1) year from the date of final acceptance of the building, as set forth in the Contract. Replace any such defective work developing during this period, unless such defects are clearly the result of bad usage of equipment by others. Where such defective work results in damage to work of other Sections of the Specifications, restore such work to its original condition by mechanics skilled in the affected trade.

1.10 DRAWINGS

- A. All work shown on the Drawings is intended to be approximately correct to scale, but shall be taken in a sense as diagrammatic. Sizes of pipes and general method of running them are shown, but it is not intended to show every offset and fitting. To carry out the true intent and purpose of the plans, furnish all necessary parts to make complete working systems ready for use. The Plumbing Drawings are intended to show the main stacks and risers and may or may not necessarily show all runout piping particularly in lavatories and gang toilet areas. Contractor shall include all runout piping to all referenced scheduled fixtures and equipment appearing on the Plumbing Drawings.
- B. All floor drains installed on this project, including all kitchen floor drains and trough drains, shall be equipped with trap primers. The trap primer and piping is not shown on the drawings and shall be located in the field by the Contractor as dictated by field piping conditions.
- C. The Plumbing Drawings and Specifications are intended to supplement each other so that any details shown on the Drawings and not mentioned in the Specifications, or vice-versa, shall be executed the same as if mentioned in the Specifications and shown on the Drawings.

- D. Refer to the Architectural, Structural, and other Mechanical and Electrical Drawings, which indicate the construction in which this Work shall be installed. Locations shown on the plans shall be checked against the general and detailed Drawings of the construction proper. All measurements shall be taken at the Building.

1.11 VALVE TAGS, NAMEPLATES, AND CHARTS

- A. All valves on pipes of every description shall have neat circular brass valve tags at least 1-1/2 in. in diameter attached with brass hook to each valve stem. Stamp on these valve tags, in letters as large as practical, the number of the valve and the service, such as "H.W., C.W., GAS", for hot water, cold water, and gas respectively. The numbers for each service shall be consecutive. Where valves are located above ACT ceilings, furnish and install valve finder ceiling tack, tack shall be minimum 7/8 in. diameter with 1/2 in. steel point, color as determined by Owner.
- B. All valves on tanks and pumps shall be numbered by 3 in. red metal discs with white numbers 2 in. high, secured to stem of valves by means of small solid link brass chain, to correspond to numbers indicated for valves on the Record Drawings and on two (2) printed detailed lists. These printed lists shall state the numbers and locations of each valve and the fixture or group of fixtures which it controls, and other necessary information such as requiring the opening or closing of another valve or valves when any one valve is to be opened and closed, and shall be prepared in form to meet approval of the Architect, and shall be framed under glass.
- C. Nameplates, catalog numbers, and rating identifications shall be securely attached to Electrical and Mechanical equipment with screws or rivets. Adhesives or cements will not be permitted.

1.12 PIPE MARKER IDENTIFICATION SYSTEM

- A. Mark all piping installed under this Section and at all Access Panels with a marking system in basic colors conforming to those specified in ANSI/ASME A-13.1. Markings shall indicate pipe content and direction of flow. Markers shall be applied at all valves and tee joints, and on straight runs of pipe at every 20 ft.-0 in. on center. Adhesive markings are not acceptable. Markers shall be painted on under the scope of this Section or may be snap-on system.
- B. Clearly mark potable and non-potable water system with 4 inch wide colored bands, with arrow for direction of flow, every twenty-five (25) feet on center on all piping installed whether it is concealed or exposed and also on both sides of floor and/or wall penetrations. Mark potable water green and non-potable yellow. Within 6 in. of each band identify with letter "Potable C.W.", Non-Potable H.W." Color of letter shall match banding. Snap-on are not to be used

1.13 SANITARY, WASTE, VENT, KITCHEN GREASE WASTE AND VENT, GARAGE WASTE AND VENT, AND STORM SYSTEMS

- A. Furnish and install complete Sanitary, Waste, Vent, Kitchen Grease Waste and Vent, and Storm Drainage Systems (all hereinafter called Drainage Systems) to convey wastes from all Soil and Waste Stacks, Fixtures, Equipment, Kitchen Fixtures, Roof Drains as indicated and/or described in these Plans and Specifications. Urinal waste shall be 2 in. cast iron or sizes indicated on the drawings. Waste piping smaller than 3 in. shall not be used underground. The use of double "Y's" in the horizontal shall not be permitted. All piping shall be installed straight and true and located concealed within building construction.
- B. All horizontal Drainage Systems Piping within the building, 3 in. and smaller, shall be pitched at least 1/4 in. per ft. in the direction of flow. Drainage Piping 4 in. and larger shall be pitched at least 1/8 in. per ft. Make changes in direction of drainage lines with 45 wyes, long turn wyes, or sweep bends.
- C. Furnish and install all cleanouts indicated on the Drawings and/or where required in Drainage Pipes regardless of size so that the distance between cleanouts does not exceed 45 ft. o.c. Cleanouts shall be installed at the base of all risers and at each change of direction.
- D. Refer to drawings for termination points, which generally are to 10 feet outside the building.
- E. The Kitchen Grease Waste System shall be a completely separate system beginning at the exterior grease interceptor through the kitchen and vented individually through the roof. Do not connect soil lines to the grease waste nor sanitary vents to the grease vent. Furnish and install the cast iron tees and associated piping within the grease trap including 5-foot length on the outlet. All the piping within the grease trap shall be made up with caulked and leaded joints. Install an exterior cleanout as detailed at the point where the line leaves the kitchen area. Grease trap is furnished and set in place including manhole access covers by the General Contractor.
- F. The Garage Drainage System shall be a complete separate system piped from the interceptor through the roof without interconnection to any other building Drainage System including sanitary waste and vent.

1.14 DOMESTIC WATER SYSTEMS (POTABLE & NON-POTABLE)

- A. Furnish, install, sterilize, and test in accordance with the documents and the Plumbing Code, complete potable and non-potable Domestic Cold, Hot, and Hot Water Recirculating Systems including all piping, valves, low point drains, shock absorbers, hangers, insulation, backflow preventers and water heating equipment. Clearly mark the systems as provided above. This work shall start as indicated on the Drawings.
- B. In general, piping shall pitch upward in the direction of flow with each branch and riser separately valved and with 1/2 in. hose end drain on the outlet side of the valve and at all low points in the system. Install shutoff valves for each battery of fixtures and other valves as necessary to isolate any part of each system.
- C. Install shock absorbers on hot and cold water piping to each fixture. Provide shock absorbers at all quick closing valves and as shown on the Drawings and/or specified.

- D. Install a 1/2 inch hose bibb in each toilet room provided with a floor drain. The hose bibb shall be installed under a lavatory.
- E. Install a 1/2 inch hose bibb in each mechanical room.
- F. Furnish and install a ball valve, balancing valve and check valve at each hot water recirculation line before it connects to another hot water recirculation line.
- G. All components of the domestic water system shall be "lead free" per Federal Standards.

1.15 COMPRESSED AIR SYSTEM

- A. Furnish and install a complete compressed air system as shown on the drawings and herein specified including all valves, piping, fittings, outlets and any incidentals to make a complete and operable system.
- B. This work includes furnishing and installing the shop air compressor as herein specified, provision of air outlets as detailed on drawings.
- C. Piping shall be run straight and true and shall be rigidly supported from the building construction. All turns and offsets shall be made with fittings as specified elsewhere. Bending of pipe shall not be permitted in this installation.

1.16 EMERGENCY TEMPERED WATER SUPPLY

- A. Furnish, Install, Sterilize and Test utilizing the same materials, methods, etc. as specified above in 1.14. A tempered water supply to service all emergency showers and eye wash units. This piping shall be hung and insulated the same as above. Piping shall start at the tempering valve. Furnish and install for wiring by the Electrical Sub-Contractor a flow switch at each and every shower. Arrange piping so that either the shower or eye wash will alarm the switch.

1.17 FUEL GAS SYSTEM

- A. Furnish and install a complete Natural Gas Supply System including pipe, fittings, valves, connections to all gas fired equipment requiring gas, and all accessories and incidentals as indicated or specified. Installation shall be made in accordance with the State Gas Code requirements. Piping shall be installed with an 8 in. long sediment leg at the base of all risers. All changes in direction shall be made with plugged tees for cleaning piping out.
- B. All horizontal Gas Piping shall be pitched not less than 1/4 in. in 15 ft. to prevent traps. Pitch piping to risers. Install an 8 in. long sediment leg at the base of all risers. All changes in direction shall be made with plugged tees for cleaning piping out. All horizontal branch outlet pipes shall be taken from the top or side of horizontal mains and not from the bottom. Install shutoff valves for each battery of equipment and other valves as necessary to isolate any part of each system.
- C. Arrange with the Local Gas Company for the installation of the gas meters, services, and gas pressure regulators. Refer to DIVISION 01 - GENERAL REQUIREMENTS for information regarding Utility Company Charges.

- D. Provide seismic restraints for all gas piping per requirements of the NH State Building Code. Refer also to Section 230548.
- E. Plumbing Sub-Contractor shall furnish and install all pressure regulators and all gas vents for all knockdown regulators whether furnished by this Section, HVAC, or any other Section. Pressure regulators shall be provided after elevated pressure header on outlet side of gas meter. The header will break out to (4) four regulators and distribution mains, (1) one for mechanical rooftop equipment, (1) one for Boilers and water heaters, (1) one for Kitchen, Science and CTC spaces and (1) one for emergency generator.
- F. Gas to the Emergency Generator shall be installed according to the following:
 - 1. A dedicated fuel line shall be installed for the Generator immediately downstream of the meter assembly.
 - 2. The fuel line for the Emergency Power Generator and the fuel line for the remaining appliances shall each have a separate shut off valve installed immediately downstream of the meter to enable each line to operate independently.
 - 3. Install separate regulators, one (1) for the each of the building mechanical systems and one (1) for the Generator. The pressure at each fuel line shall be able to be set independently of the other. The plumbing Sub-Contractor shall be responsible to coordinate this requirement carefully with the gas company and the P.C. shall bear the cost of any additional regulators and valves not normally furnished by the gas company.
 - 4. The fuel line for the Emergency Power Generator shall be labeled at the shut off valve on each side of the wall it penetrates, floor, and every 10 ft. along its run with the following:
WARNING: Emergency Power Generator. Do not shut off without the approval of appropriate authorities.

1.18 SPECIAL WASTE AND VENT SYSTEM

- A. Furnish and install a complete Special Waste and Vent System to convey waste from all laboratory fixtures and equipment as shown on the Drawings and/or herein specified and in accordance with Code requirements. The system shall be a complete independent system, using corrosion resistant piping from a point 10 feet outside building, running through a neutralization system and terminating independently through the roof. Furnish and install Neutralizer and Ph monitor where shown.
- B. Piping shall be run as indicated on the Drawings, properly secured to the building structure with iron hangers. When any end circuit vent pipe from any fixture or line of fixtures is connected to a vent line serving other fixtures, the connection shall be sufficiently more above the floor on which the fixtures are located to prevent the use of the vent line as a waste (6 in. above flood rim of fixture).
- C. All changes in pipe sizes and direction on Special Waste lines shall be made with 'Y's and cleanouts, reducing fittings or recessed reducers. 'Y's and 45 degree fittings or 45 degree combination fittings shall be used wherever possible.
- D. All offsets shall be at an angle of not more than 45 degrees. All horizontal runs of 3 in. and smaller pipe shall have a pitch of 1/4 in. to the foot; 4 in. and larger pipe shall pitch at 1/8 in. to the foot.

- E. Sanitary long sweep bends shall be used for connections to branch lines for fixtures and TY's on vertical runs of pipe only. Long turn fittings shall be used wherever conditions permit. Furnish and install cleanouts at every change in direction of Special Waste lines and where indicated on the Drawings.
- F. All fixtures shall be separately trapped. All traps shall be vented unless otherwise indicated on the Drawings for fixtures in battery vent systems. Provide bow vents where island benches are not part of a battery system.

1.19 EQUIPMENT FURNISHED BY OTHERS

- A. Miscellaneous items, including but not necessarily limited to the following, shall be furnished and set by others as specified in other SECTIONS of the Documents.
 - 1. Laboratory Casework
 - 2. Dishwashers
 - 3. Laboratory Sinks
 - 4. Kitchen Equipment
 - 5. Home Economics Equipment
 - 6. Miscellaneous Sinks
 - 7. Photo Lab
 - 8. FFE Equipment for all CTC Spaces
- B. Verify the extent of the connection requirements from the General and Mechanical Plans and Specifications and be responsible for: Setting in place, all such sinks and furnishing and installing trim and roughing including, but not limited to, drains, vent, water, gas, air or other plumbing piping, traps, tailpiece, nipples, escutcheons, faucets, and stop valves for all items which above are not so supplied. The equipment sections specify sinks including faucets and tailpieces as well as countertop turrets for gas. Include for all sinks which are installed in cabinet work a pair of 1/2 in. ball valve stops (same as specified under 2.04) and a rough bronze p-trap, special waste trap, or sediment trap as required.
- C. Include a "Bakelight" stamped adhesive marker at each faucet indicating "Water Unsafe" as called for in 1.14 above.
- D. The Plumbing Subcontractor shall be responsible in making final connections to all equipment furnished by others to ascertain complete cross-connection prevention compliance and to furnish and install vacuum breaker and backflow preventers which may be required to be Code compliant and are not so furnished with the equipment.
- E. All sinks are intended to be "Accessible" and all drain outlets on all sinks and lavatories where furnished by the Plumbing Subcontractor or the other SECTIONS shall have an off-set drain. Set all roughing tight to wall in all cases to comply with ADA Standards. Provide where required ADA insulation kits to prevent injury where a barrier is not included in the casework. Refer to Equipment Drawings.

1.20 PAINTING

- A. All interior exposed piping is to be painted and all painting, except as noted, will be done by the Painting Subcontractor. All uncovered piping and hangers shall be thoroughly cleaned of rust, oil, and other containments by the Plumbing Subcontractor and left ready to receive primer coat.
- B. Painting for pipe markings shall be done under this Section.
- C. Painting for exterior gas piping at gas meter, generator, on roof, and at rooftop equipment, shall be done under this Section.

1.21 HOISTING EQUIPMENT AND MACHINERY

- A. Unless otherwise specified, all hoisting and rigging equipment and machinery required for the proper and expeditious prosecution and progress of the Work of this Section shall be furnished, installed, operated and maintained in safe condition by each sub-contractor, as specified under Section 015000, TEMPORARY FACILITIES AND CONTROLS.

1.22 STAGING AND SCAFFOLDING

- A. Unless otherwise specified, each sub-contractor shall provide all lifts and man-lifts, and furnish, erect and maintain in safe condition, all staging and scaffolding as specified under Section 015000 Temporary Facilities and Controls, as needed for proper execution of the work of this Section. Staging and scaffolding shall be of adequate design, erected and removed by experienced stage builders having all accident prevention devices required by Federal, state and local laws.

1.23 COMMISSIONING

- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 019113 – Commissioning Requirements and Section 220800 - Commissioning of Plumbing Systems.
- B. Complete installation and startup checks and functional tests according to Section 019113 – Commissioning Requirements and Section 220800 – Commissioning of Plumbing Systems and manufacturers written instructions.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the startup procedure.
- D. Verify that equipment is installed and commissioned as per requirements of Section 019113 and Section 220800 and manufacturers written instructions/requirements.

1.24 BREAKDOWN

- A. Submit a breakdown of the contract price to aid the Architect in determining the value of the work installed as the job progresses.
- B. No requisition will be approved until the breakdown is delivered to the Architect.

1.25 ENERGY REBATE PROGRAM

- A. This project has been designed to incorporate equipment approved for energy rebate such as domestic water heaters. Provide unit prices for each equipment type scheduled to be part of Rebate Program. Assist the Owner in filling out forms for utility company rebates.

1.26 TRADE RESPONSIBILITY FOR INTERCONNECTIONS MATRIX

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Smoke Detectors (Area type)	26 00 00	26 00 00	26 00 00	23 00 00 (ATC)	26 00 00	
Smoke Detectors (Duct mounted)	26 00 00	23 00 00	26 00 00	23 00 00 (ATC)	26 00 00	
Smoke & Fire/Smoke Dampers	23 00 00	23 00 00	N/A	N/A	N/A	
Smoke & Fire/Smoke Damper Actuators	23 00 00	23 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	2
Fire Dampers	23 00 00	23 00 00	N/A	N/A	N/A	
VAV Boxes	23 00 00	23 00 00	26 00 00	23 00 00 (ATC)	N/A	2
VAV Box Damper Actuator	23 00 00 (ATC)	Box Mfr	23 00 00 (ATC)	23 00 00 (ATC)	N/A	2
VAV Box DDC Controller	23 00 00 (ATC)	Box Mfr	23 00 00 (ATC)	23 00 00 (ATC)	N/A	2
Hydronic Control Valves	23 00 00 (ATC)	23 00 00	N/A	23 00 00 (ATC)	N/A	1
Hydronic Control Valve Actuator	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	1
Sheet Metal Damper	23 00 00	23 00 00	N/A	N/A	N/A	1
Sheet Metal Damper Actuators	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	1
Natural Gas Energy Meters	22 00 00	22 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3

Electrical Energy Meters	26 00 00	26 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3
Domestic Water Meters	22 00 00	22 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3
HVAC Hydronic Energy Meters	23 00 00	23 00 00 (ATC)	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3
Airflow Measuring Stations	23 00 00 (ATC)	23 00 00 (ATC)	N/A	23 00 00 (ATC)	N/A	
DDC Panels	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	4
VFDs at AHU, EFs	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	23 00 00 (ATC)	N/A	
Elevator Hoistway Vent Damper	23 00 00	23 00 00	N/A	N/A	N/A	
Elevator Hoistway Vent Damper Actuator	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	
Boiler/DHW/Generator Breeching	22 00 00	22 00 00	N/A	N/A	N/A	
Kitchen Emergency Gas Valve	22 00 00	22 00 00	26 00 00	26 00 00	26 00 00	

Notes:

1. Division 23 00 00 and Division 23 00 00 (ATC) Contractors shall fully coordinate all airflow damper and hydronic valves sizes and quantities.
2. Smoke Damper and VAV Box power wiring shall be provided by Division 26 00 00 to junction box locations shown on electrical drawings; Division 23 00 00 (ATC) Contractor shall provide final power wiring from junction box to end device location.
3. Division 26 00 00 Contractor shall provide all line-voltage power wiring required for meters; Division 23 00 00 (ATC) Contractor shall provide all low-voltage power wiring required for meters.
4. Division 26 00 00 shall provide power at main DDC Panel. Division 23 00 00 (ATC) shall provide power to all other DDC Panels.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials and equipment furnished under this SECTION shall be new, unused, first quality of a manufacturer of established reputation. Each valve, fitting, section of pipe, and piece of equipment supplied to project shall have cast or indelibly stamped thereon the manufacturer's name, pressure rating where applicable, type, and any other specific information provided by manufacturer. Materials shall conform to International Plumbing Code as a minimum requirement and shall be approved by the Architect/Engineer.

2.2 PIPE AND FITTINGS

- A. Pipe and fittings shall conform to the latest A.S.A., A.S.T.M., C.A., and F.S. standards.
- B. All piping installed under this SECTION shall be in accordance with the following:

<u>Service</u>	<u>Material</u>
Underground Domestic Water Service	Class 52 cement lined ductile iron pipe
Underground Drainage and Vent piping	Schedule 40, DWV, solid core, Type 1 PVC
Above ground Drainage and Vent piping	Schedule 40, DWV, solid core, Type 1 PVC
Trap primer piping from Primer to floor drain	Type 'K' soft rolled copper tubing with Swaged ends
Domestic water piping above ground (potable & non-potable)	Type 'L' hard tempered copper tubing
Kitchen indirect waste piping	Type 'L' hard tempered copper tubing coated with two (2) coats of white epoxy paint
Exposed piping at fixtures and in kitchen	Schedule 40 chrome plated red brass I.P.S.
Special Waste and Vent Piping above ground (not in plenums)	Schedule 40 electric heat fused flame retardant poly-propylene piping, fittings & traps; "George Fischer Fuseal" or approved equal

Special Waste & Vent Piping below ground	Schedule 40 electric heat fused non-flame retardant polypropylene piping; fittings & traps, "George Fischer Fuseal", Orion, Zurn or equal
Compress Air Piping & Gas piping above ground	ASTM A-53 Schedule 40 black steel pipe
Gas piping below ground	ASTM A-53 Schedule 40 black steel pipe with fusion bonded epoxy coating Scotchkote 6233 or equal.
Gas piping below Ground (exterior)	AGA/UL approved gas piping and fittings, high density polyethylene by Driscoll, Uponor, Plexco or equal
Gas piping exposed in kitchen and at cooking island	ASTM A-53 Schedule 40 steel but painted with two (2) coats of white epoxy paint
C.	Fittings for drainage piping shall be drainage pattern schedule 40 P.V.C. fittings with solvent end socket fittings.
D.	Fittings for sweat indirect waste drainage piping shall be cast bronze or wrought copper of recessed drainage pattern.
E.	Fittings for Type 'L' hard tempered copper tubing for and for potable and non-potable water piping shall be cast bronze or wrought copper sweat type, water pattern fittings.
F.	Fittings for polypropylene acid-waste and acid vent (special waste system) shall be Schedule 40 polypropylene fittings with electrical resistance heat fusion joints as manufactured by George Fischer, Orion, Zurn, or equal. All underground pipe and fittings shall be bedded, jointed, backfilled with materials and methods outlined by the manufacturer's published instructions.
G.	Fittings for compressed air piping shall be threaded malleable iron air pattern fittings for screwed pipe.
H.	Fittings for gas piping 2-inch and smaller shall be threaded malleable iron gas pattern fittings for screwed pipe. All gas piping 2 ½ in. in size and larger shall be welded and shall utilize butt welded steel pipe fittings.
I.	Fittings for underground domestic water service shall be 250 psi gray iron cement lined fittings with mechanical joint ends.

2.3 JOINTS

- A. Make up all joints on P.V.C. drainage pipe with solvent welding cement and cleaner made up in accordance with manufacturer's detailed instructions.
- B. Copper tubing and sweat fittings shall be assembled with lead free solder, Silverbrite, Oatey, Harris, or equal, and a non-corrosive flux recommended by the manufacturer (includes waste piping and water piping).
- C. Joints between copper tubing and ductile iron water pipe or at flanged joints to tanks shall be made with a combination iron and brass flange with composition gasket and iron bolts.
- D. Joints at water heaters or other tanks having threaded connections shall be made up with dielectric unions.
- E. Joints between floor or wall flanges and fixtures shall be made with one-piece special molded neoprene gaskets which shall be furnished by the fixture manufacturer.
- F. Threaded pipe joints including plastics shall be made up with teflon tape.
- G. Joints on screwed gas piping shall be made up with thread compound on male threads only. Welded joints shall be made up by certified welders. All joints on piping 2-1/2 in. and larger shall be welded.
- H. Joints on polypropylene acid waste and vent up to the outlet side of all traps shall be made up with electrical resistance fused joints utilizing manufacturer supplied power unit. Slip joints shall be used only in the final makeup connection between the trap and sink tailpiece. Vertical risers shall have vertical expansion joints at 20 ft. intervals. Horizontal runs shall have expansion joints in accordance with manufacturer's recommendations.

2.4 VALVES

- A. Furnish and install valves where indicated on the Drawings or where specified and located so that they may be operated, repaired, or replaced with a minimum effort and repacked under pressure.
- B. The following list of valves is intended only as a guide for type and quality. Valves shall be as manufactured by Apollo, Milwaukee, Nibco, Elkhart, Watts or approved equal.

Shutoff valves 2 in. and smaller	Apollo #70LF-202 through #70LF-208 solder end lead-free ball valves
Shutoff valves, 2-1/2 in. and 3 in.	Apollo #70LF-109 and #70LF-100 lead-free
Balancing valves	Apollo# 70LF-222 through #70LF-228 lead free valve with memory stop
Gate valves 4 in. and larger	Jenkins 651-A
Stop and waste valves 1 in. and smaller	Apollo #95LF-203 through #95LF-205, lead-free

Check valves	Walworth #406 SJ
Gas service stops, 2 in. and smaller	Apollo #70-102-07 through #70-108-07 with tee handle
Gas service stops, 2-1/2 in. and larger	Rockwell #143 lubricated plug valve
Drain valves	Apollo #78-103-01 or #78-203-01 ball valve with cap and chain 1/2 in. x 3/4 in. hose end
Compressed air line Shutoff valves	Apollo #70-100 Series-threaded ends
Compressed air outlet valves	Apollo #70-100 Series with automatic drain
Backwater Valve (Drainage Systems)	Zurn #Z1095. At below grade installations provide with extension to grade Zurn model Z1095-FC, height as required.

2.5 INSULATION

- A. Insulation for all water piping and all horizontal roof leaders whether concealed or exposed shall be 1 in. thick, heavy density, preformed snap-on insulation equal to Johns Manville Micro-Lok HP, 850 degrees snap-on system. Insulation for cold water piping shall have a factory applied vapor barrier with ends and butts sealed with overlapping 4 in. sealing strips.
- B. Valves, fittings, and the underside of roof drain bodies shall be insulated with pre-formed fiberglass fitting insulation cut from dense fiberglass blanket and covered with pre-molded P.V.C. fitting covers. P.V.C. covers shall overlap the adjoining insulation and shall be secured with pressure sensitive vinyl tape over a vapor barrier adhesive seal at the joints. (Note: Staples or tacks are not permitted on covers).
- C. All insulation shall have self-sealing type, all service jacket (ASJ-SSL) factory applied. At all exposed piping, cover jacket with continuous P.V.C. jacket.
- D. Sealers, solvents, tapes, and adhesives, and mastics used in conjunction with the installation of insulation under this Section shall possess the maximum possible fire safe qualities available and shall be NFPA approved.
- E. Covering shall be applied over clean and dry surfaces. No covering shall be applied until after the approval of all pressure and leakage tests.
- F. Insulation shall be as manufactured by Johns Manville, Inc., Owens-Corning Fiberglass Corporation SSL II-ASJ, or Knauf Insulation 1000. Insulation shall be applied by skilled insulation mechanics in a first class manner.

2.6 TRAPS

- A. Furnish and install traps with cleanouts on all fixtures and equipment requiring connection to the sanitary system of the same size and material as the pipe on which they occur. Traps installed on threaded pipe shall be recessed drainage pattern.
- B. Traps for the special waste system shall be Sloan polypropylene 'P' traps to suit installation. Traps shall be one-piece or shall utilize electric resistance connection. All traps shall be fitted with a cleanout plug.

2.7 DRAIN VALVES

- A. It shall be possible to drain the water from all sections of the Potable and Non-Potable Hot and Cold Water Piping. Furnish and install 1/2 in. x 3/4 in. hose end ball valves with cap and chain. (see 2.04 for model no.)

2.8 SHOCK ABSORBERS

- A. Furnish and install, where shown on Drawings and where required to prevent water hammer, Zurn Manufacturing Company model 1250-XL lead free shock absorbers, or equal, as manufactured by J.R. Smith Manufacturing Company, Josam Manufacturing Company, or equal.
- B. Installation of absorbers shall be as per manufacturer's recommendations.

2.9 PIPING ACCESSORIES

- A. Pressure and Temperature Relief Valves shall be A.S.M.E. rated temperature relief 210 deg. F. double BTU rated, self-closing, as manufactured by Watts Regulator Company or equal by Wilkins, McDonnell and Miller, or equal.
- B. Vacuum reliefs shall be lead free Watts Regulator Company #LFN36 or equal by Wilkins or Lawler.
- C. Temperature gauges shall be 4-1/2 in. diameter dial thermometers, any angle, and range of 30 degrees F. to 240 degrees F. as manufactured by Weiss Instruments, U.S. Gauge, Terrice or equal.
- D. Pressure gauges shall be 4-1/2 in. diameter with a range of 0 to 160 psi as manufactured by Weiss Instruments, U.S. Gauge, Terrice or equal.
- E. Furnish and install where piping crosses building expansion joints on the domestic water piping and gas piping, expansion joints and anchors sized for 1-1/2 in. expansion per one hundred feet. Expansion joints shall be Metraflex "Metraloop", or manufactured by Flexonic Company or Hyspan, or equal. Piping shall be anchored and guided to force the expansion in the proper direction. Domestic water expansion joints shall be NSF approved. Gas expansion joints shall be AGA approved.

- F. Furnish and install where indicated on Drawings, Watts Regulator Company lead free pressure reducing valve and strainer combination size as indicated on the Drawing or equal, as manufactured by Donnelly Products Company or McDonnell and Miller.
- G. Trap primer connections are required on all floor drains to maintain trap seal. The requirement for trap primer connections shall include all floor drains in the kitchen including trough drains furnished by others. Trap primers shall be Precision Plumbing Products, Inc. Model P/N-PR-500 prime-rite trap-primer valve or shall, where appropriate, be Zurn, Josam, Smith or equal in-line connections installed on flush valve supply.

2.10 HYDRANTS AND HOSE BIBB

- A. Wall hydrants shall be Zurn Series Z-1310-PB Ecolotrol cast brass 3/4 in. non-freeze wall hydrant with integral backflow preventer, 3/4 in. hose connections, polished nickel bronze face, loose key handle, brass wall sleeve, and fitted with brass locknut.
- B. Roof hydrants shall be Zurn Series Z-1388-RK exposed non-freeze roof hydrant with dura-coated cast iron head and lift handle with lock option, bronze interior parts, galvanized steel casing, and bronze valve housing with drain port. Complete with dura-coated cast iron roof support sleeve with anchoring flange and clamp collar. Contractor shall run drain to exterior. Coordinate drain location with Architect.
- C. Hose bibb shall be T & S Brass or equal model #B-720 modified, chrome plated, 3/4 in. hose end, integral stop, vacuum breaker, modified with lock shield and loose tee handle.
- D. Hydrants shall be manufactured by Zurn, J.R. Smith, Josam, or equal. Hose bibbs shall be manufactured by T&S Brass, Speakman, Chicago, or equal.

2.11 CLEANOUTS

- A. Cleanout plugs on the Sanitary System shall be of heavy cast brass of the screwed type. Plugs shall be full size up to and including 4 inch.
- B. For piping running under floor slab, cleanouts shall be brought up to just under the floor slab level. Furnish and install access cover for all floor-type cleanouts, Zurn ZN-1400 Series with scoriated nickel bronze or by Josam, J.R. Smith, or equal. In the garage area and at exterior locations use Zurn model #Z-1474 cleanout housing set over brass cleanout plug.
- C. Wall Cleanouts shall be Watts CO-440-RD or Equal.
- D. Cleanouts for Special Waste System shall be as follows:
 - 1. On polypropylene pipe, use Zurn #Z9A-C04 polypropylene cleanout plug.
 - 2. Below floor - Bring cleanout plug to below floor level and use Zurn #ZANB-1463-VP nickel bronze scoriated floor access cover mounted on Shamrock Industries concrete sleeve. See detail on drawings.

2.12 ACCESS DOORS

- A. Furnish Access Doors for access to all concealed control valves, cleanouts, valves, expansion joints, and to all other concealed parts of the Plumbing System that require accessibility for the proper operation and maintenance of the system. These doors shall be installed under the appropriate SECTION of the Specifications as determined by the surface upon which the panels are mounted.
- B. All Access Doors shall be located in a workmanlike manner in closets, storage rooms, and/or other non-public areas, positioned so that the valve or part can be easily reached, and the size shall be sufficient for this purpose (minimum size 12 in. x 16 in.). Furnish Access Doors for each pipe space to permit thorough inspection of same. When access doors are required in corridors, lobbies, or other habitable areas, they shall be located as directed by the Architect.
- C. Access doors shall be prime painted and completed with cylinder lock and two (2) keys as manufactured by Acudor, Inland Steel Products Company "Milcor", or Walsh-Hannon-Gladwin, Inc., "Way Lector". Type shall be as follows:
 - 1. Acoustical Tile Ceiling Acudor AT-5020
 - 2. G.W.B. Surfaces Acudor DW-5040
 - 3. Masonry Construction Acudor UF-5000
 - 4. Fire Rated Construction Acudor FB-5060
- D. Access Door Shop Drawings shall be submitted to the Architect for approval.

2.13 SUPPLEMENTARY STEEL, CHANNEL, AND SUPPORTS

- A. Furnish and install all supplementary steel, channels, and supports required for the proper installation, mounting, and support of all equipment.
- B. Supplementary Steel and Channels shall be firmly connected to building construction in a manner approved by the Architect.
- C. The type and size of the Supporting Channels and Supplementary Steel shall be determined by the Plumbing Subcontractor and shall be sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for loading.
- D. All Supplementary Steel and Channel shall be installed in a neat and workmanlike manner parallel to the walls, floor, and ceiling construction. All turns shall be made with 90 deg. fittings, as necessary to suit the construction and installation conditions.

2.14 HANGERS, ANCHORS, GUIDES, AND PIERS

- A. All piping shall be supported from the Building Structure by means of approved hangers and supports. Piping shall be supported to maintain required grading and pitching of lines, to prevent vibration, and to secure piping in place, and shall be so arranged as to provide for expansion and contraction.
- B. The spacing for hangers for horizontal piping shall be in accordance with the following:
 - 1. Copper Tubing: 6 ft.-0 in. o.c. for 1-1/4 in. and smaller, and 10 ft.-0 in. o.c. for 1-1/2 in. and larger.
 - 2. Steel Pipe: 10 ft.-0 in. o.c. for 1-1/2 in. and over; 8 ft. - 0 in. for 1-1/4 in.; 6 ft. - 0 in. for 1 in. and smaller.
 - 3. PVC Drainage and Polypropylene acid waste: 4 ft.-0 in. o.c.
- C. Hanger rod diameter shall be as follows:

Pipe Size	Rod Diameter
1/2 in. thru 2 in.	3/8 in.
2-1/2 in. and 3 in.	1/2 in.
4 in. and 5 in.	5/8 in.
6 in.	3/4 in.
8 in. and over	7/8 in.

- D. Vertical lines shall be adequately supported at their bases by a suitable hanger placed in the horizontal line near the riser and at every 10 ft. interval.
- E. All Hangers (including those for acid-waste) shall be adjustable Clevis Hanger. Hanger rods shall have machine threads. Malleable iron brackets of approved type shall be used along the walls. All Hangers for copper tubing shall be copper plated except where pipe is insulated, in which case, Steel Clevis Hanger and pipe shield shall be used.
- F. Piping shall not be hung from the hangers of other trades.
- G. Provide seismic restraints for all piping per requirements of the NH State Building Code and Section 230548. All gas piping shall be seismically restrained.
- H. Hangers shall be manufactured by Grinnell, Carpenter and Paterson, Fee and Mason, or equal.
- I. Wire and strap hangers will not be permitted in this installation.
- J. Install a 14 gauge metal pipe shield between pipe insulation and all pipe hangers. Hangers shall be sized so that the pipe insulation passes through the hanger and is supported on the shield.

2.15 DRAINS

- A. Furnish and install all floor drains where shown on the Drawings. Furnish all roof drains for installation by the General Contractor.
- B. All floor drains in flooring systems without waterproofing membranes shall have galvanized iron clamping rings with 6-pound lead flashing to bond 9 in. in all directions. All drains shall be checked with Architect's Drawings to determine depth of the flashing collar. Brass extension pieces shall be provided if necessary.
- C. All floor drains installed on this project shall be fitted with Automatic Trap Primer Connections. Field determine appropriate location for Trap Primer valve and drain piping.
- D. Drain Schedule:
 - 1. Type "A" - Zurn #ZN-415B-P dura coated cast iron body floor drain with clamping collar and with 6 in. dia. nickel bronze adjustable strainer head. Trap primer connection.
 - 2. Type "B" - Zurn #Z-550-Y-P dura coated cast iron body floor drain, sediment bucket, cast iron grate. Trap primer connection
 - 3. Type "C" - Zurn #ZC-100-C-E-EA-GD-R cast iron body roof drain, under-deck clamp, galvanized cast iron dome secured, cast iron extension, roof sump receiver. Refer to Architect's Drawings for height of insulation.
 - 4. Type "D" - Zurn #Z-1910-25-P cast iron body sanitary floor drain, white acid resisting interior and A.R.E. sediment bucket, 8 in. x 8 in. nickel-bronze frame and grate. Trap primer connection.
 - 5. Type "E" - Zurn #Z-1910-25-P cast iron body sanitary floor drain, white acid resisting interior and A.R.E. sediment bucket, 6 in. Nickaloy Funnel. Trap primer connection.
 - 6. Type "F" - Zurn #Z-1901-25-2 12 in. x 12 in. x 8 in. deep A.R.E. cast iron floor drain with A.R.E. bucket and half grate.
 - 7. Type "G" - Zurn #ZN-1970-K-P-25, acid resistant cast iron body floor drain with trap primer connection, acid resisting sediment bucket, clamping collar, nickel bronze top, caulk bottom outlet, secured grate with vandal proof screws.
 - 8. Type "H" - Zurn #Z-512-G-Y-VP Galvanized heavy duty cast iron body sediment bucket, heavy duty ductile iron secured grate, caulk bottom outlet.
- E. Drains shall be of one manufacturer, by Zurn, J.R. Smith, Josam, or equal.

2.16 PLUMBING FIXTURES

- A. Furnish and install all fixtures and equipment, including supports, connections, fittings, and any incidentals, to make a complete installation in accordance with the Drawings and as specified.
- B. The Architect shall be final judge as to whether fixtures and trim fulfill the requirements of the Specifications and as to whether they are of suitable quality.
- C. All fixtures requiring hot and cold water shall have the cold water faucet on the right hand side of the fixture and the hot water faucet on the left hand side of the fixture.
- D. Escutcheons shall be furnished and installed on all supplies and traps. Escutcheons shall be one (1) piece chrome plated brass with set screws.

- E. All fixtures shall have the manufacturer's guaranteed label or trademark indicating first quality. All acid resisting enameled ware shall bear the manufacturer's symbol signifying acid resisting material.
- F. Unless otherwise specified, faucets and all exposed fittings shall be chromium plated.
- G. All supply pipes shall run in a reasonable straight vertical line from the stops to faucets. Traps shall be installed perpendicular to walls.
- H. Vitreous china and acid resisting enameled fixtures shall be of one manufacturer by Sloan, American Standard, Toto, or equal. Trim shall be Symmons, Speakman, Chicago, T & S Brass, or equal. Flush valves shall be Sloan, Toto, Zurn, or equal. Water coolers and drinking fountains shall be manufactured by Elkay, Just, Filtrine, or equal. Stainless steel sinks shall be Elkay, Just, Kindred, or equal.
- I. Note: All fixtures and fittings shall be vandal proof mounted, unless specifically noted otherwise.
- J. Carefully coordinate roughing for flush valves so that the dimension from top of fixture to C-L of flush valve is a minimum of 6 in..
- K. Special Note: There are several age groups accommodated in this building and therefore there are different mounting heights. Irrespective of the heights called for on the Documents, be responsible to re-verify in writing in field before installing any roughing for any fixture.
- L. All faucets, valves, soldering flux and components on the domestic water systems shall be "Lead-Free".
- M. Fixture Schedule:

1. P-1 Water Closet:

Sloan WETS 2450.1401-1.28 gallons per flush complete with G2 Optima plus 8111-1.28 battery powered flush valve, vitreous china, ~~manually operated flush valve~~, wall hung, elongated, siphon jet bowl, 1-1/2 in. top spud.

Olsonite 10CT solid plastic white open front seat with check hinge.

Zurn Z1203/21204# carrier. Carefully coordinate with Architect's plans to fit in wall. Use Z-1209 where required by field conditions.

2. P-1A Water Closet, Accessible:

Same as specified for P-1 except mounting height and location shall meet Accessibility Standards. Locate handle of flush valve to wide side of toilet stall.

The mounting heights are variable. Refer to Architect's Drawing and request direction in field in writing before installing.

3. P-2 Service Sink:

Elkay ESSB2520C stainless steel service sink, 12-inch backsplash, 14 gauge, 316 series stainless steel, furnished with stainless steel support brackets and LK173 cast iron P trap standard.

Chicago #631-GN2A-E35ABCP wall mounted faucet with 5-1/4 inch swing gooseneck spout, 2-3/8 inch wrist blade handles, E-2805 0.5 GPM aerator.

Pair of 1/2 in. x 3/8 in. supplies with stops and escutcheons.

4. P-3 Wall Hung Lavatory:

Kohler Soho K-2084, wall mounted 20 in. x 18 in. vitreous china lavatory, single hole, punched for concealed armchair carrier.

Chicago EQ-A11B-23ABCP single hole, self-generating with battery backup sensor faucet with 0.5gpm outlet. Faucet to be pre-set for 10 second run time.

McGuire Model 155-WC, 1-1/4 in. offset drain with open grid strainer.

McGuire Model H-167 (pair) C.P., 3/8 IPS angle supply with loose key stop.

McGuire Model B-8902 C.P., 1-1/4 in. x 1-1/2 in. cast brass adjustable 'P' trap with cleanout and #17 ga. tubing outlet to wall.

Zurn #Z-1231 floor mounted concealed arm chair carrier.

Conceal all exposed roughing and electrical wiring components under lavatory with Truebro Model #2018 rigid PVC enclosure.

5. P-4 Mop Receptor:

Florestone Model 92, 24 in. x 24 in. x 12 in. model Terrazzo mop service basin with stainless steel backsplash and caps all sides, 3 in. cast brass drain for inside caulk connection.

Kohler K-8907 service sink fitting, polished chrome, brace to wall, integral screw driver stops, vacuum breaker, 3/4 in. hose end. Install a 1/2 in. check valve on the supplies & provide access panel.

Furnish and install 1/2" hot and cold water Watts LF009 reduced pressure backflow preventer for soap dispenser.

6. P-5 Electric Water Cooler/Bottle Filler:

Oasis Aqua-point M8CREBF Bi-level Barrier Free Electric Water Cooler, 8 GPH capacity, bubbler, push button actuator, ADA compliant, stainless steel cabinet, and bottle fill station.

1-1/4 in. x 1-1/2 in. rough p-trap with cleanout; 1/2 in. ball valve stop.

7. P-6 Master Gas Control Valve:

ISIMET – LSP-T – Laboratory Service Panel with “T” handle providing manual operation of solenoid valve. Panel shall have brushed stainless steel door panel and trim with gray powder coated enclosure provided with low voltage transformer and fuse block. Enclosure shall be NEMA 1 rated. Panel shall be labeled “NATURAL GAS SERVICE PANEL”. Panel shall comply with UL508-A, Standards for Industrial Control Panels.

Panel shall have integral printed circuit board with logic device to provide 24-vac output circuit to activate integral 24-vac natural gas solenoid. Activation of output circuit shall be enabled only by switch ON and then keying.

The Panel shall be equipped with a service switch and a momentary enabling key switch. Deactivation of output circuit shall not require engagement of enabling key. Panel shall be provided with N/O momentary panic button assembly to deactivate output circuit in case of emergency. Reset after panic shall occur by re-keying. Green LED shall indicate operation ON. Red LED shall indicate that shut-down has occurred due to pressing the panic button.

Provide panel with additional terminals for integration of ISIMET Remote Panic Button Assembly and opto-isolated input terminal for integration with facility’s alarm system. A fire alarm signal shall deactivate the utility controlled by the LSP Series Panel.

Provide panel with dry contact terminals for output integration. ISIMET “Panic” shall provide a notification signal to a secondary alarm monitoring system. Reset of Service Panel shall withdraw notification signal.

Service Panel shall be furnished with ISIMET Series 300 normally closed natural gas specific zero differential solenoid. Solenoid coil shall be 24-vac. Solenoid shall be UL listed. Service Panel shall be provided with a ball valve up-stream from solenoid. Thoroughly clean piping system prior to placing into service.

Do not install wiring or cable for integrated systems, remote panic assemblies or other interface wiring within conduit for either 24-vac control or 120-vac line voltage. Each wiring system should be housed in independent conduit and not bundled with wiring for other systems. Line and 24-vac control wiring furnished and installed by Electrical Subcontractor.

8. P-7 Grease Interceptor:

Zurn #Z-1170-REAL, size 800, recessed mounted, recessing receiver, acid resistant coated interior and exterior, aluminum cover, complete with flow control fitting.

9. P-8 Grease Interceptor:

Zurn #Z-1170-REAL, size 700, recessed mounted, recessing receiver, acid resistant coated interior and exterior, aluminum cover, complete with flow control fitting.

10. P-9 Hair Interceptor:

Zurn #Z-1175 hair interceptor connected at accessible location, mounted on floor tight to wall. (Rough as tight to wall as feasible).

11. P-10 Plaster Trap:

Zurn No. Z-1180 acid-resistant interior and exterior fabricated steel solids interceptor mounted on floor tight to wall. (Rough as tight to wall as feasible).

12. P-11 Clothes Washer:

Symmons #W-602-X Laundry-Mate Supply and Drain Fixture, recessed mounting box 1/2 in. hot and cold water connections, 2 in. waste connection, integral stops and check valves on supplies.

13. P-12 Shower, Accessible:

Symmons 1-25-FSB-E-VB Safetymix Pressure Balancing Mixing valve with lever handle, factory pre-set temperature limit stops, FS hand spray unit with 1.5 GPM flow restrictor, in-line vacuum breaker, 60 in. flexible hose, 30 in. wall mounted slide bracket rod with heavy duty (250 lb) anchors.

Aquabath model C-4136-BF-FUS-3/4-WRS with right or left mounting as shown on Architect's Drawings. Unit shall be white acrylic with Accessible threshold and shall include fold-up seat, continuous grab bar, curtain rod, drain body, and water retention strip (WRS) or collapsible dam.

14. P-13 Emergency Shower and Eyewash (Science)

Guardian Model GBF2170 Recessed barrier free face wash and shower safety station with wall mounted stainless steel shower head and drain pan. Shower head shall be 10 inch diameter stainless steel

Guardian mixing valve, Model G3807LF thermostatic mixing valve with recessed stainless steel cabinet mounted at 7'-0" above floor.

Furnish and install Guardian AP275-615 flow switch.

15. P-14 Emergency Shower and Eyewash, (Mechanical)

Guardian Model GBF1994 all stainless steel barrier free Safety Station.

Guardian mixing valve, Model G3800LF thermostatic mixing valve, mounted on wall at 7'-0" above floor. Furnish and install Guardian AP275-615 flow switch.

16. P-15 Sink, Accessible:

Elkay LRADQ-2219 single bowl, 22 in. x 19 in. x 6 in. deep self-rimming countertop mounted, 18 GA type 304 stainless steel sink with offset rear outlet; three (3) hole punched faucet ledge & quick clip mounting system, sound deadening underside.

Chicago #201A-GN8A-E2805-5CP-369 concealed deck faucet with 8 in. swing gooseneck spout, 2-3/8 inch wrist blade handles, E-2805 0.5 GPM aerator.

Elkay LKAD-35 crumb cup strainer with 1-1/2 in. offset tailpiece and stainless steel ground seat stopper.

1-1/2 in. x 2 in. chrome plated P-trap with cleanout, waste outlet with escutcheon.

Pair of 1/2 in. x 3/8 in. supplies with stops and escutcheons.

17. P-16 Sink:

Elkay DLR-2219 single bowl, 22 in. x 19 in. x 10 in. deep self-rimming countertop mounted, 18 GA type 304 stainless steel sink with center drain; three (3) hole punched faucet ledge & quick clip mounting system, sound deadening underside.

Chicago #201A-GN8A-E2805-5CP-369 concealed deck faucet with 8 in. swing gooseneck spout, 2-3/8 inch wrist blade handles, E-2805 0.5 GPM aerator.

Elkay LK-35 crumb cup strainer with 1-1/2 in. tailpiece and stainless steel ground seat stopper.

1-1/2 in. x 2 in. chrome plated P-trap with cleanout, waste outlet with escutcheon.

Pair of 1/2 in. x 3/8 in. supplies with stops and escutcheons.

18. P-17 General Science Sink, Accessible:

Elkay LRADQ-2219 single bowl, 22 in. x 19 in. x 6 in. deep self-rimming countertop mounted, 18 GA type 316 stainless steel sink with offset rear outlet; single hole punched faucet ledge & quick clip mounting system, sound deadening underside.

Chicago #930-GN8BVB-E2805-CP, deck faucet with 8 in. swing gooseneck spout, 2-3/8 inch wrist blade handles, E-2805 0.5 GPM aerator.

Elkay LKAD-35-316 crumb cup strainer with 1-1/2 in. offset tailpiece and type 316 stainless steel ground seat stopper.

1-1/2 in. x 2 in. chrome plated P-trap with cleanout, waste outlet with escutcheon.

Pair of 1/2 in. x 3/8 in. supplies with stops and escutcheons.

19. P-18 General Science Sink:

Elkay DLR-2219 single bowl, 22 in. x 19 in. x 10 in. deep self-rimming countertop mounted, 18 GA type 316 stainless steel sink with center drain; single hole punched faucet ledge & quick clip mounting system, sound deadening underside.

Chicago #930-GN8BVB-E2805-CP, deck faucet with 8 in. swing gooseneck spout, 2-3/8 inch wrist blade handles, E-2805 0.5 GPM aerator.

Elkay LK-35-316 crumb cup strainer with 1-1/2 in. tailpiece and type 316 stainless steel ground seat stopper.

1-1/2 in. x 2 in. chrome plated P-trap with cleanout, waste outlet with escutcheon.

Pair of 1/2 in. x 3/8 in. supplies with stops and escutcheons.

20. P-19 Kitchen Sink, Accessible:

Elkay LRADQ-2219 single bowl, 22 in. x 19 in. x 6 in. deep self-rimming countertop mounted, 18 GA type 304 stainless steel sink with offset rear outlet; four (4) hole punched faucet ledge & quick clip mounting system, sound deadening underside.

Chicago #200A-GN8A-E2805-5CP-369 concealed deck faucet with 8 in. swing gooseneck spout, 2-3/8 inch wrist blade handles, E-2805 0.5 GPM aerator, and vegetable spray.

Elkay LKAD-35 crumb cup strainer with 1-1/2 in. offset tailpiece and stainless steel ground seat stopper.

1-1/2 in. x 2 in. chrome plated P-trap with cleanout, waste outlet with escutcheon.

Pair of 1/2 in. x 3/8 in. supplies with stops and escutcheons.

21. P-20 Art Sink, Accessible:

Elkay LRADQ-2219 single bowl, 22 in. x 19 in. x 6 in. deep self-rimming countertop mounted, 18 GA type 316 stainless steel sink with offset rear outlet; three (3) hole punched faucet ledge & quick clip mounting system, sound deadening underside.

Chicago #201A-GN8A-E2805-5CP-369 concealed deck faucet with 8 in. swing gooseneck spout, 2-3/8 inch wrist blade handles, E-2805 0.5 GPM aerator.

Elkay LKAD-35-316 crumb cup strainer with 1-1/2 in. offset tailpiece and type 316 stainless steel ground seat stopper.

1-1/2 in. x 2in. chrome plated P-trap with cleanout, waste outlet with escutcheon.

Pair of 1/2in. x 3/8in. supplies with stops and escutcheons.

Zurn No. Z-1180 acid-resistant interior and exterior fabricated steel solids interceptor mounted on floor tight to wall. (Rough as tight to wall as feasible).

22. P-21 Air Hose Reel:

Hannay Reels, Inc. model N716-23-24-15.5G-TR, compressed air hose reel with 75-foot 3/8" hose. Mount with Hannay model 9908.9990 swivel mounting bracket.

2.17 BACKFLOW PREVENTERS

- A. Backflow preventers shall be reduced pressure type furnished complete with shutoff valves. Backflow preventers 2-1/2 inch and smaller shall be Watts #LF009-QT-S. Backflow preventers 3 inch and larger shall be Watts 957-QT. Backflow preventers shall be lead free, all bronze, complete with strainer and soft seated check valve. Size shall be as indicated on Drawings.
- B. Mount backflow preventer 3 ft.(+/-) above finished floor. Provide indirect waste funnel and run pipe to an air gapped discharge at sink or floor drain. Furnish a spare parts kit and parts list mounted in the vicinity of the device.
- C. Prior to the installation of devices in the name of the Owner file for, pay for, and obtain all required permits and approvals for cross connection control devices from the Authority having Jurisdiction.
- D. Backflow preventers shall be of one manufacturer, by Watts, Wilkins, Beeco, or equal.

2.18 UNION AND NIPPLES

- A. All connections between copper tubing and galvanized piping or between copper tubing and all tanks (such as water heaters, chillers, and similar equipment) shall be made with dielectric unions and nipples.
- B. All connection to Water Heaters, Meters, Pumps, and other equipment requiring maintenance or alteration shall be made up with unions. Unions on brass piping, 2 in. and smaller, shall be brass composition "E" in strict accordance with Federal Specification WW-U-516. On plastic piping, use unions of the same material as the piping.

- C. All close and shoulder nipples shall be corresponding materials as the pipe and shall be extra heavy.

2.19 POTABLE WATER HEATER (WH-1 & WH-2)

- A. The potable domestic water heaters shall be by Lochinvar, Heat Transfer Products, Hubbell, or approved equal.
- B. The two water heaters shall be a Lochinvar Armor Model AWN-501-PM having a modulating input rating of 500,000 Btu/Hour each, a recovery capacity of 582 gallons per hour at a 100 degrees F rise and shall be operated on natural gas. The water heater shall be capable of full modulation firing down to 20% of rated input with a turn down ratio of 5:1.
- C. The water heaters shall bear the ASME "H" stamp and shall be National Board listed for inputs in excess of 200,000 Btu/Hr. There shall be no banding material, bolts, gaskets or "O" rings in the header configuration. The stainless steel combustion chamber shall be designed to drain condensation to the bottom of the heat exchanger assembly. A built-in trap shall allow condensation to drain from the heat exchanger assembly. The complete heat exchanger assembly shall carry a five (5) year limited warranty.
- D. The water heaters shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.10.3 test standard for the US. The water heater shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The water heaters shall operate at a minimum of 95% thermal efficiency. The water heaters shall be certified for indoor installation.
- E. The water heaters shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. A burner/flame observation port shall be provided. The burner shall be a premix design and constructed of high temperature stainless steel with a woven metal fiber outer covering to provide modulating firing rates. The water heaters shall be supplied with a gas valve designed with negative pressure regulation and be equipped with a variable speed blower system, to precisely control the fuel/air mixture to provide modulating water heater firing rates for maximum efficiency. The water heaters shall operate in a safe condition at a derated output with gas supply pressures as low as 4 inches of water column.
- F. The water heaters shall utilize a 24 VAC control circuit and components. The control system shall have an electronic display for water heater set-up, water heater status, and water heater diagnostics. All components shall be easily accessed and serviceable from the front and top of the jacket. The water heaters shall be equipped with; a high limit temperature control certified to UL353, ASME certified pressure relief valve, outlet water temperature sensor, inlet water temperature sensor, a UL 353 certified flue temperature sensor, low water flow protection and built-in freeze protection. The manufacturer shall verify proper operation of the burner, all controls and the heat exchanger by connection to water and venting for a factory fire test prior to shipping.
- G. The water heaters shall feature the "Smart System" control with a Multi-Colored Graphic LCD display with Navigation Dial and Soft Keys, password security, pump delay with freeze protection, pump exercise, and USB PC port connection. The water heaters shall feature night setback for the domestic hot water tank and shall be capable of controlling a building recirculation pump while utilizing the night setback schedule for the building recirculation pump. The water heater shall have the capability to accept a 0-10 VDC input connection for

BMS control of modulation or setpoint and enable/disable of the water heater, and a 0-10VDC output of water heater modulation rate. The water heaters shall have a built-in cascading sequencer with modulation logic options of "lead lag" or "efficiency optimized". Both modulation logic options should be capable of rotation while maintaining modulation of up to eight water heaters without utilization of an external controller. Supply voltage shall be 120 volt / 60 hertz / single phase.

- H. The water heaters shall be equipped with two terminal strips for electrical connection. A low voltage connection board with data points for safety and operating controls, i.e., Auxiliary Relay, Auxiliary Proving Switch, Alarm Contacts, Runtime Contacts, Manual Reset Low Water Cutoff, Flow Switch, High and Low Gas Pressure Switches, Tank Thermostat, Tank Sensor, Building Management System Signal, Modbus Control Contacts and Cascade Control Circuit. A high voltage terminal strip shall be provided for supply voltage. The high voltage terminal strip plus integral relays are provided for independent control of the Domestic Hot Water Pump and Building Re-circulation Pump.
- I. The water heaters shall be installed and vented with a sidewall vent and air intake system. The flue and air intake material shall be CPVC. The water heater's total combined air intake length shall not exceed 100 equivalent feet. The water heater's total combined exhaust venting length shall not exceed 100 equivalent feet.
- J. Water heaters shall have direct spark ignition with electronic supervision firing control system.
- K. Furnish and install condensate neutralizing kit with each water heater. Run condensate piping, after neutralized, to the nearest existing floor drain.
- L. The circulating pump shall be all bronze and operate on a 120 volt, 60 cycle, 1 phase power supply. The pump shall be wired to run with intermittent pump operation.
- M. Furnish and install one vertical water storage tank. Storage tank shall be a Lochinvar Lock-Temp RCA0500 tank having a storage capacity of 500 gallons. The tank shall be constructed with an inner chamber designed to receive all circulation to and from the water heater to eliminate turbulence in the tank. The baffled tank shall supply 80% of tank capacity without a drop in outlet temperature. The storage tank shall be constructed in accordance with ASME requirements. The storage tank shall have a working pressure of 150 psi. The storage tank shall be cement lined and carry a five (5) year limited warranty. The tank shall be constructed with a heavy gauge galvanized steel jacket assembly, primed and pre-painted on both sides.
- N. The jacket and tank base shall be a water tight construction with a built-in drain pan, complete with a 3/4" drain connection. The Storage Tank shall be completely encased in high density insulation of sufficient thickness to meet the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The entire assembly shall be mounted on "I" beam skids to facilitate handling and installation.
- O. Expansion Tank: Furnish and install as shown on plans a 35 gallon(12 gallon acceptance volume), 16" diameter x 45" (high) pre-charged steel thermal expansion tank with a fixed FDA approved butyl bladder. The tank shall have a top NPT stainless steel system connection and a .301" - 32 charging valve connection (standard tire valve) to facilitate the on-site charging of the tank to meet system requirements. The tank must be constructed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code and stamped 150 psi working pressure. Tank shall be Wessels model number TTA-80 or by Amtrol, Taco, or approved equal.

2.20 ELECTRIC NON-POTABLE WATER HEATER (WH-3)

- A. Furnish and install where shown on the Drawings AO Smith Model DRE-52-6 or by Rudd, State or equal electric water heater, 50 gallon tank with 6,000 watt heating element wired for 480V, 3 phase, 60 cycles. Refer to details on Drawings. Provide mixing valve and expansion tank all as detailed on drawings.

2.21 TEMPERING VALVES

- A. Furnish and install where shown for temperature control at the domestic storage tank, Leonard Valve Company TM-920-RF-DT-TC High-Lo Thermostatic Water Mixing Valve, inlet check-stops, outlet volume/shutoff valve, dial thermometer, and test connection. Valves are to be furnished in rough bronze finish and are to be factory assembled and tested.
- B. Furnish and install where shown for temperature control at the non-potable water heater Leonard Valve Company, Type TM-26E thermostatic mixing valve size as indicated with integral check-stops, outlet volume/shutoff valve, and dial thermometer. Valves are to be furnished in rough bronze finish and are to be factory assembled and tested.
- C. Furnish and install a 4 in. diameter thermometer on the outlet side of the tempering valve and where indicated on the Drawings as manufactured by U.S. Gauge Company, Powers Regulator Company, and/or Trerice Company.

2.22 RECIRCULATING HOT WATER PUMPS

- A. Circulators shall be all-bronze booster type, Grundfos Magna3 40-80 or equal by Bell & Gossett, Taco or approved equal.
- B. Furnish and install, where shown on the Drawings, an immersion aquastat, Honeywell #L-4006-A set to start and stop pump at a 10 degree differential temperature.
- C. Circulators shall be connected to the Building Management System by Section 230000.

2.23 CONDENSATE NEUTRALIZING TUBES

- A. Contractor shall furnish and install condensate neutralizing tubes for new boilers and domestic water heater condensate drains and flue pipe condensate drains.
- B. Neutralizer tubes shall be as manufactured by JJM Boiler Works, or approved equal, and sized according to input rating of each piece of equipment.
- C. The boiler/water heater and flue condensate drains shall not be combined, Provide separate neutralizing tubes for boiler/water heater and flue condensates. All piping shall be per manufacturer's piping diagrams and directions. Secure neutralizing tubes to the floor.

2.24 NATURAL GAS SUB-METER

- A. Furnish and install, where shown on the Drawings, ONICON or equal, model F-5300 thermal mass flow meter. Furnish 24VDC power supply with plug connection. Coordinate power wiring with Section 260000. Include Onicon N-100 network interface module.

- B. Unit shall be capable of providing BACnet output. All BACnet control wiring shall be by Section 230000.

2.25 WATER METER

- A. Furnish and install water meter with inlet strainer in accordance with the standards of the Local Water Department. Coordinate the installation with the water department and include in the Plumbing Bid the cost of the meter. Refer to Part 1 of this section regarding assessments, and the like.

2.26 DOMESTIC WATER SUB-METER

- A. Furnish and install ONICON or equal, model F-3500 water flow meter at the main water service entrance downstream of the water meter. Furnish 24VDC power supply with plug connection. Coordinate power wiring with Section 260000. Include Onicon N-100 network interface module.
- B. Unit shall be capable of providing BACnet output. All BACnet control wiring shall be by Section 230000.

2.27 GAS SOLENOID VALVE

- A. Gas solenoid valve where shown on the Drawings shall be normally closed FM approved gas solenoid valve ASCO "Red-Hat" Series 8040/8215. Valve shall operate on 120volt power and shall close the gas flow on the main gas feed to the Kitchen cooking equipment.
- B. Gas solenoid valves shall be manufactured by ASCO, QMI, ISIMET, or equal.

2.28 COMPRESSED AIR REGULATORS

- A. At all compressed air connections furnish and install Parker, or equal, series C105/C255 combination air filter and pressure regulator.

2.29 FIRESTOP SYSTEMS

- A. General: Provide firestopping at all new fire-rated construction where penetrated by the Work of this Section.
- B. Refer to Section 078400 - Firestopping, for all product requirements for maintaining integrity of fire-rated construction at penetrations.

2.30 SCAFFOLDS AND STAGING

- A. General: Trade Contractors shall obtain required permits for, and provide scaffolds, staging, and other similar raised platforms, required to access their Work as specified in Section 01 50 00 - Temporary Facilities and Controls and herein.
 - 1. Scaffolding and staging required for use by this Trade Contractor pursuant to requirements of Section 01 50 00 - Temporary Facilities and Controls shall be

furnished, erected, maintained in a safe condition, and dismantled when no longer required, by this Trade Contract requiring such scaffolding.

2. Each Trade Contractor is responsible to provide, maintain and remove at dismantling, all tarpaulins and similar protective measures necessary to cover scaffolding for inclement weather conditions other than those required to be provided, maintained and removed by the General Contractor pursuant to MGL (Refer to Section 01 50 00 - Temporary Facilities and Controls and as additionally required for dust control).
3. General Contractor is responsible to provide enclosures required for temporary heat; refer to Section 01 50 00 - Temporary Facilities and Controls.
- a. Furnishing portable ladders and mobile platforms of all required heights, which may be necessary to perform the work of this trade, are the responsibility of this Trade Contractor.

2.31 HOISTING MACHINERY AND EQUIPMENT

- A. All hoisting equipment, rigging equipment, crane services and lift machinery required for the work by this Trade Contractor shall be furnished, installed, operated and maintained in safe conditions by this Trade Contractor, as referenced under Section 01 50 00 - Temporary Facilities and Controls.

2.32 ACID NEUTRALIZATION SYSTEM (NT-1)

- A. Furnish and install complete acid neutralization and PH monitoring systems including all piping, equipment, and interconnection power and control wiring from power panel to all components. Power to panel is furnished under the Electrical Section of the Specifications. Plumbing Subcontractor is responsible to furnish and install using properly licensed personnel all conduit and wiring between the panels and monitoring points. All materials and methods used for this wiring shall be consistent with the requirements of section 26 00 00. Furnish for installation by General Contractor, access hatch detailed on drawings.
- B. System shall be as manufactured by Burt Process Equipment and consist of the following:
 1. Acid neutralizing tanks shall be polyethylene; 350 gallon capacity, and be fitted with 4-inch inlet, 4-inch outlet, and 4-inch vent connections as detailed on Drawings. Tanks shall be installed as shown on the drawings. Include full charge of limestone chips and a second charge of chips.
 2. PH sensors shall be compatible with controller, encapsulated electrodes with automatic temperature compensation, measuring range of 0-14 PH sensitivity, and have 2 conductor shield cable.
 3. PH receivers to accept 4-20 MA signal, with both digital and simulated analog display capabilities.
 4. The recorders shall be strip chart type, single pen with a 2-5/16" chart width. The chart shall record for a minimum of 30 days. The unit shall operate on a 0-1 MA signal with a power requirement of 115v AC 60 Hz.
 5. Receivers and recorders shall be housed in a NEMA IV styrene enclosure with single weatherproof door.
 6. Control panels shall be completely pre-wired and pre-tested, NEMA IV type enclosure, wall mounted, hinged and locked front panel with components as follows:
 - a. Receiver/Analyzer
 - b. Strip Chart Recorder
 - c. PH Out of Spec Hi/Lo Alarms
 - d. System On/Off Switch
 - e. Alarm Test and Silence Buttons

7. U-Trap Assembly shall be heat fusion jointed polypropylene pipe and fittings with an extension section to house the effluent PH probe.
8. All components and instrumentation for the neutralization systems shall be furnished for installation from a single source and shall be installed in strict accordance with the manufacturer's recommendations.
9. System calibration and start-up shall be included in the package provided by the manufacturer. The manufacturer shall also be responsible for conducting a training seminar for the site facilities people prior to the system being turned over to the Owner (minimum 4 hours).
10. The manufacturer, as part of his package, shall be responsible for making not less than three visits during the first year of operation to check up on the workability of the system.

2.33 AIR COMPRESSOR (AC-1) **(AC-2)**

- A. Furnish and install a tank mounted air compressor with all required accessories to provide an automatic supply of shop air to serve station outlets
- B. Air compressor shall be Qunicy Model QGS-10T1D, rotary screw air compressor, 35 CFM, 10HP, 480V, 3 phase 60 HZ motor, 120 gallon ASME receiver, compressor-mounted full-function motor starter with a 120 volt control voltage transformer with on-off switches and manual resets, automatic condensate drain, tank mounted pressure gage, service valve and safety valve. Compressor to be supplied with QMF-75 coalescing filter. Rated for 150 psi full flow.
- C. Run auto-drain discharge to nearest floor drain.

2.34 TRENCH DRAIN

- A. Furnish and install in the Apparatus Bay as shown on the Plumbing Drawings, Zurn Z-882-GHPDE 12 in. wide pre-sloped trench drainage system including Z-887-GHPDE 12 in. x 24 in. catch basin. All trench section modular 8 ft. lengths with interlocking ends complete with anchor studs at surface, combination anchor tabs/leveling devices at appropriate locations, and extra heavy-duty galvanized heel-proof grate with lockdowns. Trench drains shall be approximately 56 ft. in total length as shown on drawings. Provide complete installation per manufacturer's instructions including minimum 6 in. concrete around trench system.

2.35 MANHOLE AND PRECAST CONCRETE OIL/GAS SEPARATOR STRUCTURE

- A. Manholes and precast concrete structures shall be constructed as shown on Drawings. Conform accurately to indicated dimensions.
 1. Precast concrete manhole barrel, base, and cone sections shall conform to ASTM C-478 and shall be furnished complete with integral cast aluminum polymer coated steel steps. Sections shall be assembled with Kentseal #2 gaskets, or equal.
 2. Brick for constructing channels and adjustments to grade shall be waterstruck sewer brick, Grade 'A' concrete brick conforming to ASTM C-55, or precast concrete grade rings mortared in place.

3. Cement mortar for parging and for joining brick shall be made of one (1) part portland cement and two (2) parts sand mixed to the proper consistency. Add approximately twenty (20) pounds of hydrated lime for each sack of cement.
 4. Precast concrete structures for oil/gas separator shall be as manufactured by A. Rotondo & Sons, Inc. or equal by Scituate Concrete pipe or Shea precast. Structures shall conform to the form and dimensions shown, be reinforced with ASTM A-615-79 Grade 60 reinforcing steel having a minimum 1" cover, and constructed of 5,000 PSI concrete. All field joints shall be sealed with rubber gasket and shall be grouted with hydraulic cement for watertightness. Design loading for all structures shall meet H-20 wheel loading design
- B. Conform to the Concrete Section of the specification for 4,000 PSI 6% air entrained concrete for all concrete structures for the work of this section. Including reinforcing steel where detailed.
- C. Cast iron manholes, frames, and covers, shall be of the form, dimensions, and manufacture shown on the Contract Drawings. Manhole extensions shall be neatly and accurately brought to dimensions of the base of the frame. Casting shall be of tough gray iron, free from cracks, holes, and cold shuts. All castings shall be made accurately to dimensions and shall be machined to provide even bearing surfaces. Covers must fit the frames in any position and, if found to rattle under traffic, shall be replaced. Filling to obtain tight covers will not be permitted. No plugging, burning-in, or filling will be allowed. All castings shall be carefully coated inside and out with coal tar pitch varnish of approved quality.
- D. Castings shall be as detailed on drawings or castings that appear on the Massachusetts Highway Department approval list for manhole frame & cover castings. Castings shall be by LeBaron Foundry, Neenah Foundry, or Campbell Foundry.

PART 3 - EXECUTION

3.1 WORKMANSHIP AND INSTALLATION METHODS

- A. All work shall be installed in a first-class manner consistent with the best current practices. All materials shall be securely installed plumb and/or level, and all flush mounted equipment shall have front edge flush with finished wall surface.
- B. All piping shall be installed true to line and grade in the case of underground piping. All piping above ceilings or exposed shall be grouped together, be parallel to each other, and be either parallel or perpendicular to the structure. Utilize gang hangers wherever feasible. Group all valves together where feasible.

3.2 WORK COORDINATION AND JOB OPERATIONS

- A. The equipment shall not be installed in congested and possible problem areas without first coordinating the installation of same.
- B. Particular attention shall be directed to the coordination of piping and other equipment installed in the ceiling areas. Coordinate the elevations of all piping in hung ceiling areas to insure adequate space for the installation of recessed lighting fixtures before other mechanical equipment is installed.

- C. Furnish to the General Contractor, and all other Subcontractors, all information relative to the portion of the Plumbing installation that will affect them, sufficiently in advance so that they may plan their work and installation accordingly.
- D. In case of failure to give proper information as indicated above sufficiently in advance, pay for all back-charges for the modification, renovation, and relocation of any portion of the work already performed.
- E. Obtain from the other trades, all information relative to the Plumbing Work to be executed in conjunction with the installation of their respective equipment.

3.3 CUTTING AND CORE DRILLING

- A. Perform all cutting and core drilling operations that are outlined in Part 1 of this SECTION. Throughout the performance of the cutting and coring work, ensure that the structural integrity of the walls, floors, overhead structure, and other structural components, which are to remain, is maintained until permanent work is installed. Prior to any coring or cutting, verify all locations of same with the General Contractor. All cutting and coring is to be performed in accordance with approved Coordination Drawings
- B. Cut all masonry and concrete with an approved diamond blade concrete saw in a neat straight direction, perpendicular to the plane of the wall or floor.
- C. Use a core drilling process which produces clean, sharp edges and the minimum hole size which will accommodate the size of pipe sleeve specified. Submit procedures for cutting thru existing steel beams to Architect for review.
- D. The patching of holes shall be performed by Plumbing Sub-contractor utilizing methods outlined for the finish trade involved. Holes shall be patched to the satisfaction of the Architect.

3.4 CLEANING AND PROTECTION

- A. Protect all materials and equipment during shipment and so as to prevent damage. Water closets, lavatories, and sinks shall be boarded over and all other fixtures shall be protected with pasted on paper. Post notice prohibiting the use of the fixtures prior to completion. Assume full responsibility for protection of work until its completion and final acceptance.
- B. Keep the premises reasonably clean at all times and remove rubbish caused by the Plumbing Work as directed by the Architect.
- C. Upon completion of this work, clean all fixtures and equipment installed herein and replace damaged parts. Failure to fulfill this obligation will result in back-charges for correction of the defective work.

3.5 SLEEVES, INSERTS, AND ESCUTCHEONS

- A. All piping passing through slabs, floors, walls, and partitions shall be sleeved and all such sleeves shall be furnished and installed by the Plumbing Subcontractor as detailed on the Drawings and herein specified. Set sleeves in concrete floors and walls as soon as forms are set and before concrete is poured. Core drilling openings shall have a sleeve caulked and leaded in place.

- B. All pipes passing through floor, whether slab-on grade or above grade levels, shall be sleeved with sleeve extending 1 in. above floor. This includes all piping in toilet room pipe space, stairwells, closets, partitions and pre-cast planks.
- C. All sleeves shall be Schedule 40 galvanized steel and shall be reamed. There shall be a minimum of 1 in. annular space between the sleeve and pipe provide greater clearance where seismic requirements dictate. Sleeves on insulated pipe shall be large enough to allow insulation to pass through sleeve. Sleeves on drywall, masonry, or concrete walls and partitions, shall be flush with wall on both sides.
- D. The space between sleeve and pipe in all cases shall be filled with a U.L./F.M. approved caulking compound. This includes pipes concealed in chases and/or partitions.
- E. Inserts where required shall be furnished and set by the Plumbing Subcontractor and where necessary may be drilled or power driven and shall be sized such that the insert will not exceed a depth of penetration of 1 in. into concrete.
- F. Escutcheons: All exposed pipe, uncovered, passing through walls or floors or ceilings shall be fitted with C.P. brass spun or split type escutcheons with approved clamping device for holding in position. Floor escutcheons shall be deep enough to fit over sleeves, fastened to pipe, and extend down to floor.

3.6 TESTING

- A. Test all Work in the presence of the Architect and/or Engineer and as required by Local Codes.
- B. After Soil, Storm, Special Waste, and Vent Piping is in place and before being buried or furred in, plug lower ends and fill the system with water up to the top of stacks. Piping is to be left tight under these conditions and water level shall be maintained intact for the period of at least four (4) hours.
- C. Test all water piping by applying a hydrostatic pressure of 150 PSIG using a pump for this purpose. Make sure that all lines are properly plugged or capped and that air has been vented before applying pressure which shall remain constant without pumping for two (2) hours at least.
- D. Test gas piping per State Gas Code.
- E. Any leaks in joints or evidence of defective pipe on fittings disclosed by test shall be immediately corrected by replacing defective parts with new joints or materials. No makeshift repair effected by caulking threaded pipe with lead wool, application or Wilky or patented compounds will be permitted.
- F. Gas/Oil Separator Manhole Exfiltration Test:
 - 1. Plug pipes in manhole; remove water in manhole; observe plugs over period of not less than 2 hours to ensure there is no leakage into manhole.
 - 2. Fill manhole with water to within 4 inches of top of cover frame. Prior to test, allow manhole to soak from minimum of 4 hours to maximum of 72 hours; after soak period, adjust water level inside manhole to within 4 inches of top of cover frame.
 - 3. Measure water level from top of manhole frame; at end of 4 hour test period, again measure water level from top of manhole frame; there shall be no drop in water level during test period.

4. When unsatisfactory test results are achieved, repair manhole and retest until result meets criteria; repair visible leaks regardless of quantity of leakage.

3.7 CHLORINATION

- A. Upon completion of the Plumbing Work, thoroughly chlorinate the entire domestic water system before putting same in service. Chlorinate all work in the presence of the Architect and/or Engineer. The chlorinating agent shall be as a solution of sodium hypochlorite. Water shall be fed slowly into the new line with chlorine in the proper amount to produce a dosage of 50 PPM. Open and close all valves while system is being chlorinated.
- B. After the sterilization agent has been applied for 24 hours, pay for an independent testing agency to test for residual chlorine. A residual of not more than 5 PPM shall be required in all parts of the line.
- C. If test show 5 PPM or greater of residual chlorine, flush out system until all traces of the chemical used are removed.
- D. Provide testing report from independent testing agency.

3.8 INSTALLATION OF FIRESTOP SYSTEMS

- A. General: Install firestop systems at all fire-rated construction where penetrated by the Work of this Section.
- B. Refer to Section 078400 - Firestopping, for all installation requirements for maintaining integrity of fire-rated construction at penetrations.

END OF SECTION

SECTION 22 08 00 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.

1.2 SUMMARY

- A. This section includes commissioning process requirements for Plumbing systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
- C. Certificates of readiness
- D. Certificates of completion of installation, prestart, and startup activities.
- E. O&M manuals
- F. Test reports

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired

resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the contractor for the equipment being tested. For example, the plumbing contractor of Division 22 shall ultimately be responsible for all standard testing equipment for the plumbing system in Division 22, except for equipment specific to and used by TAB in their commissioning responsibilities.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems.
- B. Red-lined Drawings: The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.

- C. Operation and Maintenance Data: Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the contractor.
- D. Demonstration and Training: Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior to the training session.

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Perform tests as required by Division 22.
- B. Attend construction phase controls coordination meetings as required.
- C. Participate in Plumbing systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- D. Provide information requested by the CxA for final commissioning documentation.
- E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- F. Prepare preliminary schedule for Plumbing system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.
- G. Update schedule as required throughout the construction period.
- H. Assist the CxA in all verification and functional performance tests.
- I. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- J. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.
- K. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- L. Notify the CxA a minimum of two weeks in advance of the time for start of the balancing work..
- M. Participate in, and schedule vendors and contractors to participate in the training sessions.
- N. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 - 1. Plumbing equipment including domestic water heaters, controls, pumps, valves plumbing fixtures, and all other equipment furnished under this Division.
- O. The equipment supplier shall document the performance of his equipment.

- P. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- Q. Balance Contractor
 - 1. At the completion of the balancing work, and the submittal of the final balancing report, notify the Plumbing contractor and the CM/GC.
- R. Equipment Suppliers
 - 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 - 2. Assist in equipment testing per agreements with contractors.
 - 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- S. Refer to Division 01 Section “General Commissioning Requirements” for additional contractor responsibilities.

3.3 CxA'S RESPONSIBILITIES

- A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

3.4 TESTING PREPARATION

- A. Certify in writing to the CxA that Plumbing systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that Plumbing instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify in writing that balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.5 DOMESTIC WATER BALANCING

- A. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness balancing Work.

3.6 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of Plumbing testing shall include entire Plumbing installation. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA along with the Plumbing contractor, balancing subcontractor shall prepare detailed testing plans, procedures, and checklists for Plumbing systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the Plumbing system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.7 PLUMBING SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 22 sections. Provide submittals, test data, inspector record, and certifications to the CxA.
- B. Plumbing Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 22 Sections. Assist the CxA with preparation of testing plans.
- C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment: Test requirements are specified in Division 22 piping Sections. Plumbing Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
 - 1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 - 2. Description of equipment for flushing operations.
 - 3. Minimum flushing water velocity.
 - 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

- D. Plumbing Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of domestic water distribution systems.
- E. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls as required.
- F. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
 - 1. Plumbing Systems and all equipment forming a part of these systems including, but not limited to, potable and non-potable water systems, water pressure booster systems, service water heating systems, sanitary waste and vent systems, grey water systems, laboratory waste and acid neutralization systems, storm water systems including rain water reclamation systems, natural gas systems, and compressed air systems.

3.8 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.9 APPROVAL

- A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.10 DEFERRED TESTING

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.11 OPERATION AND MAINTENANCE MANUALS

- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
- B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.12 TRAINING OF OWNER PERSONNEL

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

END OF SECTION 22 08 00

SECTION 221113

FACILITY WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water-distribution piping and related components outside the building.
2. Hydrants.
3. Valves and appurtenances.
4. Complete, disinfected, tested and ready for use, for combined water service and fire-service mains.
5. All necessary joints, fittings, and connections as required.

1.2 SUBMITTALS

- A. Notarized Certificate of Compliance for all materials delivered to the site shall be submitted to the City of Dover's Representative for review.
- B. Product Data: For each type of product indicated.
- C. Field quality-control test reports.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with all applicable requirements of the City of Dover Construction Standards, latest edition, including but not limited to the following:
 - a. Tapping of water mains and backflow prevention.
 - b. Potable-water-service piping, including materials, installation, testing, and disinfection.
 - c. Fire-suppression water-service piping, including materials, hose threads, installation, and testing.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

C. NSF Compliance:

1. Comply with ANSI/NSF Standard 61 by either the Underwriters Labs (UL) or the National Sanitation Foundation (NSF) for materials for water-service piping and specialties for domestic water.

1.4 PROJECT CONDITIONS

- A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only

after arranging to provide temporary water-distribution service according to requirements indicated:

1. Notify the City of Dover Public Works Department and the Owner's Representative no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of water-distribution service without City of Dover Public Works Department and Owner's Representative's written permission.

1.5 COORDINATION

A. Coordinate all water system work with the City of Dover Public Works Department.

1. Prior to the storing of water pipe on the job site, the City of Dover's Representative shall be notified at least 24 hours in advance as to when pipe and fittings will arrive. Upon arrival, Engineering Services will visually inspect the pipe for class rating and evidence of mishandling.
2. Prior to the start of water utility installation, the Contractor shall contact the City's Representative, who will oversee and inspect the water utility construction process for compliance with City standards.
3. The Contractor shall coordinate with the City of Dover so that a City Representative may be present for all water utility testing.
4. The Contractor shall coordinate with the City of Dover upon completion of water utility installation for final inspection and water meter installation.
5. City of Dover Engineering Services will not provide a Certificate of Occupancy Permit until the water meter is installed and all outstanding project related (onsite and offsite) issues are addressed.

B. STORAGE AND HANDLING

1. All materials shall be handled in a manner to prevent warping, twisting, bending, breaking, chipping, rusting or any damage whatsoever. Pipe and structures shall be lifted and moved with the appropriate apparatus without being pushed, pulled or rolled by equipment.
2. All materials that have become so damaged as to be unfit for the intended use shall be promptly removed from the work site.
3. After approval of the pipe and fittings, by the City of Dover, the Contractor shall be required to provide a watertight seal at both ends of the pipe, with a minimum of 1.5 mil polyethylene plastic wrap. This shall be accomplished using sheet plastic or bags secured with duct tape.
4. All pipes shall be stacked on 4" x 4" timbers in tiers with chocks nailed at each end to prevent movement of the pipe. The maximum stacking height for water pipe shall be in accordance with City of Dover Construction Details, latest edition.
5. Loader forks are allowed for the unloading and stacking of pipe provided it is done with care. If pipe hooks are used in the ends of pipe for unloading purposes, they should be of special shape and padded so as to fit either the plain or bell end without damaging the pipe lining. Lifting chains will not be allowed in place of pipe hooks due to safety precautions.
6. Moving the pipe from the stacked pile to the trench by loader forks or approved hooks is acceptable provided it is done with care. The pipe may not be strung along the ditch line until the Engineering Services Division has reviewed and approved the locations.
7. Fittings, valves, and fire hydrants must be stored off the ground so they will not collect moisture or be damaged.

PART 2 - PRODUCTS

2.1 PIPE

A. Ductile-Iron Pipe:

1. Ductile-Iron Pipe 3- to 10-inches in diameter shall meet, or exceed, the current AWWA C151 specifications for ductile-iron water pipe. Pressure Class 350. Thickness Class 52.
2. Maximum length is twenty (20) feet.
3. Double cement lining, seal coating inside and bituminous outside coating shall meet, or exceed, AWWA C104.
4. Joints: Shall conform to current AWWA C111 push-on or mechanical for general buried service; flanged for exposed service unless otherwise shown.
5. Pipe to be furnished complete with gaskets and lubricant.

2.2 GATE VALVES

A. All valves to be mechanical joint.

- #### B. For sizes 3-inch through 12-inch, gate valves shall be required. Gate valves will be resilient seat, cast iron body, with non-rising stem and conform to, or exceed, current AWWA specification C509. Valves are to be supplied with all accessories. The "O" ring sealing mechanism shall provide zero leakage at water working pressure against line flow from either direction and be designed such that no exposed metal seams, edges, screws, etc. are within waterway in close position. Gate shall not be wedged into pocket nor slide across seating surface to obtain tight closure. All internal and external ferrous surfaces of valve, including interior of gate, shall be coated with protective coating conforming to AWWA C550, latest revision. Coating shall be applied to castings prior to assembly to assure all exposed areas will be covered. Valves shall be rated at 200 psi working pressure. Unless otherwise noted, underground valves shall have an operating nut and exposed valves shall have hand wheel operator.

C. Direction to open – LEFT (coded black)

D. Acceptable makes and models:

1. Clow - (F series)
2. Kennedy - (Ken-Seal)
3. Mueller G.V. (A-2360)
4. M & H (style 4067)
5. AFC-2500

2.3 Post indicator gate valves will be resilient seat and shall open to the LEFT (coded black).

2.4 TAPPING SLEEVE

- #### A. Tapping sleeves shall be type designed for making connections to existing water lines without loss of water or interruption of service. Sleeves shall be cast iron split repair type suitable for 200 psi working pressure. Joints shall be suitable for intended use.

2.5 FITTINGS

- A. Fittings shall be gray cast iron or ductile iron with mechanical joints. Fittings and accessories shall conform to or exceed current AWWA C153. Compact ductile iron fittings meeting AWWA C153 are acceptable. Fittings to be new, unused, free from rust, coated, and cement lined.
- B. Ductile iron - Class 350.
- C. Mechanical joints and accessories shall meet AWWA C111.
- D. Double cement lining, inside seal coating and bituminous outside coating shall meet AWWA C104 for all fittings.
- E. Restrained joints shall use Romac "Grip Ring / Meg-A-Lug" or approved equal.
- F. All bolts shall be Cor-ten Steel.

2.6 VALVE BOXES

- A. Each valve buried in the ground shall be provided with an approved type of valve box and cover. Boxes shall be adjustable slip-joint or screw type.
- B. Valve boxes shall be made of close-grained gray cast iron, in three pieces.
 - 1. Base pieces: Shall be belled at bottom to fit around stuffing box gland and rest on valve bonnet, 36-inch or longer to suit grade. No stacking of base sections is permitted;
 - 2. Upper (Top): Shall be flared on lower end to telescope on socket to receive cap or cover. 5 1/4" x 24" or 26" with top flange;
 - 3. Cap or Cover: Shall have the word "Water" cast on upper surface in raised letters. All castings shall be thoroughly cleaned and heavily coated with asphalt or coal-tar varnish.
- C. Each valve box shall be provided with concrete valve marker/protector as detailed in the City of Dover Standard Construction Detail Drawings.
- D. Each valve box shall be fitted with an extension stem for use with buried service non-rising stem valves. Stem shall be of metal and used to extend position of 2" operating nut within 6-inches of grade. Each stem shall be fitted with self-centering disk below operating nut to keep stem aligned in valve box and minimize amount of grit that can enter valve box.
- E. Two piece boxes are required.
- F. Only North American Made valve boxes are acceptable.

2.7 HYDRANTS

- A. Acceptable makes and models:
 - 1. Clow Eddy F2641
 - 2. Darling B62B
 - 3. Mueller Centurion 200

B. Features:

1. Direction to open – LEFT
2. Breakable flange (Traffic model).
3. Valve opening 5-1/4".
4. Two 2½" NST hose nozzles.
5. One 4½" NST pumper nozzle.
6. Operating nut and nozzle caps - NS pentagon 1½" flat to point.
7. Depth of trench - 6 foot.
8. Six inch mechanical joint connection with accessories for 7.10" O.D. ductile iron pipe.
9. Drain hole shall be plugged.
10. Marker flag with retro-reflective marker plate.
11. All hydrants shall be bagged until placed in service.

2.8 WATER METERS

- A. The Contractor is responsible for paying for all fees, including water meters, and should contact Public Works for pricing. Water meters will be furnished by City of Dover Public Works Department and remain the property of the Public Works Department.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

- A. The Contractor shall be responsible for providing a watertight seal at both ends of the pipe, with a minimum of 1.5 mil polyethylene plastic wrap. This shall be accomplished using sheet plastic or bags secured with duct tape. Pipes shall be stored in accordance with City of Dover Standards.
- B. Proper and suitable tools for safe and convenient handling and laying of pipe shall be used, and great care shall be taken to prevent pipe coating from being damaged, particularly on inside of pipes.
- C. All pipe shall be carefully examined for cracks and other defects and no pipe or castings shall be laid which is known to be defective. If any pipe or other casting is discovered to be cracked, broken or defective, after being laid, it shall be removed and replaced by sound pipe, without further charge to the Owner.
- D. Before laying, inside of bell and outside of spigot of pipe shall be thoroughly cleaned.
- E. Water mains and services must be bedded on a 6-inch sand cushion with properties as outlined in Division 31 Section "Earth Moving" and covered with a minimum 12-inch layer of compacted sand – no stones. Where unsuitable/unstable material is encountered below pipe grade it will be removed and replaced with crushed stone or suitable gravel fill below the sand bedding as directed.

- F. Laying depth must be 5 feet 6 inches (5.5 feet) compacted from the top of the pipe to the finished grade of the proposed pavement surface or ground surface. Where extra depth may be required at utility crossings the pipe must return to the specified laying depth by the use of fittings as directed by the Engineering Services Division. In no case will the pipe depth be allowed in excess of 6-feet at the gate valve.
- G. The use of insulation installed over the top of the pipe when the required depth cannot be achieved, will not be permitted without the approval of the City of Dover Representative.
- H. Joint deflection of ductile iron pipe is not acceptable.
- I. Water mains must be separated from storm drain systems for frost protection. Should the separation be less than 3 feet from a storm drain manhole, catch basin, or pipeline, 2" rigid polystyrene thermal insulation with a minimum "R" value of 10 will be required two-feet each side of the utility and a distance to be specified by the City of Dover's Representative, (a minimum of 8' is required). The City of Dover's Representative shall be contacted prior to the installation of the insulation.
- J. State of New Hampshire regulations require water mains and services to be separated from sanitary sewer mains and services by a minimum of 10-feet (horizontally). This applies for new construction and renovations to existing structures.
- K. Minimum vertical separation between water and sewer mains or services is 18 inches. Whenever it is necessary for water mains to cross over sewer, water main shall be laid at such an elevation that bottom of water main is at least 18-inches above top of sewer, unless local conditions or barriers prevent an 18-inch vertical separation, in which case both water and sewer shall be constructed of Class 52 ductile iron and with joints that are equivalent to water main standards for distance of 10-feet on each side of point of crossing.
 - 1. Where this vertical separation cannot be obtained, sewer shall be constructed of AWWA approved water pipe, pressure tested in place without leakage prior to backfilling.
 - 2. Sewer manhole shall be of water-tight construction and tested in place.
- L. In conflicts requiring the relocation of utilities, preference shall be given to:
 - 1. Utilities with grade restrictions.
 - 2. Existing utilities already in service.
- M. Crossing water main under sewer: Whenever it is necessary for water main to cross under sewer, both water main and sewer shall be constructed of Class 52 ductile iron and with joints equivalent to water main standards for a distance of 10 feet on each side of point of crossing. Section of water main pipe shall be centered at point of crossing.
- N. Water lines shall not pass through or come into contact with any sewer manhole.
- O. No trench shall be left open at the end of the workday. Contractor shall take all the necessary precautions to "button-up" the work zone for the general public during the night. Precautions include but not limited to, placing steel plates over the trench, barricades, lighting, signs, etc. Contractor shall contact the City of Dover's Representative before leaving the site at the end of the day, to ensure that work zone has been adequately closed up for the safety of the public.
- P. A "watertight plug" must be inserted as each length or fitting is installed. This "end plug" will be left in place at the end of the workday.

- Q. Detectable "Water" marking tape shall be laid continuously in trench backfill approximately 12-inches above the crown of the pipe. Underground warning tapes are specified in Division 31 Section "Earth Moving."

3.3 BLOCKING, VALVES, MECHANICAL FITTINGS, SPECIALS, AND APPURTENANCES

- A. Concrete Blocking shall be installed at all bends, tees and plugs. Concrete blocking shall consist of 3000 psi concrete from pipe to undisturbed ground to dimensions shown on the Drawings. Plant mix concrete is preferred although field mix concrete (Sacrete or equal) may be used as long as it is properly mixed in clean containers with potable water. Concrete shall receive 24-hour cure before being backfilled. Concrete placed against plug shall contain weakness plane (using heavy paper to make this joint), so that when struck with hammer, it will separate and allow plug to be removed. If ground is soft, restrained joint fitting shall be used as directed by Owner's Representative.
- B. Valves, Specials, and all other Appurtenances are to be placed as shown on the Drawings or at location and in manner designated by Owner's Representative. Any omissions of any of these appurtenances shall be corrected by Contractor and same set as originally planned without expense to Owner. Over each valve, a valve box is to be firmly set.
- C. All main line valves at pipe intersections (including hydrant valves) are to be placed within 2-feet of the tees.
- D. Install valve boxes with a cushion of sand between the valve and the valve box. A Gate Box Aligner shall be required under the operating nut. In wet areas, washed stone is to be placed around the valve box with a layer of geotextile filter fabric to prevent fine soil from mixing with stone during initial backfill.
- E. Exercise each valve in the presence of the inspector. The number of turns must be recorded before the valve is installed.
- F. Mechanical Fittings: A torque wrench must be used on all fittings to insure manufacture's recommended torque.
Generally Accepted Torques:
70 lbs. on set screws
75-90 lbs. on glands with 3/4" (19 mm) bolts
60 lbs. on glands with 5/8" (16 mm) bolts
- G. Assembly Instructions for Ductile Iron Pipe (Mechanical Fitting Joints):
1. Clean bell and spigot end and lubricate gasket with approved pipe lubricant. Set gasket into position to assure even seating in the bell. When gland is in position, insert bolts and tighten with fingers. Tighten bolts to the normal range of bolt torque while maintaining approximately the same distance between the gland and the face of the socket. A proper joint is accomplished by: 1) partially tightening the bottom bolt, 2) the top bolt; 3) the bolts at both sides; and 4) the remaining bolts. Repeat this process until all bolts are within the appropriate torque range.
- H. Stainless steel tapping sleeves are acceptable.
- I. No contractor will operate City of Dover valves without the explicit permission of the City of Dover.

3.4 WATER METER INSTALLATION

- A. Temporary meters shall be required for City water use during construction. The Contractor must agree to adhere to City operational procedures. Seasonal requirements may apply such as a hydrant being pumped after each use in winter conditions. The contractor can be fined a minimum of \$1,000.00 without the proper authorization from the City of Dover.
- B. It is the responsibility of the Contractor to install meter setter horns or flanges in which the City will place the permanent meter.
- C. Meters shall be placed where they will be easily accessible for reading and maintenance. The General Services Department will install and seal the meter.
- D. Prior to having the meter installed the following must occur:
 - 1. Application for service made at the Public Works Department Utility Billing Office – (address) in Dover, New Hampshire.
 - 2. All fees and charges including Special Investment Fees if applicable are paid. This includes the Water Investment Fee (WIF) and the Sewer Investment Fee (SIF).
 - 3. Final Inspection of the project by the Engineering Services Division. No water meter will be installed until all outstanding project related issues, if any, are addressed.

3.5 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.

3.6 TESTING AND CLEANING REQUIREMENTS

- A. Water Line Testing:
 - 1. Testing shall be scheduled with and performed in the presence of a City of Dover Representative.
 - 2. The contractor shall provide all materials necessary for water line testing including; corporations, ball valves, blow-offs, etc. for main line testing.
 - 3. Fire hydrants shall be used as “blow-off valves”, venting, etc. When field conditions do not allow the use of a fire hydrant, use of a blow-off valve (type and location) shall be determined by the City of Dover Representative; the contractor shall not install a blow-off valve without the proper authorization.
- B. Pressure Testing:
 - 1. Pressure/leakage test of water mains shall be in accordance the more stringent of the following:
 - a. City of Dover Construction Standards;
 - b. Services and mains 2-inches in diameter or greater must be pressure tested as follows: Pressurize the water line to 150 psi (min) or 1.5 times the static pressure in excess of 100 psi - not to exceed 200 psi. The static pressure must hold for one hour to be acceptable.
 - 2. Tests will be performed by the Contractor or a reputable testing firm. A City of Dover Representative shall be present to witness the test. The test results shall be forwarded to Engineering Services or their consultant for review and acceptance.

3. All visible leaks at exposed joints, all leaks evident on surface where joints are covered, shall be repaired and leakage minimized, regardless of total leakage as shown by test.
4. All pipe, fittings, and other material found to be defective under test shall be removed and replaced at Contractor's expense.
5. Lines which fail to meet tests shall be repaired and retested as necessary, until requirements are complied with.
6. Pipe lines with resilient gasket materials should be held under normal operating pressure at least 3 days before testing.

C. Bacterial Testing/Disinfection:

1. All water lines greater than two inches in diameter must be disinfected. Disinfection shall be in accordance with the American Water Works Association (AWWA) standard C651-86 (Disinfecting Water Mains) Section 5.2, Continuous-Feed Method and in accordance with the City of Dover Construction Standards, more stringent applies.
2. Preliminary Flushing. Before being chlorinated, main shall be filled to eliminate air pockets and shall be flushed to remove particulates. Flushing velocity in main shall not be less than 2.5 ft/s unless OWNER's Representative or job superintendent determines that conditions do not permit required flow to be discharged to waste. Table 1 shows rates of flow required to produce velocity of 2.5 ft/s in pipes of various sizes. Note that flushing is no substitute for preventive measures during construction. Certain contaminants, such as caked deposits, resist flushing at any feasible velocity.

Table 1. Required Flow and Openings to Flush Pipelines
 (40 psi Residual Pressure in Water Main)

Pipe Diameter (inches)	Flow Required to Produce 2.5 ft/s (approx.) Velocity in Main (gpm)
4	100
6	200
8	400
10	600
12	900
16	1600

- a. Water from existing distribution system or other approved source of supply shall be made to flow at constant, measured rate into newly laid water main. In absence of meter, rate may be approximated by methods such as placing Pitot gauge in discharge or measuring time to fill container of known volume.
- b. At point not more than 10 ft downstream from beginning of new main, water entering new main shall receive dose of chlorine fed at constant rate such that water will have not less than 50 mg/L chlorine residual. To assure that this concentration is provided, measure chlorine concentration at regular intervals using appropriate chlorine test kits.
- c. During application of chlorine, valves shall be positioned so that strong chlorine solution in main being treated will not flow into water mains in active service. Chlorine application shall not cease until entire main is filled with heavily chlorinated water. Chlorinated water shall be retained

in main for at least 24-h, during which time all valves and hydrants in treated section shall be operated to ensure disinfection of appurtenances.

- d. Direct-feed chlorinators, which operate solely from gas pressure in chlorine cylinder, shall not be used for application of liquid chlorine. Preferred equipment for applying liquid chlorine is solution-feed, vacuum-operated chlorinator and booster pump. Vacuum-operated chlorinator mixes chlorine gas in solution water; booster pump injects chlorine-gas solution into main to be disinfected. Hypochlorite solutions may be applied to water main with gasoline or electrically powered chemical-feed pump designed for feeding chlorine solutions. Feed lines shall be of such material and strength as to safely withstand corrosion caused by concentrated chlorine solutions and maximum pressures that may be created by pumps. All connections shall be checked for tightness before solution is applied to main.
 - e. Highly chlorinated water should remain in line until chlorine residual drops below 5 ppm or minimum of 96 hours, whichever is first. After this period, water will be wasted by pumping into air to dissipate remaining chlorine residual. Pumping shall be at rate not to exceed 25 GPM. Pressure and nozzle size shall be such as to produce an 8 foot (vertical) spray.
 - f. System should then be flushed with potable water and sampling program started. Sampling shall consist of taking one representative sample every 5000 feet and at each blow-off. Samples shall then be tested by State approved laboratory for indication of bacteriologically satisfactory water. Three (3) copies of this laboratory test shall be submitted to OWNER's Representative.
- D. Prepare reports of testing activities and purging and disinfecting activities, then submit to the City of Dover.

END OF SECTION 221113

SECTION 221313
FACILITY SANITARY SEWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sanitary sewer service to a point within 5' of the building.
2. Pipe and fittings.
3. Manholes.
4. Testing.

1.2 SUBMITTALS

- A. Notarized Certificate of Compliance shall be provided to the OWNER's Representative for all materials delivered to the site.
- B. Product Data: For each type of product indicated.
- C. Product Certificates: For each type and size of pipe and fitting, from manufacturer.
- D. Field Quality-Control test reports.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with all applicable requirements of the City of Dover Construction Standards, latest edition.

B. Storage and Handling of Materials:

1. Preventing damage: All materials shall be handled in a manner to prevent warping, twisting, bending, breaking, chipping, rusting or any damage whatsoever. Pipe and structures shall be lifted and moved with the appropriate apparatus without being pushed, pulled or rolled by equipment.
2. Storage of cement: Cement shall be stored under cover, off the ground, and shall be kept completely dry at all times.
3. Storage of reinforcing steel: All reinforcing steel shall be stored off the ground, or otherwise to prevent accumulations of dirt or grease, and in a position to prevent accumulations of standing water to minimize rusting.
4. Precast concrete handling: Precast concrete units shall be handled in a manner to prevent chipping or cracking.
5. Handling and storage of masonry products: Brick, block and similar masonry products shall be handled and stored in a manner to reduce breakage, chipping, cracking and spalling.

6. Damaged materials: All materials that have become so damaged as to be unfit for the intended use shall be promptly removed from the work site.

1.4 COORDINATION

- A. Coordinate all sewer system work with the City of Dover.
 1. Prior to the start of sewer utility installation, the Contractor shall contact the City's Representative, who will oversee and inspect the sewer utility construction process for compliance with City standards.
 2. The Contractor shall coordinate with the City of Dover so that a City Representative may be present for all sewer utility testing.

PART 2 - PRODUCTS

2.1 POLYVINYL CHLORIDE (PVC) PIPE

- A. Gravity pipe and fittings shall conform to ASTM D-3034 and shall be SDR 35.
- B. Pressure Sewer Pipe and fittings shall conform to ASTM D-2241 or ASTM D-1785 and shall be SDR 21.
- C. Pipe and pipe fittings between manholes are to be of the same manufacturer.
- D. All pipe and fittings shall be push-on with snug fit. Joint compression rings shall be of an oil resistant rubber type or flexible elastomeric seals conforming to tightness requirements of ASTM D-3212.
- E. Insulation for sewer main and services, if required, shall be extruded rigid board material having a thermal conductivity of 0.23 BTU/hour/square foot/degree Fahrenheit/per inch thickness, maximum, at 40 degrees F mean, a comprehensive strength of 35 psi minimum, and water absorption of 0.25 percent by volume maximum.
 1. Unless otherwise specified in the Drawings or Specifications, board dimensions shall measure 8 feet long, 4 feet wide, and 2 inches thick.
- F. Manufacturer's certificate of compliance shall be furnished to the City prior to installation.

2.2 STRUCTURES AND APPURTENANCES

- A. Precast Sanitary Sewer Manhole Structures: Precast reinforced concrete structures may be used. Structures must meet local and state standards.
 1. Manholes will be of precast concrete construction; precast concrete barrel sections and precast manhole bases shall conform to ASTM Designation C478.
 2. The wall thickness shall not be less than 5 inches for 48 inch inside diameter structures, or 6-inches for 60-inch and 7-inches for 72-inch inside diameter barrel sections.
 3. Lift holes are to be sealed with Portland cement (Type II) mortar flush to the outside structure wall prior to backfilling.
 4. Reinforcing steel shall conform to the requirements of NHDOT 544.

5. Fibers shall only be used in structures with 4 feet or less inside diameter and shall be as shown on the NHDOT Qualified Products List.
6. Eccentric cone sections with 30-inch openings are required, except where the cover over the top of the pipe is less than 4-feet for 48-inch diameter manholes, or 7-feet for 60-inch and 72-inch diameter manholes, in which case, precast concrete top slabs designed for H-20 loading may be allowed.
7. The use of water plug is permitted for special applications where the City Engineer deems appropriate.
8. Requirements for manhole covers shall be in accordance with Env-Wq 704.13(a) (4) through (8).

B. Concrete:

1. Concrete for sewer appurtenances construction shall be 3,000 psi.

C. Frames and Covers:

1. North American and India castings are allowed, provided the India castings are from SIGMA Corporation or approved equal. All castings shall be designed for H-20 Loading. Material shall be ASTM A 48 Class 30 cast iron unless otherwise indicated.
2. 30-inch ID by 7- to 9-inch riser, with 4-inch- minimum-width flange and 30-inch-diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "SANITARY SEWER."

2.3 CLEANOUTS

A. Plastic Cleanouts:

1. Description: SDR-35 PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.
2. Refer to Contract Drawings for additional information.

2.4 MASONRY

A. Brick:

1. Brick shall be solid, sound, hard, and have plain or smooth surfaces on both ends and on the face side, and be satisfactory to the City Engineer. Brick shall comply with A.S.T.M. Standard Specifications for Sewer Brick, Designation C32, for Grade SS, Hard Red Brick. Brick samples will be required for approval prior to incorporation in the work.

B. Cement:

1. Cement shall be straight Portland Cement, Type II. Lime mortar or Masonry cement is not to be used on structures.

C. Mortar Sand:

1. Mortar sand shall meet the following gradation requirements:

<u>Sieve Size</u>	<u>% Passing</u>
No. 8	100
No. 16	60-100
No. 50	15-35
No. 100	2-15
No. 200	0-5

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."
- B. Excavation shall be accomplished by methods that preserve the undisturbed state of the subgrade soils.
- C. A trench may be excavated by machinery to the designated subgrade, provided that the bottom of the trench remains in the undisturbed state and provides the proper foundation for the pipe bedding.
- D. Equipment may have to be modified by welding a blade to the bucket teeth to achieve the required shape to fit the lower 1/3 of the pipe exterior for pipe 36" in diameter and larger.

3.2 PIPING INSTALLATION

- A. Sewer manholes are required at every change in vertical grade or horizontal pipe alignment along a main.
- B. Should construction operations reveal or expose a water main running under, approximately parallel to (less than 10-feet from a proposed sewer installation), and where it is not practical to relocate the sewer, the sewer shall be reconstructed of ductile iron pressure class pipe until the minimum 10-foot separation can be achieved. Whenever sewers must cross over water mains, the sewer shall be constructed of ductile iron pressure class pipe for a minimum distance of 9 feet each side of the crossing. Joints shall be water pressure rated with zero leakage when tested at 25 pounds per square inch for gravity sewers and 1½ times working pressure for force mains, and joints shall not be located within 9 feet of the crossing point. Should the vertical separation of the sewer and water main be less than 18", the water main or the sewer main must be relocated to achieve the required separation. In conflicts requiring the relocation of utilities, preference shall be given to:
 - 1. Utilities with grade restrictions.
 - 2. Existing utilities already in service.
- C. Sewer service lateral sizing shall be as follows:
 - 1. Commercial, Industrial or multifamily = 6-inch minimum.

- D. Sewer service laterals shall be constructed with the following minimum slope, yet not to exceed a 10% slope:
 - 1. 6 inch service = 1/8 inch per foot = 1%
- E. All pipe utilizing Bell and Spigot joints shall be laid with the spigot end downstream. Bells will not be permitted in structures.
- F. Install sewer lines in straight line and on uniform rate of grade between points where changes in alignment or grade are shown. Bed barrel of pipe firmly at required line and grade. Keep stopper in mouth of pipe when pipe-laying is not in progress. Support barrels of pipe continuously and scoop out space for proper clearance of bell.
- G. Begin backfilling only after piping has been inspected by City of Dover's representative.
- H. Green detectable "sewer" tape shall be installed in the sewer trench on top of the 12-inch sand blanket on all sanitary sewer mains and services. Underground warning tapes are specified in Division 31 Section "Earth Moving."
- I. Whenever feasible, all service connections shall be tied into a sanitary sewer manhole, if this is not possible then sanitary sewer service connections shall be accomplished by using an approved sanitary tee fitting, as described in the City of Dover's Building and Plumbing Code Regulations, at the sanitary sewer main in the City street. The connection shall be made in accordance with the City of Dover's Building and Plumbing Code Regulations, and the International Plumbing Code.
- J. Brick shelves shall be constructed to the top of connecting service laterals. Service laterals shall outlet into manholes 2" above the outlet of the main where it leaves the manhole. Refer to the City of Dover's Construction Details for additional information.
- K. Service laterals greater than six (6) inches in diameter must terminate in a sanitary sewer manhole structure.
- L. Ninety degree (90°) bends are not permitted for sanitary sewer service connections.
- M. A backflow valve shall be installed where plumbing fixtures are subject to backflow from the public sewer (BOCA Plumbing Code P-1003.2). Generally where the first floor elevation is lower than the street this will be required.
- N. Sewer service laterals shall be designed for a minimum of four (4) feet of cover at the building foundation. Insulation will be required should the sanitary sewer lateral be less than the required four feet deep. Under no circumstances will the use of insulation be permitted without the authorization of the City of Dover's Representative.
- O. No trench shall be left open at the end of the workday. Contractor shall take all the necessary precautions to "button-up" the work zone for the general public during the night. Precautions include but not limited to, placing steel plates over the trench, barricades, lighting, signs, etc. Contractor shall contact the City of Dover's Representative before leaving the site at the end of the day, to ensure that work zone has been adequately closed up for the safety of the public.

3.3 MANHOLE INSTALLATION

- A. Install precast concrete sanitary sewer manhole in accordance with City of Dover Construction Standards, latest edition.
- B. The use of sanitary sewer “doghouses” are not permitted unless approval has been granted by the City Engineer.

3.4 CLEANOUT INSTALLATION

- A. Cleanouts shall be constructed on service laterals as directed by the City’s inspector and shall be located as follows:
 - 1. 4 inch and 6 inch service: One cleanout is required prior to any horizontal and/or vertical directional change greater than 45°. If a service changes direction more than once, a cleanout will be required 5’ from the right-of-way for every two elbows regardless of the angle of change. (i.e. 1-22.5° & 1-45° requires one cleanout.).
 - 2. Cleanouts will be constructed using wyes (either 4x4x4 or 6x6x6 inch) and incorporating a 45° elbow to bring the stack vertical.
 - 3. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Install piping so cleanouts open in direction of flow in sewer pipe.
 - 4. Use Extra-Heavy-Duty, top-loading classification cleanouts in paved driveway area.
 - 5. In vehicular-traffic areas, use NPS 4 SDR-35 PVC pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 18 by 18 by 12 inches deep. Set top of cleanout flush with grade.
 - 6. A cast iron cleanout box with cover marked “sewer” is required over 4” & 6” sewer service cleanouts.
 - 7. Cleanouts will be required at or near the property line for testing purposes should the installation not be completed to a building or a manhole structure.
 - 8. Cleanouts shall be located outside of the City of Dover’s R.O.W.
 - 9. Cleanouts shall be located one per 100’ with no greater than 100-foot separation unless otherwise directed by the BOCA Plumbing Code.
 - 10. Cleanouts shall be the same diameter as the carrying pipe, except for cleanouts on service laterals greater than six (6) inches, where a six (6) inch cleanout is acceptable.
 - 11. Cleanouts shall be installed just upstream of bends (manufactured fittings). Only one cleanout is necessary when two 45° bends are used to make up a 90° turn. A minimum of 2-feet of exposed pipe is required between bends.
 - 12. A cleanout is required should a service lateral diameter be reduced between the building and the sewer main.

3.5 EXCAVATION

- A. Excavation shall be accomplished by methods that preserve the undisturbed state of the subgrade soils.
- B. A trench may be excavated by machinery to the designated subgrade, provided that the bottom of the trench remains in the undisturbed state and provides the proper foundation for the pipe bedding.
- C. Equipment may have to be modified by welding a blade to the bucket teeth to achieve the required shape to fit the lower 1/3 of the pipe exterior for pipe 36" in diameter and larger.

3.6 CRUSHED STONE BEDDING

- A. Contractor shall place $\frac{3}{4}$ " crushed stone: for bedding, to the crown of the pipe and a minimum 6" beneath the pipe throughout the bottom of the excavated trench. If bedrock ledge is encountered, ledge shall be excavated and backfilled with crushed stone bedding a minimum of 12" below the pipe, per Env-Wq 704.11(o). PVC sanitary sewers and laterals shall be installed in accordance with ASTM D2321-89.

3.7 MORTAR

- A. Mortar shall consist of 4.5 parts mortar sand to 1.5 parts Portland Cement.
- B. To obtain the proper ratio, one and one half bags of Type II Portland Cement should be mixed with four and one half - five gallon buckets of mortar sand.
- C. The mix shall be thoroughly blended only in such quantity as may be required for immediate use, and shall be used before the initial set has taken place.
- D. The mix shall be constantly worked over with hoe or shovel to keep it workable. Adding water after mixing to bring a hardened mix "back to life" will not be allowed.

3.8 BRICK MASONRY

- A. Brick masonry shall be protected from too rapid drying by approved means and shall be protected from weather and frost, as required.
- B. Bricks shall be laid in a full bed and joint of mortar without requiring subsequent grouting, flushing, or filling. Joints between bricks shall not exceed $\frac{3}{8}$ inch and shall be tooled flush to the brick surface.
- C. Brick masonry during winter conditions must be protected from freezing. A suitable heated shelter will be required to assure all materials remain above freezing for 3 days.
- D. All brickwork used to adjust manhole frames to grade shall be sealed on the outside of the structure with mortar.

3.9 INVERTS

- A. Manhole inverts shall be constructed to provide an uninterrupted flow channel and shall correspond in shape to the lower half of the pipe.
- B. Brick shall be laid on edge. Mortar joints shall be tooled flush to the face of the brick to prevent minor depressions. Shelves shall be constructed to the highest pipe crown in the manhole.
- C. The brick shelf shall be pitched to drain toward the through channel with one inch of difference from the structure wall to the channel edge. Puddles or undue turbulence through the manhole trough will necessitate reconstruction.
- D. The use of fiberglass inverts may not be allowed.

3.10 ADJUSTING FRAMES TO GRADE

- A. Frames shall be centered over the manhole opening and are to be set no less than 1/8-inch lower or no more than 1/4 inch lower than finish pavement.
- B. A minimum of 2 courses of brick are required under the structure frame, yet the adjusting course shall not exceed approximately one foot of brick - (normally 5 course maximum).
- C. The final course of brick may be laid on edge. Brick and mortar is the only masonry material to be used between the precast structure and the cast iron frame. The use of barrel blocks and concrete grade rings is not permitted.
- D. All brickwork used to adjust manholes to grade shall be laid in a header course pattern - (end showing) as opposed to a batter course – (edge showing).

3.11 INSPECTION REQUIREMENTS

- A. All sanitary sewer lines, including service connections, shall be substantially watertight and shall be inspected and tested for excessive leakage upon completion and before connections are made to the service by others. Each test section of the sewer shall be subjected to testing and shall be videotaped as required by the City of Dover.
- B. The Engineering Services Division's representative shall perform full time inspections to assure that all sanitary sewer work conforms to City standards.
- C. Visual Inspections
 - 1. Visual inspections are normally required to confirm the hydraulic integrity of sanitary sewer systems. Pipelines are required to be true to alignment and at a uniform slope between structures.
 - 2. All sewer lines shall be inspected visually by CONTRACTOR and checked by OWNER's Representative to verify accuracy of alignment and freedom from debris and obstructions. Full diameter of pipe should be visible when viewed between consecutive manholes.
 - 3. "Ponding" or deviations in alignment will be cause for rejection.
- D. Video Inspection
 - 1. All pipelines will be subject to the scrutiny of a video inspection prior to acceptance to assure proper jointing and flow characteristics. All video inspections shall be performed by the City of Dover General Services Division.
 - 2. Camera inspections will not be scheduled until construction of other utilities in the same area are completed and the pipeline under consideration has been backfilled and compacted to subgrade elevation for at least thirty days prior to the scheduled inspection. The Contractor shall contact General Services to schedule the inspection.
 - 3. All structures are to be accessible to the video inspection vehicle and all pipelines shall be cleaned of all debris prior to the inspection. The presence of debris or insufficient flushing water will necessitate re-inspection following correction.
 - 4. Video camera inspections will be performed after flushing the sanitary sewer main or lateral with water containing a visible dye and allowed to drain. Excessive ponding or alignment deviation deemed by the City of Dover's representative is cause for rejection.

5. Only tractor-type units will be utilized for mainline inspections, push cameras will only be allowed for lateral inspections.
6. The camera shall have pan and tilt capabilities.
7. The camera shall be approved by the manufacturer for the pipe size being inspected (typical camera is rated for 8"-24", without additional accessories).
8. Optional: The camera should be equipped with an inclinometer (these only show the general trend of the pipe slope, not to be viewed alone as acceptance criteria).
9. The camera footage shall be shown on-screen.
10. The unit should be able to provide accurate footage, (1'±) and all measurements shall be taken from the center of manhole structures.
11. The beginning of the inspection shall consist of a title screen that indicates the following information; date, time, location, company doing the inspection, contractor that laid the pipe, type of structure, pipe size and material, and if manhole numbers or line segments are not specifically labeled on the approved plans; than station numbers compete with right or left offsets shall be used to identify line segments.
12. When a lateral line is encountered during the inspection; the camera operator shall stop the camera unit and, using the pan and tilt function, inspect the lateral opening to the best of the camera's ability (dye should be introduced into the lateral, if feasible, to view flow characteristics).
13. When a questionable pipe joint is encountered during the inspection; the camera operator shall stop the camera unit and using the pan and tilt function, inspect the joint to the best of the camera's ability. Operator should also traverse the joint with the camera unit to observe the amount of drop/rise the camera experiences over questionable joints.
14. When a sag is encountered during the inspection; the camera operator shall record the beginning and end of said sag, if of questionable depth, then the operator shall drag a ½" tall non-buoyant object through the sag with the camera unit to observe and record actual depth.
15. All defects observed shall be logged into some sort of data management software (PACP or WRC compliant) and compiled into a video report to be submitted with the video inspection.
16. All video inspection submittals shall be DVD format, no VHS will be accepted.
17. Any submittal not meeting these requirements will be rejected.
18. All costs associated with the video inspection shall be the responsibility of the contractor. Contact the General Service Division for the current fee schedule.

3.12 TESTING REQUIREMENTS

A. Sewer Main Low Pressure Air Testing

1. All new gravity sewers shall be tested for water tightness by the use of low-pressure air tests. The low pressure air testing shall be in conformance with ASTM F1417-92(2005) "Standard Test Method for installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air" or uni-Bell PVC Pipe Association Uni-B-6 "Low Pressure Air Testing of Installed Sewer Pipe" (1998)
2. This test may be performed by an independent testing agency after notice to the City Engineer or their designee. Should the contractor conduct their own test, an Engineering Services inspector must be present to witness the results.
3. Test Requirements: The sanitary sewer main between structures, including laterals and all connections, regardless of length, must hold a positive pressure of 4 PSI over a period of 5 minutes with a maximum pressure loss of 1 psi.

B. Deflection Testing

1. Deflection tests will be conducted a minimum of 30 days but no more than 90 days following installation of pipe and after the road has been constructed to subgrade and is ready for select materials.
2. Deflection tests shall be performed on the entire length of the sewer main line on a manhole-to-manhole basis.
3. The go, no-go mandrel test method shall be used and not performed before all utilities have been installed.
4. Maximum deflection shall not exceed 5% of the pipe's internal diameter. A rigid ball or mandrel with a diameter of at least 95% of the average inside pipe diameter shall be used for testing pipe deflection. The deflection test shall be conducted without mechanical pulling devices.
5. If Owner's Representative directs as result of visual test, a closed circuit television video shall be provided to prove pipe deflection is within allowable limits. Contractor may, at his option, use a deflectometer, calibrated television or photography.
6. All new gravity sewers shall be: (1) Cleaned and visually inspected using a lamp test and by introducing water to determine that there is no standing water in the sewer; and (2) True to line and grade following installation and prior to use.

C. Sewer Service Testing

1. The service lateral shall be tested at the point of connection with the public sewer to a point within the foundation as provided by the plumber.
2. A water test under a head of 10 feet for 15 minutes or an air test of 4 psi for 5 minutes will be accepted.

D. Sewer Manhole Testing

1. Vacuum Test
 - a. The vacuum test method is the preferred method to insure manhole integrity. Testing shall be in accordance with ASTM C1244 as required in Env-Wq 704.17.
 - b. All sanitary sewer manholes will be vacuum tested prior to backfilling around the structure. If the structure is struck by equipment during backfilling operations, the contractor shall be responsible for re-testing of the manhole.
 - c. The initial test pressure is to be negative 10-inches of mercury. Minimum allowable test time for a 1-inch loss in pressure from negative 10-inches of mercury to negative 9-inches of mercury is 120 seconds for a structure up to ten (10) feet deep (as measured from the floor of the structure to the top of the precast unit).
 - d. Structures over 10 feet and up to 15 feet deep require 150 seconds without a 1-inch total loss of vacuum.
 - e. Structures over 15 feet and up to 20 feet deep require 180 seconds without a 1-inch total loss of vacuum.
 - f. Structures over 20 feet and up to 25 feet deep require 210 seconds without a 1-inch total loss of vacuum.

E. Test Failure and Remedy

1. In the event of test failure on any test section, testing shall be continued until all leakage has been detected and corrected to meet the requirements. All repair work shall be subject to approval of the Owner's Representative. Introduction of sealant substances by means of test water will not be permitted.

2. Unsatisfactory repairs or test results may result in an order to remove and replace pipe as the City Representative considers necessary for conformance. All repair and replacement work shall be at the Contractor's expense.

3.13 CLEANING

- A. Clean dirt and superfluous material from interior of piping. Flush with potable water.

END OF SECTION 221313

SECTION 230000

HVAC

PART 1 GENERAL 1

1.1 GENERAL PROVISIONS 1

1.2 SECTION INCLUDES..... 1

1.3 RELATED SECTIONS..... 2

1.4 COMMISSIONING 3

1.5 CODES, ORDINANCES, AND PERMITS 3

1.6 QUALITY ASSURANCE 4

1.7 HAZARDOUS MATERIALS..... 5

1.8 DISCREPANCIES IN DOCUMENTS..... 5

1.9 CONTRACT DRAWINGS..... 6

1.10 COORDINATION DRAWINGS..... 6

1.11 ACCESSIBILITY 7

1.12 ROUGH IN..... 7

1.13 NOTIFICATION OF RELATED TRADES 7

1.14 MECHANICAL INSTALLATIONS 7

1.15 CUTTING AND PATCHING 8

1.16 SUBMITTALS 8

1.17 SUBSTITUTIONS..... 9

1.18 PRODUCT LISTING 10

1.19 NAMEPLATE DATA 10

1.20 DELIVERY, STORAGE AND HANDLING 10

1.21 RECORD DOCUMENTS..... 11

1.22 OPERATION AND MAINTENANCE DATA 11

1.23 WARRANTIES..... 12

1.24 ENERGY REBATE PROGRAM..... 13

1.25 HOISTING EQUIPMENT AND MACHINERY 13

1.26 STAGING AND SCAFFOLDING 13

1.27 WELDING QUALIFICATIONS..... 13

1.28 TRADE RESPONSIBILITY COORDINATION MATRIX 14

PART 2 PRODUCTS 15

2.1 ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT 15

2.2 VALVES..... 17

2.3 METERS AND GAGES 22

2.4 HANGERS & ATTACHMENTS 24

2.5 MECHANICAL IDENTIFICATION 26

2.6 MECHANICAL INSULATION..... 28

2.7 GREASE DUCT INSULATION 30

2.8 HYDRONIC PIPING AND ACCESSORIES..... 31

2.9 REFRIGERANT PIPING..... 38

2.10 HIGH EFFICIENCY, GAS-FIRED CONDENSING BOILER 39

2.11 PUMPS (P) 41

2.12 AIR INTAKE AND EXHAUST BREECHING, CHIMNEYS AND STACKS..... 42

2.13 CONDENSATE NEUTRALIZING TUBES 43

2.14 ROOFTOP UNITS (RTU) 43

2.15 AIR COOLED CHILLER 51

2.16 TERMINAL HEATING UNITS (HYDRONIC) 53

2.17 TERMINAL HEATING UNITS (ELECTRIC) 60

2.18 INDUCTION TERMINAL UNIT (ACTIVE CHILLED BEAMS)..... 61

2.19	POWER AND GRAVITY VENTILATORS	62
2.20	VEHICLE EXHAUST SYSTEM.....	66
2.21	METAL DUCTWORK	67
2.22	DUCTWORK ACCESSORIES	76
2.23	ACOUSTIC DUCT LINING	80
2.24	SOUND ATTENUATORS (SA).....	80
2.25	AIR OUTLETS AND INLETS.....	81
2.26	DUCTLESS COOLING UNITS	86
2.27	CONDENSATE DISCHARGE PUMPS.....	88
2.28	VARIABLE AIR VOLUME BOX (VAV).....	88
2.29	DUST COLLECTOR SYSTEM.....	90
2.30	FIRESTOP SYSTEMS.....	94
2.31	WALL AND CEILING ACCESS DOORS.....	95
2.32	AUTOMATIC TEMPERATURE CONTROLS (DDC).....	95
PART 3 EXECUTION		120
3.1	CUTTING AND PATCHING:	120
3.2	INSTALLATION OF VALVES	120
3.3	INSTALLATION OF METERS AND GAGES.....	122
3.4	INSTALLATION OF HANGERS & ATTACHMENTS.....	122
3.5	INSTALLATION OF MECHANICAL IDENTIFICATION.....	124
3.6	INSTALLATION OF MECHANICAL INSULATION.....	125
3.7	INSTALLATION OF GREASE DUCT INSULATION	127
3.8	INSTALLATION OF HYDRONIC PIPING AND ACCESSORIES.....	128
3.9	INSTALLATION OF REFRIGERANT PIPING AND ACCESSORIES	131
3.10	INSTALLATION OF CONDENSING BOILERS	131
3.11	INSTALLATION OF HVAC PUMPS	133
3.12	INSTALLATION OF AIR INTAKE AND EXHAUST BREECHING, CHIMNEYS AND STACKS...133	
3.13	INSTALLATION OF CONDENSATE NEUTRALIZING TUBES	134
3.14	INSTALLATION OF HVAC ROOFTOP UNITS (RTU)	134
3.15	INSTALLATION OF AIR COOLED CHILLER.....	135
3.16	INSTALLATION OF TERMINAL HEATING UNITS (HYDRONIC)	135
3.17	INSTALLATION OF TERMINAL HEATING UNITS (ELECTRIC).....	137
3.18	INSTALLATION OF POWER AND GRAVITY VENTILATORS.....	138
3.19	INSTALLATION OF VEHICLE EXHAUST SYSTEM.....	139
3.20	INSTALLATION OF METAL DUCTWORK.....	139
3.21	INSTALLATION OF DUCTWORK ACCESSORIES.....	141
3.22	INSTALLATION OF ACOUSTIC DUCT LINING	141
3.23	INSTALLATION OF SOUND ATTENUATORS	141
3.24	INSTALLATION OF AIR OUTLETS AND INLETS	142
3.25	INSTALLATION OF DUCTLESS COOLING UNIT SYSTEMS	142
3.26	INSTALLATION OF CONDENSATE DISCHARGE PUMPS.....	143
3.27	INSTALLATION OF VARIABLE AIR VOLUME BOXES	143
3.28	INSTALLATION OF DUST COLLECTOR SYSTEM	144
3.29	INSTALLATION OF FIRESTOP SYSTEMS.....	144
3.30	INSTALLATION OF WALL AND CEILING ACCESS DOORS	145
3.31	AUTOMATIC TEMPERATURE CONTROLS (DDC).....	145
3.32	TESTING, ADJUSTING, AND BALANCING	147

END OF INDEX

SECTION 230000

HVAC

PART 1 GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 SECTION INCLUDES

- A. The work described herein shall be interpreted as work to be done by the HVAC Subcontractor. Work to be performed by other trades will always be specifically referenced to that trade.
- B. Furnish all staging, rigging, temporary supports, labor and materials to perform all operations in connection with the installation of the HVAC work. Refer to Section 015000 and 013100 for coordination of requirements by this trade subcontractor.
- C. Without limiting the generality thereof, the work to be performed under this section includes complete new HVAC systems with the following major sub systems:
 - 1. Low Pressure, Hot Water and Chilled Water Piping, Insulation and accessories
 - 2. Refrigeration Piping
 - 3. Exhaust Fans and Roof Intake Hoods
 - 4. Ductwork With Insulation, Diffusers, Registers And Grilles
 - 5. Terminal Heating Units including Unit Heaters, Radiant Panels, Unit Ventilators, VAV Terminal Boxes, Fan Coils and Wall Mounted Radiation
 - 6. Pumps and Accessories
 - 7. High Efficiency Condensing Boilers
 - 8. Rooftop HVAC Units
 - 9. Ductless Cooling Unit Systems
 - 10. Air Cooled Liquid Chiller
 - 11. Induction Units
 - 12. Chemical Treatment System
 - 13. Direct Digital Automatic Temperature Controls
 - 14. Testing Adjusting and Balancing
 - 15. Sound Attenuators and Acoustic Liner
 - 16. Vibration and Seismic Restraints
- D. Refer to Section 230548 "Vibration Control and Seismic Restraint" for additional work to be provided under this Section 230000.

- E. Smoke and Firestopping Seals and sealing of all wall penetrations as detailed on the drawings. Refer to Section 078400 which defines the smoke and firestopping materials and methods.
- F. Louvers specified in Section 089000 – LOUVERS AND VENTS to be furnished and installed by Division 230000.
- G. Cutting, coring and patching through all construction shall be in accordance with section 017329 – CUTTING AND PATCHING.
- H. It shall be the responsibility of this Division 230000 to provide all personnel to fully coordinate with the commissioning agent. The hours of training and instruction outlined in this Division 230000 and the testing requirements shall be in addition to those tests and requirements outlined in Section 019113 –COMMISSIONING REQUIREMENTS and Section 230800 – COMMISSIONING OF HVAC SYSTEMS.
- I. Include the following work as needed to perform the work of this section.
 - 1. Cutting, Core drilling and patching shall be in accordance with Section 017329 – CUTTING AND PATCHING.
 - 2. Temporary facilities, including but not limited to stairs and ladders, staging, scaffolding, chutes and hoisting in accordance with Section 015000 –TEMPORARY FACILITIES AND CONTROLS.
 - 3. Furnish wall and ceiling access doors and frames in accordance with Section 083100 – ACCESS DOORS AND FRAMES.
- J. For mechanical system commissioning refer to Section 019113 – COMMISSIONING REQUIREMENTS and Section 230800 – COMMISSIONING OF HVAC SYSTEMS.
- K. Change all air handling unit (RTU, UH, UV, FC, DCU) filters as required by Section 018119 - INDOOR AIR QUALITY REQUIREMENTS flush out procedures and adhere to IAQ Management Procedures.

1.3 RELATED SECTIONS

- A. The following work is included in other sections. Coordinate the work of this section as required per those sections.
- B. For temporary controls refer to Section 015000. If Owner authorizes use of the permanent HVAC system for temporary use during construction, provide temporary controls to adequately control the unit and not void the warranty. Coordinate extent of temporary controls with General Contractor. Use of the new equipment for temporary heat will not start product warranty until substantial completion is achieved. Clean unit, ductwork and change filters prior to using equipment for building occupancy by the owner. Comply with all requirements of Section 018119 - Indoor Air Quality Requirements and IAQ Management Procedures.
- C. For flashing of vents through roof and setting of roof curbs and flashing of such, refer to Section Division 07 – THERMAL AND MOISTURE PROTECTION.
- D. For power wiring of mechanical equipment refer to Section 260000.
- E. For excavation and backfill of below grade mechanical and related systems refer to Division 31 – EARTHWORK.
- F. For structural steel refer to Section 051200 – STRUCTURAL STEEL FRAMING.

- G. For firestopping not called for in this Section refer to Section 078400.
 - H. For finished painting of mechanical systems not called for in this Section, refer to Section 09 90 00 – PAINTING AND COATING.
 - I. For Food Service Equipment refer to Section 114000.
 - J. For interior concrete work relating to this Section refer to Section 033000 – CAST-IN-PLACE CONCRETE.
 - K. For exterior concrete work relating to this Section refer to Division 32 – EXTERIOR IMPROVEMENTS.
 - L. For mechanical system commissioning refer to Section 019113 – COMMISSIONING REQUIREMENTS and Section 230800 – COMMISSIONING OF HVAC SYSTEMS.
 - M. Change all air handling unit (RTU, UH, UV, FC, DCU) filters as required by Section 018119 INDOOR AIR QUALITY REQUIREMENTS flush out procedures and adhere to IAQ Management Procedures referenced in Section 018119.
 - N. Section 019113 – COMMISSIONING REQUIREMENTS and Section 230800 – COMMISSIONING OF HVAC SYSTEMS.
 - O. The following work is performed by other sections however, associated costs are borne by this HVAC sub-contractor. Coordinate the Work of this Section as required:
 - 1. Cutting and patching in masonry construction, and associated lintels.
 - 2. Patching of masonry and non-masonry construction.
- 1.4 COMMISSIONING
- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 019113 – COMMISSIONING REQUIREMENTS and Section 230800 – COMMISSIONING OF HVAC SYSTEMS.
 - B. Complete installation and startup checks and functional tests according to Section 019113 – COMMISSIONING REQUIREMENTS and Section 230800 – COMMISSIONING OF HVAC SYSTEMS and manufacturers written instructions.
 - C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the startup procedure.
 - D. Verify that equipment is installed and commissioned as per requirements of Sections 019113 and 230800, and manufacturers written instructions/requirements.
- 1.5 CODES, ORDINANCES, AND PERMITS
- A. Perform all work in accordance with the requirements of Dover Building Department, State Building Code and applicable State and Federal Laws. Give all requisite notices, file all requisite plans, and obtain all permits required to perform HVAC Work.

- B. Permits: Be responsible for filing documents, and securing of inspection and approvals. Pay all local connection and permit fees. Costs related to temporary service, refer to Section 015100 and refer to Division 01 - General Requirements.
- C. All HVAC equipment shall be installed to meet all State, Local and Federal sound ordinances.

1.6 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. HI Compliance: Design, manufacture, and install HVAC pumps in accordance with HI Hydraulic Institute Standards".
 - 2. UL Compliance: Design, manufacture, and install HVAC pumps in accordance with UL 779 "Motor Operated Water Pumps".
 - 3. ANSI Standards: Comply with ANSI A13.1 for pipe, valve, and equipment identification.
 - 4. I=B=R Compliance: Provide boilers that have been tested and rated in accordance with Institute of Boiler and Radiator Manufacturers (I=B=R) "Testing and Rating Standard for Cast Iron and Steel Heating Boiler", and bear I=B=R emblem on nameplate affixed to boiler.
 - 5. NFPA Compliance: Install boilers in accordance with NFPA Standard 54.
 - 6. ASME Compliance: Construct cast iron boilers in accordance with ASME Boiler and Pressure Vessel Code, Section IV "Heating Boilers".
 - 7. UL and NEMA Compliance: Provide boiler ancillary electrical components and safety control devices, which have been listed and labeled UL, and comply with NEMA Standards.
 - 8. FM Compliance: Provide control devices and control sequences in accordance with requirements of Factory Mutual System (FM).
 - 9. IRI Compliance: Provided control devices and control sequences in accordance with requirements of Industrial Risk Insurance (IRI).
 - 10. AMCA Compliance: Test and rate air handling units in accordance with AMCA standards.
 - 11. AGA Compliance: Provide gas controls and devices in accordance with American Gas Associates.
 - 12. ARI Compliance: Test and rate air handling units in accordance with ARI 430 "Standard for Central-Station Air Handling Units", display certification symbol on units of certified models.
 - 13. ASHRAE Compliance: Construct and install refrigerant coils in accordance with ASHRAE 15 "Safety Code for Mechanical Refrigeration".
 - 14. NFPA Compliance: Provide air handling unit internal insulation having flame spread rating not over 25 and smoke developed rating no higher than 50; and complying with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".
 - 15. UL and NEMA Compliance: Provide electrical components required as part of air handling units, which have been listed and labeled by UL and comply with NEMA standards.
 - 16. NEC Compliance: Comply with National Electrical Code (NFPA 70) as applicable to installation and electrical connections of ancillary electrical components of air handling units.
- B. MSS Standard Practices: Comply with the following standards for valves:
 - 1. MSS SP-45: Bypass and Drain Connection Standard
 - 2. MSS SP-67: Butterfly Valves
 - 3. MSS SP-70: Cast Iron Gate Valves, Flanged and Threaded Ends
 - 4. MSS SP-71: Cast Iron Swing Check Valves, Flanged
 - 5. MSS SP-72: Ball Valves with Flanged or Butt-Welding Ends for General Service

6. MSS SP-78: Cast Iron Plug Valves, Flanged and Threaded Ends
 7. MSS SP-80: Bronze Gate, Glove Angle and Check Valves
 8. MSS SP-84: Steel Valves - Socket Welding and Threaded Ends
 9. MSS SP-85: Cast Iron Globe and Angle Valves, Flanged with Threaded Ends
 10. MSS SP-92: MSS Valve User Guide
- C. Automatic Temperature Control subcontractor Qualifications: Branch Factory Owned Authorized dealers specializing in manufacturing and installation of control system for not less than 10 years.
1. Codes and Standards:
 - a. Electrical Standards: Provide electrical components of control systems which have been UL-listed and labeled, and comply with NEMA standards.
 - b. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

1.7 HAZARDOUS MATERIALS

- A. The HVAC Subcontractor shall be responsible for removing and legally disposing of any and all hazardous waste associated with HVAC systems, including but not limited to:
1. All chemical treatment used in flushing out HVAC piping systems.
 2. Un-used excess material such as adhesives used in ductwork and piping installations.
 3. Refrigerant in all AC systems to be removed.
 4. Glycol in water piping systems.
 5. Items specifically noted on drawings.

1.8 DISCREPANCIES IN DOCUMENTS

- A. Where Drawings or Specifications conflict or are unclear, advise Architect in writing before Award of Contract. Otherwise, Architect's interpretation of Contract Documents shall be final, and no additional compensation shall be permitted.
- B. Where Drawings or Specifications do not coincide with manufacturers recommendations, or with applicable codes and standards, alert Architect in writing before installation.
- C. If the required material, installation, or work can be interpreted differently from drawing to drawing, or between drawings and specs, this subcontractor shall provide that material, installation, or work which is of the more stringent.
- D. It is the intent of these contract documents to have the subcontractor provide systems and components that are fully complete and operational and fully suitable for the intended use. There may be situations in the documents where insufficient information exists to precisely describe a certain component or subsystem, or the routing of a system. In cases such as this, where the subcontractor has failed to notify the Architect of the situation in accordance with Paragraph (A) above, the subcontractor shall provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in workmanlike manner.

1.9 CONTRACT DRAWINGS

- A. All work shown on the drawings is intended to be approximately correct to scale, but shall be taken in a sense as diagrammatic. Sizes of ductwork and pipes and general method of running them are shown, but it is not intended to show every offset and fitting. To carry out the true intent and purpose of the plans, furnish all necessary parts to make complete working systems ready for use.
- B. The HVAC Drawings and Specifications are intended to supplement each other so that any details shown on the Drawings and not mentioned in the Specifications, or vice-versa, shall be executed the same as if mentioned in the Specifications and shown on the Drawings.
- C. Refer to the Architectural, Structural, Mechanical, Plumbing, Fire Protection and Electrical Drawings which indicate the construction in which this work shall be installed. Locations shown on the plans shall be checked against the general and detailed Drawings of the construction proper. All measurements must be taken at the building.

1.10 COORDINATION DRAWINGS

- A. Coordination requirements specific to the Work of this Section include the following:
 - 1. Before materials are purchased or work is begun, the respective Subcontractor shall prepare and submit to the Architect Coordination Drawings showing the size, elevation and location of his equipment, fixtures, ductwork, conduit, and piping lines relevant to the complete system. He shall ensure that these drawings are compatible and correctly annotated and cross-referenced at their interfaces.
 - 2. Coordination drawings are for the Contractor's and the Architect's use during construction and shall not be construed as replacing any shop or record drawings required elsewhere in the Contract Drawings.
 - 3. All coordination drawings shall be prepared in a large enough scale to accurately identify work of each trade and in addition to each sub-contractors systems, shall also show architectural floor plan, reflected ceiling plan, and structural framing with grid identification.
 - 4. The coordination drawings shall accurately and neatly show actual size and location of respective equipment and work. Each subcontractor shall note apparent conflicts, suggest alternate solutions and return drawings to Contractor, the drawing shall be submitted for ductwork approval by the engineer. After approval, the drawing shall be circulated to the remaining sub-contractors for application of their work.
 - 5. During coordination drawing preparation the sub-contractors shall meet periodically to discuss overall coordination of all sub systems, and shall adjust their systems accordingly. When all drawings are complete the General Contractor shall submit to the architect and engineers for review.
 - 6. Areas of conflict that cannot be resolved between the sub-contractor must be flagged on the drawings with adequate information to assist the architect and engineer in resolving noted issues.
 - 7. Associated with all costs, additional time to redraw coordination drawings for areas in conflict will be completed at no additional cost to the owner or project.
- B. Refer to Section 013100 – PROJECT MANAGEMENT AND COORDINATION of these Contract Documents for general requirements and additional procedures relative to the preparation of Coordination Drawings.

1.11 ACCESSIBILITY

- A. Install equipment and materials to provide required access for servicing and maintenance as well as code required clearances. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing.
- B. Extend all grease fittings to an accessible location.

1.12 ROUGH IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

1.13 NOTIFICATION OF RELATED TRADES

- A. Notify all other trades responsible for installing chases, inserts, sleeves, anchors, louvers when ready for such installation and for final checking immediately before concrete is placed. Cooperate with such trades to obtain proper installation.
- B. Leave openings in walls for pipes, and ducts for mechanical and electrical work as shown on drawings or required by layout of mechanical or electrical systems.

1.14 MECHANICAL INSTALLATIONS

- A. Coordinate mechanical equipment and materials installation with other building components before installing.
- B. Verify all dimensions by field measurements.
- C. Arrange for chases, slots, and openings in other building components to allow for mechanical installations.
- D. Coordinate the installation of required supporting devices and sleeves to be set in poured in place concrete and other structural components, as they are constructed.
- E. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.
- F. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials.
- G. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.
- H. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

- I. Coordinate connection of mechanical system with overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

1.15 CUTTING AND PATCHING

- A. Penetrations through construction as required for the work of this Section:
 1. Coring: Perform all coring for required work.
 2. Notify Masonry Sub-Contractor of exact locations and sizes for openings required in new or existing masonry, to be executed under Section 042000 – UNIT MASONRY, utilizing lintels furnished per Section 055000 – METAL FABRICATIONS.
 3. Cut openings in new and existing non-masonry construction where required for penetrations. All cutting shall conform to the requirements of Section 017329 – CUTTING AND PATCHING.
- B. Patching around penetrations through construction as required for the Work of this Section:
 1. Notify Masonry Sub-Contractor when work is complete at penetrations through masonry construction, and ready for patching under Section 042000 – UNIT MASONRY and Section 017329 – CUTTING AND PATCHING.
 2. Notify appropriate Sub-Contractors when work is complete at penetrations through non-masonry construction, and ready for patching under Section 017329 – CUTTING AND PATCHING.
 3. Patching of surfaces shall be performed by the trade responsible for the surface penetrated, associated costs for patching shall be borne by this HVAC Sub-contractor.
- C. Throughout the performance of the cutting and coring work, ensure that the structural integrity of the existing walls, floors, overhead structure, and other structural components, which are to remain, is maintained until permanent work is installed. Prior to any coring or cutting verify all locations of same with the General Contractor. All cutting and coring is to be performed in accordance with approved coordination drawings. All cutting or coring of structural must receive approval of the Architect prior to proceeding.
- D. No additional compensation will be authorized for cutting and patching work that is necessitated by ill-timed, defective, or non-conforming installations.
- E. Refer to related architectural sections including Section 017700 for additional reference.

1.16 SUBMITTALS

- A. General: Refer to Section 013300– SUBMITTAL PROCEDURES for general requirements for submittal of product data, shop drawings and other materials for review by the Architect and their Consultants. The following paragraphs supplement the requirements of Section 013300.
- B. Submittal of Shop Drawings, product data, and samples will be accepted only when submitted by the General Contractor. Data submitted by Sub-contractors and material suppliers directly to the Architect/Engineer will not be processed.

- C. Submittal requirements specific to the Work of this Section include the following:
1. Valves
 2. Meters and Gages
 3. Hangers and Attachments
 4. Mechanical Identification
 5. Mechanical Insulation
 6. Hydronic Piping
 7. Refrigeration Piping
 8. Boilers
 9. Pumps and Accessories
 10. Terminal Heating Units (HW & Elec)
 11. Variable Air Volume Boxes
 12. Rooftop Units
 13. Kitchen Make-Up Air Units
 14. Ductless Cooling Unit Systems
 15. Power and Gravity Ventilators
 16. Metal Ductwork
 17. Ductwork Accessories
 18. Air Outlets and Inlets
 19. Sound Attenuators and Acoustic Lining
 20. Condensate Discharge Pumps
 21. Automatic Temperature Controls (Include sample graphics and displays)
 22. Testing, Adjusting, Balancing, and Commissioning
- D. If a Shop Drawing is not accepted after two submissions, a third submission from the same manufacturer will not be considered.
- E. Check Shop Drawings and other submittals to assure compliance with contract documents before submittal to A/E.
- F. Review of Shop Drawings is final and no further changes shall be considered without written application. Shop Drawings review does not apply to quantities, nor relieve this Subcontractor of his responsibility for furnishing materials or performing his work in full compliance with these Contract Drawings and Specifications. Review of these shop drawings shall not be considered a guarantee of the measurements of this building or the conditions encountered.
- G. After the BAS system submittal is approved for construction, submit sample operator workstation graphics for typical systems for approval. Print and submit the graphics that the operator will use to view the systems, change set points, modify parameters and issue manual commands. Programming shall not commence until typical graphics are approved.

1.17 SUBSTITUTIONS

- A. Refer to Section 013301 for requirements in requesting substitutions. The following paragraphs supplement the requirements of Section 013301.

- B. If materials or equipment are substituted for basis of design specified items that alter the systems shown or its physical characteristics, or which have different operating characteristics, clearly note the alterations or difference and call it to the attention of the Architect/Engineer. Any and all substitutions are required to meet the specification and drawing requirements. Subcontractor shall be responsible for coordinating dimensional fit of equipment that varies from basis of design equipment. Under no circumstances shall substitutions be made unless material or equipment has been successfully operated for at least three consecutive years.
- C. Any modifications to the design, as a result of approving a substitution from the basis of design equipment, shall be the responsibility of this Sub-contractor. Any additional cost to this Sub-contractor or any other contractor, directly or indirectly, as a result of such substitutions, shall be the responsibility of this Sub-contractor.

1.18 PRODUCT LISTING

- A. Prepare listing of major mechanical equipment and materials for the project.
- B. Provide all necessary information.
- C. Submit to the A/E through the General Contractor, within 20 days of signing contract, this listing indicating all equipment and manufacturers, as a part of the submittal requirement. If the product list is not submitted, it will be the responsibility of the sub-contractor to submit one of the three named equal manufacturers.
- D. When two or more items of same material or equipment are required they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, pipe, tube, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units, and similar items used in work, except as otherwise indicated.
- E. Provide products, which are compatible within systems and other connected items.

1.19 NAMEPLATE DATA

- A. Provide permanent operational data nameplate on each item of power operated mechanical equipment, indicating manufacturer, product name, mode, number, serial number, capacity, operating, and power characteristics labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

1.20 DELIVERY, STORAGE AND HANDLING

- A. Refer to Section General Conditions for delivery, storage, and handling of equipment. The following paragraphs supplement the requirements of Section General Conditions.
- B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

- C. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage and seal open ended ducts and pipes to prevent dust and debris from entering them.
- D. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

1.21 RECORD DOCUMENTS

- A. General: Refer to Section 01 77 00 – CLOSEOUT PROCEDURES and Section 017839 – PROJECT RECORD DOCUMENTS for general requirements for maintaining as-built drawings and submitting final reproducible record documents. The following paragraphs supplement the above.
- B. Provide Record Drawings for the Work of this Section and include the following: Provide electronic AutoCAD drawings and hard copy to indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, balancing and control, dampers, isolation and control valves, and other control devices, filters, boxes, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; concealed equipment, dimensioned to column line; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located. Also provide ATC Drawings showing As-Built conditions indicating point to point wiring from field devices to the control panels as well as floor plans indicating actual controller locations and communication wiring routes, modified sequences, field changes and any additional HVAC items added through change orders, ASI & RFI.
- C. Refer to Section 017700 – CLOSEOUT PROCEDURES and Section 017839 – PROJECT RECORD DOCUMENTS for additional requirements.

1.22 OPERATION AND MAINTENANCE DATA

- A. General: Refer to Section 017700 – CLOSEOUT PROCEDURES general requirements for submittal of operations and maintenance manuals, training of personnel and related closeout procedures. The following paragraphs supplement the requirements of Section 017700.
- B. Closeout procedures specific to the Work of this Section include the following:
 - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
 - 2. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down, and emergency instructions; and user summer and winter operating instructions.
 - 3. Maintenance procedures for routine preventative maintenance and trouble-shooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - 4. Servicing instructions and lubrication charts and schedules.
 - 5. Provide start-up reports for all major HVAC systems and equipment, including but not limited to, boilers, all air handling equipment, ductless cooling unit systems, pumps and fans.
 - 6. Provide DVD recording of operation and maintenance training sessions and include as part of Operation and Maintenance Manual submittal. Provide indexed table of contents for DVD recording.

7. Cooperate with Commissioning agent as required to complete system and equipment start-up reports and testing. Refer to Sections 019113 and 230800.
 8. ATC Drawings/submittal of As-Built conditions.
 9. Parts list for each piece of equipment including filter sizes and quantities for all equipment.
- C. Contractor shall provide a computerized maintenance management system spreadsheet in format compatible with School Dude (excel or other similar program) for all HVAC equipment. The preventative maintenance program includes the following fields:
1. Step 1: PM Schedule Name
 2. Step 2: Classification
 3. Step 3: Type
 4. Step 5: Location
 5. Step 6: Building
 6. Step 9: Job Startup
 7. Step 10: Safety Points
 8. Step 11:
 - a. Task 1
 - b. Task 2
 - c. Task 3
 - d. Task 4
 - e. Task 5
 - f. Task 6
 - g. Task 7
 - h. Task 8
 - i. Task 9
 - j. Task 10
 9. Step 12: Tools
 10. Step 14: Journal Notes
 11. Step 15:
 - a. Assigned To
 - b. Hours
 - c. Craft
 - d. Budget
 - e. Project
 - f. Custom
 - g. Category
 12. Step 16: PM Frequency
- D. Submittals shall be confirmed by City hired staff who will input Contractor provided data into School Dude.

1.23 WARRANTIES

- A. The subcontractor shall provide a one year minimum warrantee on all product (unless otherwise stated in the product specification for a specific product) and labor for work under this section. Refer to general conditions for additional warranty requirements. Warranty period will begin once substantial completion is issued.
- B. Refer to Section 017700 – CLOSEOUT PROCEDURES for additional procedures and submittal requirements for warranties.

- C. In addition to the one year warranty period against component and/or workmanship defects, the 40 hours of training and the 40 hours of extra programming as it relates to the control system and as indicated in section 230000 paragraphs 2.32 & 3.31, the ATC contractor shall provide a seasonal site visit to confirm, verify and modify as required the sequence and/or programming of each piece of equipment to ensure the system is functioning as required and per the sequence of operations. The ATC contractor shall provide 16 labor hours per season (four times within a year, total of 64 hours). During each visit they shall, for each piece of equipment confirm operation and functionality, modify and/or repair any control related issues and/or programming and provide training as requested by the owner. This requirement will ensure the equipment/building is operating properly and efficiently as it cycles through each season. These seasonal site visits shall begin the following season after substantial completion of the project is issued. Upon substantial completion the engineer of record shall issue four dates to the ATC contractor and owner. Signatures and time logs will be kept by both parties to ensure these visits occur.

1.24 ENERGY REBATE PROGRAM

- A. This project has been designed to incorporate equipment approved for energy rebate such as boilers, high efficiency motors, rooftop units and condensing units. Subcontractor shall review Utility Company requirements prior to submitting shop drawing to ascertain that submittal meets program guidelines. All submitted equipment shall meet utility company rebate program efficiency requirements. Subcontractor shall furnish equipment submittals, related equipment/system pricing data and all required rebate application information, and forms to utility company.

1.25 HOISTING EQUIPMENT AND MACHINERY

- A. Unless otherwise specified, all hoisting and rigging equipment and machinery required for the proper and expeditious prosecution and progress of the Work of this Section shall be furnished, installed, operated and maintained in safe condition by each sub-contractor, as specified under Section 015000, TEMPORARY FACILITIES AND CONTROLS.

1.26 STAGING AND SCAFFOLDING

- A. Unless otherwise specified, each sub-contractor shall provide all lifts and man-lifts, and furnish, erect and maintain in safe condition, all staging and scaffolding as specified under Section 015000 Temporary Facilities and Controls, as needed for proper execution of the work of this Section. Staging and scaffolding shall be of adequate design, erected and removed by experienced stage builders having all accident prevention devices required by Federal, state and local laws.

1.27 WELDING QUALIFICATIONS

- A. Piping shall be welded in accordance with qualifications procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPV IX. Welding procedures qualified by others, and welders and welding operations qualified by another employer may be accepted as permitted by ASME B31.1. The Owner's Representative shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practicable. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. Structural members shall be welded in accordance with Division 01.

- B. When open-flame or spark producing tools such as welding equipment, and the like are required in the process of executing the work, the General Contractor shall be notified not less than twenty four hours in advance of the time that the work is to begin and the location where work is to be performed. Provide fire protective covering and maintain constant fire watch/fire detail (by the Arlington Fire Department) where work is being performed and until it is completed. This Subcontractor shall be responsible for obtaining required permit and paying all permit fees and Firewatch detail expenses.

1.28 TRADE RESPONSIBILITY COORDINATION MATRIX

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Smoke Detectors (Area type)	26 00 00	26 00 00	26 00 00	23 00 00 (ATC)	26 00 00	
Smoke Detectors (Duct mounted)	26 00 00	23 00 00	26 00 00	23 00 00 (ATC)	26 00 00	
Smoke & Fire/Smoke Dampers	23 00 00	23 00 00	N/A	N/A	N/A	
Smoke & Fire/Smoke Damper Actuators	23 00 00	23 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	2
Fire Dampers	23 00 00	23 00 00	N/A	N/A	N/A	
VAV Boxes	23 00 00	23 00 00	26 00 00	23 00 00 (ATC)	N/A	2
VAV Box Damper Actuator	23 00 00 (ATC)	Box Mfr	23 00 00 (ATC)	23 00 00 (ATC)	N/A	2
VAV Box DDC Controller	23 00 00 (ATC)	Box Mfr	23 00 00 (ATC)	23 00 00 (ATC)	N/A	2
Hydronic Control Valves	23 00 00 (ATC)	23 00 00	N/A	23 00 00 (ATC)	N/A	1
Hydronic Control Valve Actuator	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	1
Sheet Metal Damper	23 00 00	23 00 00	N/A	N/A	N/A	1
Sheet Metal Damper Actuators	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	N/A	1
Natural Gas Energy Meters	22 00 00	22 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3
Electrical Energy Meters	26 00 00	26 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3
Domestic Water Meters	22 00 00	22 00 00	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3
HVAC Hydronic Energy Meters	23 00 00	23 00 00 (ATC)	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	3
Airflow Measuring Stations	23 00 00 (ATC)	23 00 00 (ATC)	N/A	23 00 00 (ATC)	N/A	
DDC Panels	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00 & 23 00 00 (ATC)	23 00 00 (ATC)	N/A	4
VFDs at AHU, EFs	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	23 00 00 (ATC)	N/A	

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Elevator Hoistway Vent Damper	23 00 00	23 00 00	N/A	N/A	N/A	
Elevator Hoistway Vent Damper Actuator	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	23 00 00 (ATC)	26 00 00	
Boiler/DHW/Generator Breeching	23 00 00	23 00 00	N/A	N/A	N/A	
Kitchen Emergency Gas Valve	22 00 00	22 00 00	26 00 00	26 00 00	26 00 00	

Notes:

1. Division 23 00 00 and Division 23 00 00 (ATC) Contractors shall fully coordinate all airflow damper and hydronic valves sizes and quantities.
2. Smoke Damper and VAV Box power wiring shall be provided by Division 26 00 00 to junction box locations shown on electrical drawings; Division 23 00 00 (ATC) Contractor shall provide final power wiring from junction box to end device location.
3. Division 26 00 00 Contractor shall provide all line-voltage power wiring required for meters; Division 23 00 00 (ATC) Contractor shall provide all low-voltage power wiring required for meters.
4. Division 26 00 00 shall provide power at main DDC Panel. Division 23 00 00 (ATC) shall provide power to all other DDC Panels.

PART 2 PRODUCTS

2.1 ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT (Refer to Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 – COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)

- A. Pursuant to New Hampshire General Laws, a New Hampshire Licensed electrician shall install all low voltage wiring required by this section.
- B. General: The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.
 1. All motors for all mechanical equipment shall be NEMA premium efficiency matching the following and all motors associated with variable frequencies drives shall be inverted duty motor with Aegis bearing protection rings:

	HP	RPM	Efficiency
a.	1	1800	85.5 percent
b.	1.5	1800	86.5 percent
c.	2	1800	86.5 percent
d.	3	1800	89.5 percent
e.	5	1800	89.5 percent
f.	7.5	1800	91.0 percent
g.	10	1800	91.7 percent
h.	15	1800	93.0 percent
i.	20	1800	93.0 percent
j.	25	1800	93.6 percent
k.	30	1800	94.1 percent

- I. 40 1800 94.1 percent
 - m. 50 1800 94.5 percent
 2. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
 3. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.
 4. Temperature Rating: Rated for 40 degrees C. environment with maximum 50 degrees C temperature rise for continuous duty at full load (Class F Insulation). All ratings shall be for inverter duty applications.
 5. Starting Capability: Frequency of starts as indicated by automatic control system and not less than five evenly time spaced starts per hour for manually controlled motors.
 6. Service Factor: 1.15 for poly-phase motors and 1.35 for single phase motors.
 7. Motor Construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque.
 8. Frames: NEMA Standard No. 48 or 54; use driven equipment manufacturer's standards to suit specific application.
 9. Bearings:
 - a. Ball or roller bearings with inner and outer shaft seals.
 - b. Re-greasable, except permanently sealed where motor is normally inaccessible for regular maintenance.
 - c. Designed to resist thrust loading where belt drivers or other drives produce lateral or axial thrust in motor.
 - d. For fractional horsepower, light duty motors, sleeve type bearings are permitted.
 10. Enclosure Type:
 - a. Open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation.
 - b. Guarded drip-proof motors where exposed to contact by employees or building occupants.
 - c. Weather protected Type I for outdoor use, Type II where not housed.
 11. Overload Protection: Built-in thermal overload protection and, where indicated, internal sensing device suitable for signaling and stopping motor at starter.
 12. Noise Rating: "Quiet".
 13. Efficiency: "Premium Efficient" motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112, test method B. If efficiency not specified, motors shall have a higher efficiency than "average standard industry motors", in accordance with IEEE Standard 112, Test Method B.
 14. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.
 15. Provide AEGIS magnetic bearing protection ring for all inverter rated motors that are controlled by variable speed drives. The bearing protection ring shall channel harmful shaft voltages to ground to protect bearing races from pitting.
- C. Starters, Electrical Devices, And Wiring: (Provided By The HVAC Subcontractor For Each Packaged Piece Of HVAC Equipment Requiring Such):
 1. Motor Starter Characteristics:
 - a. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have NEC proper class and division.
 - b. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.
 2. Manual Switches shall have:
 - a. Pilot lights and extra position for multi-speed motors.
 - b. Overload Protection: Melting alloy type thermal overload relays.

3. Magnetic Starters:
 - a. Maintained contact push buttons and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
 - b. Trip-free thermal overload relays, each phase.
 - c. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division 23 Controls Sections.
 - d. Built-in 120 volts control circuit transformer, fused from line side, where service exceeds 240 volts.
 - e. Externally operated manual reset.
 - f. Under-voltage release or protection.
4. Capacitors:
 - a. Individual unit cells.
 - b. All welded steel housing.
 - c. Each capacitor internally fused.
 - d. Non-flammable synthetic liquid impregnant.
 - e. Craft tissue insulation.
 - f. Aluminum foil electrodes.
 - g. KVAR size shall be as required to correct motor power factor to 90 percent or better and shall be installed on all motors one horsepower and larger, that have an uncorrected power factor of less than 85 percent at rated load.
5. Disconnect Switches:
 - a. Fusible Switches: Fused, each phase; general duty; horsepower rated; non-teasible quick-make, quick-break mechanism; dead front line side shield; solderless lugs suitable for copper or aluminum conductors; spring reinforced fuse clips; electro silver plated current carrying parts; hinged doors; operating lever arranged for locking in the "OPEN" position; arc quenchers; capacity and characteristics as indicated.
 - b. Non-fusible Switches: For equipment two horsepower and smaller, shall be horsepower rated; toggle switch type; quantity of poles and voltage rating as indicated. For equipment larger than two horsepower, switches shall be the same as fusible type.

2.2 VALVES

- A. General:
 1. Comply with ASME B31.9 for building services piping, and ASME B31.1 for power piping.
 2. Valves shall have rising stem, or rising outside screw and yoke stems; except, non-rising stem valves may be used where headroom prevents full extension of rising stems.
 3. Pressure and temperature ratings shall be as required to suit system pressures and temperatures.
 4. Unless otherwise indicated, provide valves of same size as upstream pipe size. Automatic control valves shall be sized by the ATC Subcontractor and shall not exceed a three PSI drop.
 5. Provide the following special operator features:
 - a. Handwheels fastened to valve stem, for valves other than quarter turn, by brass nut on a square-topped stem.
 - b. Lever handle on quarter-turn valves 6 in. and smaller, except for plug valves. Provide one wrench for every 10 plug valves, and one years' supply of recommended lubricant and sealant.
 - c. Chain-wheel operators for valves 2-1/2 in. and larger installed 72 in. or higher above finished floor elevation. Extend chains to an elevation of 5 ft. - 0 in. above finished floor elevation.

6. Where insulation is indicated or specified, provide extended stems arranged to receive insulation.
7. Bypass and drain connections shall comply with MSS SP-45.
8. End connections shall be as specified in the individual valves specifications.
 - a. Threads: Comply with ANSI B2.1.
 - b. Flanges: Comply with ANSI B16.1 for cast iron ANSI B16.5 for steel, and ANSI B16.24 for bronze valves.
9. Solder-Joint: Comply with ANSI B16.18.
10. Caution: Where soldered end connection are used, use solder having a melting point below 840 degrees F. for gate, globe, and check valves; below 421 degrees F. for ball valves.

B. Gate Valves:

1. Gate Valves (Hot Water and Chilled Water) – 2 in. and smaller: MSS SP-80; Class 150, body and union bonnet of ASTM B 62 cast bronze, threaded ends, solid disc, bronze alloy stem with less than 6 percent zinc content, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel.

THREADED

MANUFACTURER	NRS	RS
Crane:	x	431UB
Jenkins:	x	47CU
Lunkenheimer:	x	3151
Nibco:	T-136	T-134
Stockham:	B-130	B-120
Milwaukee:	41M	1151M

Or equal

2. Gate Valves (Hot Water and Chilled Water) 2-1/2 in. and larger: MSS SP-70; Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B, flanged ends, and "Teflon" impregnated packing and two-piece backing gland assembly.

MANUFACTURER	OS&Y RS	NRS
Crane:	465-1/2	461
Jenkins:	651C	326C
Lunkenheimer:	1430	1428
Nibco:	F-617-0	F-619
Stockham:	G-623	G-612
Milwaukee:	F-2885-M	F-2882-M

Or equal

C. Ball Valves:

1. Ball Valves (Hot Water and Chilled Water) 1 in. and smaller: Rated for 150 psi saturated steam pressure, 600 psi WOG pressure, 2-piece construction, bronze body conforming to ASTM B 62, standard (or regular) port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide solder ends for heating hot water service, threaded ends for heating hot water.

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Milwaukee:	BA-100	BA-150
Conbraco (Apollo)	70-100	70-200
Crane:	9302	9322
Jamesbury:	21-1000TT	x
Jenkins:	900A	902A
Lunkenheimer:	AQ311	x
Nibco:	T-585	S-585
Watts:	B-6000	B-6001
Stockham:	S-216 BR-R-T	S-216 BR-R-S
Or Equal		

2. Ball Valves (Hot Water and Chilled Water) 1-1/4 in. to 2 in.: Rated for 150 psi saturated steam pressure, 600 psi WOG pressure; 3-piece construction, bronze body conforming to ASTM B 62, conventional port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide solder ends for heating hot water service, threaded ends for heating hot water.

MANUFACTURER	THREADED ENDS	SOLDER ENDS
Milwaukee:	BA-300	BA-350
Conbraco Apollo):	82-100	82-200
Nibco:	T-595-Y	S-595-Y
Watts:	B-6800	B-6801
Stockham:	S-216 BR-R-T	S-216 BR-R-T
Or equal		

For grooved end connections use Victaulic Style 721 or equal.

D. Plug Valves

1. Plug Valves – 2 in. and smaller: 150 psi WOG, bronze body, straightaway pattern, square head, threaded ends.
 MANUFACTURER
 Rockwell: 214.
 Lunkenheimer: 454.
 Crane: 250.
 Or equal
2. Plug Valves - 2-1/2 in. and larger: MSS SP-78; 175 psi, lubricated plug type, semi-steel body, single gland, wrench operated, flanged ends.
 MANUFACTURER
 Rockwell: 305.
 Nordstrom: 143.
 Serck-Audco: LSW-133-GG.
 Homestead: 612.
 Victaulic Series 377
 Or equal

E. Globe Valves:

1. Globe Valves (Hot Water and Chilled Water) – 2 in. and smaller: MSS Sp-80; Class 150, body and union bonnet of ASTM B 62 cast bronze, threaded ends, brass or replaceable composition disc, bronze alloy stem with less than 6 percent zinc content, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel.

MANUFACTURER

Jenkins: 106-B.
 Lunkenheimer: 407.
 Nibco: T-235-Y.
 Stockham: B-22.
 Or equal

2. Globe Valves (Hot Water and Chilled Water) - 2-1/2 in. and larger: MSS SP-85; Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B; outside screw and yoke, bronze mounted, flanged ends, and "Teflon" impregnated packing and two-piece backing gland assembly.

STRAIGHTANGLE

MANUFACTURER	BODY	BODY
Milwaukee:	F-2981-M	x
Crane:	351	353
Jenkins:	613C	x
Lunkenheimer:	1123	x
Nibco:	F-718-B	x
Stockham:	G-512	G-515
Or equal		

F. Butterfly Valves:

1. Butterfly Valves (Hot Water and Chilled Water) - 2-1/2 in. and larger: MSS SP-67; 200 psi, cast iron body conforming to ASTM A 126, Class B. Valves shall have field replaceable EPDM sleeve, with aluminum bronze disc, stainless steel, and EPDM O-ring stem seals. Sizes two through six in. shall have lever operators with locks, and sizes eight through 24 in. shall have gear operators with position indicator. Valves on dead end service or requiring additional body strength shall be lug-wafer type, drilled and tapped.

MANUFACTURER	WAFER	
	LEVER	GEAR
Milwaukee:	x	MW-123-E
Center Line:	x	Series A
Crane:	42	x
Keystone:	100	x
Nibco:	WD-20003	WD-20003
Stockham:	LG-512-BS3E	LG-522-BS3E
Or equal		

LUG

	LUG	
	LEVER	GEAR
Milwaukee:	x	ML-123-E
Center Line:	x	Series LT
Crane:	44	x
Keystone:	129	x
Nibco:	LD-20003	LD-20005
Stockham:	LG-712-BS3E	LG-722-BS3E
Or equal		

Grooved Ends: Victaulic Series Vic 300 2-12 in. Victaulic series 709 14-24, or equal.

G. Check Valves:

1. Swing Check Valves (Hot Water and Chilled Water) – 2 in. and smaller: MSS SP-80; Class 150, cast bronze body and cap, conforming to ASTM B 62, horizontal swing, with a Teflon disc, and having threaded ends. Valve shall be capable of being repaired while the valve remains in the line.

MANUFACTURER

Milwaukee: 510T
Crane: x
Jenkins: 352C
Lunkenheimer: 230-70
Nibco: T-433-Y
Stockham: B-321

Or equal

For grooved connections use Victaulic Series 716, 779, or equal.

2. Swing Check Valves (Hot Water and Chilled Water) - 2-1/2 in. and larger: MSS SP-71; Class 125 (Class 175 FM approved for fire protection piping systems), cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line.

MANUFACTURER	CLASS 125	CLASS 175
Milwaukee:	F-2974-M	x
Crane:	373	375
Jenkins:	624C	477
Lunkenheimer:	1790	x
Nibco:	F-918B	x
Stockham:	G-931	G-940

Victaulic Series 716, 779.

Or equal

3. Wafer Check Valves (Hot Water and Chilled Water) - (Non-Slam): Class 250, cast iron body, replaceable lapped bronze seat, lapped and balanced twin bronze flappers and stainless steel trim. Valve shall be designed to open and close at approximately one foot differential pressure. Twin flappers shall be loaded with a stainless steel torsion spring to minimize flapper drag and assure even non-slam checking action.

MANUFACTURER

Milwaukee: 1400-2C
Center Line: CLC
Metraflex: Chexx
Mission: 12HMP
Stockham: WG970

Or equal

For grooved connection use Victaulic Series 716 and 779.

4. Lift Check Valves – two in. and smaller: Class 125, cast bronze body and cap conforming to ASTM B 62, horizontal, lift type valve, bronze disc and threaded ends. Valve shall be capable of being refitted and ground while the valve remains in the line.

MANUFACTURER HORIZONTAL

Milwaukee: 544
Hammond: 901
Jenkins: 117C
Lunkenheimer: 2142
Or equal

2.3 METERS AND GAGES

A. Glass Thermometers

1. General: Provide glass thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
2. Case: Die cast aluminum finished in baked epoxy enamel, glass front, spring secured, nine in. long.
3. Adjustable Joint: Die cast aluminum, finished to match case, 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal plane, with locking device.
4. Tube and Capillary: Magnifying lens, one percent scale range accuracy, shock mounted.
5. Scale: Satin faced, non-reflective aluminum, permanently etched markings.
6. Stem: Copper-plated steel, or brass, for separable socket, length to suit installation.
7. Range: Conform to the following:
 - a. Hot Water: 30 degrees – 240 degrees F. with five degrees F. scale.
8. Manufacturer: Subject to compliance with requirements, provide glass thermometers of one of the following:
 - a. Ernst Gage Co.
 - b. Marshalltown Instruments, Inc.
 - c. Trerice (H.O.) Co.
 - d. Weis Instruments, Inc.
 - e. Or Equal.

B. Thermometer Wells

1. General: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide two in. extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.
2. Manufacturer: Subject to compliance with requirements, provide glass thermometers of one of the following:
 - a. Ernst Gage Co.
 - b. Marshalltown Instruments, Inc.
 - c. Trerice (H.O.) Co.
 - d. Weis Instruments, Inc.
 - e. Or Equal.

C. Pressure Gages

1. General: Provide pressure gages of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
2. Type: General use, one percent accuracy, ANSI B40.1 grade A, phosphor bronze bourdon type, bottom connection.
3. Case: Drawn steel or brass, glass lens, 4-1/2 in. diameter.
4. Connector: Brass with 1/4 in. male NPT. Provide protective siphon when used for steam service.
5. Scale: White coated aluminum, with permanently etched markings.

6. Range: Conform to the following:
 - a. Water: 0 - 100 psi.
50 - 300 psi.
 7. Manufacturer: Subject to compliance with requirements, provide pressure gages of one of the following:
 - a. Ametek/U.S. Gauge.
 - b. Marsh Instrument Co., Unit of General Signal.
 - c. Marshalltown Instruments, Inc.
 - d. Trelice (H.O.) Co.
 - e. Weiss Instruments, Inc.
 - f. Or Equal.
- D. Pressure Gage Cocks
1. General: Provide pressure gage cocks between pressure gages and gage tees on piping systems. Construct gage cock of brass with 1/4 in. female NPT on each end, and "T" handle brass plug.
 2. Siphon: 1/4 in. straight coil constructed of brass tubing with 1/4 in. male NPT on each end.
 3. Manufacturer: Same as for pressure gages.
- E. Annular Element Flow Meters And Fittings
1. General: Provide as indicated, flow metering elements constructed of brass and stainless steel, equipped with readout valves to facilitate connecting of differential pressure meter to flow meter. Equip each readout valve with integral shut-off valve designed to minimize system fluid loss during monitoring process. Provide ball type brass isolation valve. Provide calibrated nameplate with flow meter detailing its flow range through range of differential head pressures. Each element shall be of the bi-directional type having four diametrically opposed sensing ports on both upstream and downstream sides in order to ensure average velocity and static pressure. Elements shall be capable of operating at a maximum temperature of 300 degrees F. and maximum pressure of 250 psig.
 2. Manufacturer: Subject to compliance with requirements, provide flow meters of one of the following:
 - a. Preso Industries Corp.
 - b. Meriam Instrument.
 - c. Dieterich Standard Corp.
 - d. Or Equal.
- F. Calibrated Balance Valves
1. General: Provide as indicated, calibrated balance valves equipped with readout valves to facilitate connecting of differential pressure meter to balance valves. Equip each readout valve with integral EPT check valve designed to minimize system fluid loss during monitoring process. Provide calibrated nameplate to indicated degree of closure of precision machined orifice. Construct balancing valve with internal EPT O-ring seals to prevent leakage around rotating element. Provide balance valves with preformed polyurethane insulation suitable for use on heating and cooling systems, and to protect balance valves during shipment.
 2. Manufacturer: Subject to compliance with requirements, provide calibrated balance valves of one of the following:
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Taco, Inc.
 - c. Armstrong Pumps Inc.
 - d. Tour and Andersson
 - e. Or Equal.

2.4 HANGERS & ATTACHMENTS (Refer to SECTION 23 05 48 for Coordination)

A. Horizontal-Piping Hangers and Supports:

1. General: Except as otherwise indicated, provide factory-fabricated horizontal piping hangers and supports complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacture for each piping service. Select size of hangers and supports to exactly fit pip size for bare piping, and to insulated piping. Provide copper-plated hangers and supports for copper-piping systems.
 - a. Adjustable Steel Clevises Hangers: MSS Type 1.
 - b. Steel Pipe Clamps: MSS Type 4.
 - c. Pipe Slides and Slide Plates: MSS Type 35, including one of the following plate types:
 - 1) Plate: Unguided type.
 - 2) Plate: Guided type.
 - 3) Plate: Hold-down clamp type.
 - d. Pipe Saddle Supports: MSS Type 36, including steel pipe base-support and cast-iron floor flange.
 - e. Pipe Stanchion Saddles: MSS Tube 37, including steel pip base support and cast-iron floor flange.
 - f. Adjustable Pipe Saddle Supports: MSS Type 38, including steelpipe base support and cast-iron floor flange.
 - g. Single Pipe Rolls: MSS Type 41.
 - h. Adjustable Roller Hangers: MSS Type 43.
 - i. Pipe Roll Stands: MSS Type 44.
 - j. Pipe Rolls and Plates: MSS Type 45.
 - k. Adjustable Pipe Roll Stands: MSS Type 46.
2. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:
 - a. Carpenter and Patterson, Inc.
 - b. Corner & Lada Co., Inc.
 - c. Elcen Metal Products Co.
 - d. Fee & Mason Mfg. Co.; Div. Figgie International
 - e. Tyco Grinnell
 - f. Or Equal.

B. Vertical-Piping Clamps:

1. General: Except as otherwise indicated, provide factory-fabricated vertical-piping clamps, complying with MSS SP-58, of one of the following types listed, selected by Installer to suit vertical piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copper-plated clamps for copper-piping systems.
 - a. Two-Bolt Riser Clamps: MSS Type 8.
 - b. Four-Bolt Riser Clamps: MSS Type 42.
2. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:
 - a. Carpenter and Patterson, Inc.
 - b. Corner & Lada Co., Inc.
 - c. Elcen Metal Products Co.
 - d. Fee & Mason Mfg. Co.; Div. Figgie International
 - e. Tyco Grinnell
 - f. Or Equal.

- C. Hanger-Rod Attachments:
1. General: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-pipe hangers and building attachments, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hanger-rod attachments to suit hanger rods. Provide copper-plated hanger-rod attachments for copper-piping systems.
 - a. Steel Turnbuckles: MSS Type 13.
 - b. Swivel Turnbuckles: MSS Type 15.
 - c. Malleable Iron Sockets: MSS Type 16.
 2. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:
 - a. Carpenter and Patterson, Inc.
 - b. Corner & Lada Co., Inc.
 - c. Elcen Metal Products Co.
 - d. Fee & Mason Mfg. Co.; Div. Figgie International
 - e. Tyco Grinnell
 - f. Or Equal.
- D. Building Attachments:
1. General: Except as otherwise indicate, provide factory-fabricated building attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit building substrate conditions, in accordance with MSS SP-69 and manufacturer's published product information. Select size of building attachments to suit hanger rods. Provide copper-plated building attachments for copper-piping systems.
 - a. Concrete Inserts: MSS Type 18.
 - b. Top Beam C-Clamp: MSS Type 19.
 - c. Side Beam or Channel Clamps: MSS Type 20.
 - d. Center Beam Clamps: MSS Type 21.
 - e. Welded Beam Attachments: MSS Type 22.
 - f. C-Clamps: MSS Type 23.
 - g. Top Beam Clamps: MSS Type 25.
 - h. Side Beam Clamps: MSS Type 27.
 - i. Steel Beam Clamps W/Eye Nut: MSS Type 28.
 - j. Linked Steel Clamps W/Eye Nut: MSS Type 29.
 - k. Malleable Beam Clamps: MSS Type 30.
 - l. Steel Brackets: One of the following for indicated loading:
 - 1) Light Duty: MSS Type 31.
 - 2) Medium Duty: MSS Type 32.
 - 3) Heavy Duty: MSS Type 33.
 - m. Side Beam Brackets: MSS Type 34.
 - n. Plate Lugs: MSS Type 57.
 - o. Horizontal Travelers: MSS Type 58.
 2. Manufacturer: Subject to compliance with requirements, provide hangers and supports of one of the following:
 - a. Carpenter and Patterson, Inc.
 - b. Corner & Lada Co., Inc.
 - c. Elcen Metal Products Co.
 - d. Fee & Mason Mfg. Co.; Div. Figgie International
 - e. Tyco Grinnell
 - f. Or Equal.

- E. Saddles and Shields:
1. General: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.
 2. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
 3. Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation.
 4. Manufacturer: Subject to compliance with requirements, provide thermal hanger shields of one of the following:
 - a. Elcen Metal Products Co.
 - b. Pipe Shields, Inc.
 - c. Carpenter Patterson, Inc.
 - d. Tyco Grinnell
 - e. Or Equal.
- F. Miscellaneous Materials:
1. Metal Framing: Provide products complying with NEMA STD ML 1.
 2. Steel Plates, Shapes, and Bars: Provide products complying with ASTM A 36.
 3. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.
 4. Heavy Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.
 5. Pipe Guides: Provide factory-fabricated guides, of cast semi-steel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

2.5 MECHANICAL IDENTIFICATION (Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 - COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)

- A. Plastic Pipe Markers:
1. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1
 2. Pressure-Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, complying with ANSI A13.1
 3. Insulation: Furnish 1 in. thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125 degrees F (52 degrees C) or greater. Cut length to extend 2 in. beyond each end of plastic pipe marker.
 4. Small Pipes: For external diameters less than 6 in. (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:
 - a. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
 - b. Adhesive lap joint in pipe marker overlap.
 - c. Laminated or bonded application of pipe marker to pipe (or insulation).
 - d. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4 in. wide; full circle at both ends of pipe marker, tape lapped 1-1/2 in.

- B. Application: Provide pipe labels for the following piping system:
1. Heating hot supply and return.
 2. Refrigerant liquid, suction and hot gas bypass.
 3. Condensate drain.
- C. Valve Tags:
1. Brass Valve Tags: Provide 19-gage polished brass valve tags with stamp-engraved piping system abbreviation in 1/4 in. high letters and sequenced valve numbers 1/2 in. high, and with 5/32 in. hole for fastener.
 - a. Provide 1-1/2 in. diameter tags, except as otherwise indicated.
 - b. Provide size and shape as specified or scheduled for each piping system.
 - c. Fill tag engraving with black enamel.
 2. Valve Tag Fasteners: Provide manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.
- D. Valve Schedule Frames:
1. General: For each page of valve schedule, provide glazed display frame, with screws for removable mounting on masonry walls. Provide frames of finished hardwood or extruded aluminum, with SSB-grade sheet glass.
- E. Plastic Equipment Markers:
1. General: Provide manufacturer's standard laminated plastic, color-coded equipment markers. Conform to the following color code:
 - a. Green: Cooling equipment and components.
 - b. Yellow: Heating equipment and components.
 - c. Yellow/Green: Combination cooling and heating equipment and components.
 - d. Blue: Equipment and components that do not meet any of the above criteria.
 2. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
 - a. Equipment label "ID" from schedules.
 - b. Design capacity from schedules.
 3. Size: Provide approximate 2-1/2 in. x 6 in. markers for each piece of equipment.
 4. Application: Provide equipment labels for the following equipment:
 - a. Boilers
 - b. Pumps
 - c. Expansion Tanks
 - d. Rooftop Units
 - e. Exhaust Fans
 - f. Roof Intakes
 - g. Air Cooled Condensing Units
 - h. Terminal Heating Units equipped with fans
 - i. Ductless Cooling Unit Systems (locate label on the inside)
- F. Ductwork Labels:
1. Provide painted stencils or standard laminated plastic, color coded labels for the following systems:
 - a. Supply Ductwork
 - b. Return Ductwork
 - c. Exhaust Ductwork
 - d. Hazardous Exhaust
 - e. Outside Air Ductwork
 - f. Grease Ductwork

2.6 MECHANICAL INSULATION

A. Piping Insulation Materials:

1. Fiberglass Piping Insulation: ASTM C 547, Class 45 required.
 - a. Class 1 for use to 450 degrees F; Class 2 for use to 650 degrees F; Class 3 for use to 1200 degrees F.
2. Flexible Unicellular Piping Insulation: ASTM C 534, Type as required.
 - a. Type I - tubular; Type II - sheet. For use between -40 degrees F and 200 degrees F.
3. Jackets for piping Insulation: ASTM C 921, ATM C1136, ASTM E96/E96M, with vapor barrier for piping with temperatures below ambient.
4. Encase pipe fittings insulation with one-piece pre-molded PVC fitting covers, fastened as per manufacturer's recommendations.
5. Encase straight pipe insulation, where exposed in occupied areas, with one piece 20-mil thick PVC Jacketing. Fasten and seal as per manufacturer's recommendations.
6. Encase exterior piping insulation with aluminum jacket with weather-proof construction.
7. Staples, Bands, Wires and Cement: As recommended by insulation manufacturer for applications indicated.
8. Adhesives, Sealants and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

B. Piping Insulation Application and Thickness:

1. Application: Cold Piping (40 Degrees F to Ambient):
 - a. Insulate the following cold HVAC piping systems:
 - 1) HVAC make-up water piping.
 - 2) Air conditioner condensate drain piping.
 - 3) Refrigerant liquid and suction piping.
 - 4) Chilled water supply and Return Piping
 - b. Insulate HVAC chilled water, make-up condensate drain and refrigerant piping system specified above with the following type and thickness of insulation:
 - 1) Fiberglass: 1-1/2 in. thick for all pipe sizes.
2. Application: Hot HVAC Piping (to 200 Degrees F)
 - a. Insulate the following hot HVAC piping systems
 - 1) HVAC hot water supply and return piping.
 - 2) Hot gas refrigerant piping.
 - b. Insulate each piping system specified above with the following type and thickness of insulation:
 - 1) Fiberglass: 1-1/2 in. thick for pipe sizes up to and including 1-1/4 in, 2 in. thick for all 1 1/2 in. pipe and larger.
 - 2) Flexible Unicellular: (Refrigerant piping only) 1 in. thick.
3. Insulation of Piping Exposed to Weather: Protect outdoor insulation from weather by installing outdoor protective finish aluminum jacketing installed as recommended by the manufacturer. Insulation thickness shall be increased by one size versus specified pipe insulation thickness.

C. Ductwork Insulation Materials:

1. Rigid Fiberglass Ductwork Insulation (R-8): ASTM C 612, Class as required.
CLASS 2 - 400 DEGREES F; 4 LBS./FT3.
CLASS 3 - 850 DEGREES F; 12 LBS./FT3.
CLASS 4 - 1000 DEGREES F; 12 LBS./FT3.
CLASS 5 - 1800 DEGREES F; 20 LBS./FT3.
2. Flexible Fiberglass Ductwork Insulation (R-6): ASTM C 512, Class as required.
CLASS 2 - 400 DEGREES F; .75 LBS./FT3.
CLASS 3 - 850 DEGREES F; 1.5 LBS./FT3.

3. Jackets for Ductwork Insulation: ASTM C 921, ASTM C1136, ASTM E96/E96M, with vapor barrier.
 4. Ductwork Insulation Accessories: Provide staples, bands, wire, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.
 5. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes and similar compounds as recommended by insulation manufacturer for applications indicated.
- D. Ductwork Insulation Application and Thickness:
1. Application: Ventilation and AC System Ductwork:
 - a. Insulate the following ductwork:
 - 1) Outdoor air intake ductwork between air entrance and air handling unit inlet.
 - 2) HVAC supply ductwork between HVAC unit discharge and room terminal outlet.
 - 3) Insulate neck and bells of supply diffusers.
 - 4) HVAC return ductwork between room terminal inlet and HVAC unit inlet.
 - 5) HVAC plenums and unit housing not pre-insulated at factory or lined.
 - 6) Exhaust ductwork between in-line exhaust fan and point of exit in building.
 - 7) Combustion air ductwork associated with boilers.
 - b. Insulate each ductwork system specified above with the following type and thickness of insulation:
 - 1) Rigid Fiberglass: In machine rooms, fan rooms, and mechanical spaces insulate all supply air, return air, exhaust air, and outside air ductwork with minimum 2 in. thick rigid (minimum R-8). All exposed ductwork in occupied areas shall be insulated internally with same thickness and material. Duct sizes located on plans are clear inside dimensions.
 - 2) Flexible Fiberglass: Minimum 1-1/2 in. installed thickness (minimum R-6).
 - 3) All outside air ductwork shall be 2 in. rigid (R-8).
 2. Equipment Insulation Materials:
 3. Rigid Fiberglass Equipment Insulation (R-8): ASTM C 612, Class as required.
CLASS 2 - 400 DEGREES F; 12 LBS./FT³.
CLASS 3 - 850 DEGREES F; 12 LBS./FT³.
CLASS 4 - 1000 DEGREES F; 12 LBS./FT³.
CLASS 5 - 1800 DEGREES F; 20 LBS./FT³.
 4. Flexible fiberglass Equipment Insulation (R-5): ASTM C 553, Type and Class.
TYPE I - RESILIENT, FLEXIBLE;
CLASS B-1 - 0.65 LBS./FT³
CLASS B-2 - 0.75 LBS./FT³
CLASS B-3 - 1.00 LBS./FT³
CLASS B-4 - 1.50 LBS./FT³
CLASS B-5 - 2.00 LBS./FT³
CLASS B-6 - 3.00 LBS./FT³

TYPE II - FLEXIBLE; CLASS F-1 - 4.50 LBS./FT³
TYPE III - SEMIRIGID; CLASS F-2 - 4.50 LBS./FT³
 5. Flexible Unicellular Equipment Insulation: ASTM C 534, Type as required.
TYPE I - TUBULAR.
TYPE II - SHEET.
 6. Jacketing material for Equipment Insulation: Provide pre-sized glass cloth jacketing material, not less than 7.8 ounces per square yard, or metal jacket at Installer's option, except as otherwise indicated.

7. Equipment Insulation Compounds; Provide adhesives, cements, sealers, mastics and protective finishes as recommended by insulation manufacturer for applications indicated.
 8. Equipment Insulation Accessories: Provide staples, bands, wire, wire netting, tape, corner angles, anchors and stud pins as recommended by insulation manufacturer for applications indicated.
- E. Equipment Insulation Application and Thickness:
1. Application: Hot and Chilled Water Equipment
 - a. Insulate the following:
 - 1) Expansion and Buffer Tanks
 - 2) Air Separators
 - b. Insulate each item of equipment specified above with the following type and thickness of insulation:
 - 1) Fiberglass 2 in. thick.

2.7 GREASE DUCT INSULATION

A. MATERIAL

1. Thermal Material: 2192 degrees F rated core blanket, manufactured from patented bio-soluble Superwool chemistry (Calcium Magnesium Silicate).
 - a. Product: FireMaster FastWrap XL or Pyroscat Duct Wrap XL as manufactured by Thermal Ceramics.
 - b. Fully encapsulated thermal material in fiberglass reinforced aluminum/polypropylene scrim (FSP).
 - 1) Encapsulation FSP marked with UL Classification Mark.
 - 2) Encapsulation FSP marked with ICC-ES report number ESR 2213 or ESR 2832.
 - 3) Collars supplied in 6 in. (150 mm) wide by 25 ft.t (7620 mm) long rolls.
2. Product Characteristics:
 - a. Thickness: 1-1/2 in. (38 mm).
 - b. Nominal Density: 6 pcf.
 - c. R-Value: 7.35 per layer of FireMaster FastWrap XL or Pyroscat Duct Wrap XL when tested in accordance with ASTM C 518 at 75 F.
 - d. Flame Spread: <25 when tested in accordance with ASTM E 84.
 - e. Smoke Development: <50 when tested in accordance with ASTM E 84.

B. ACCESSORY MATERIALS:

1. Glass Filament Tape: Minimum 3/4 in. (19 mm) wide - used to temporarily secure blanket until permanent attachment using steel banding and/or steel insulation pins.
2. Aluminum Foil Tape: Minimum 3 in. (76 mm) used to seal cut edges.
3. Carbon Steel or Stainless Strapping Material Minimum: 1/2 in. (13 mm) wide and 0.015 in. (.38 mm) thick
4. Steel Insulation Pins: Minimum 12-gauge, length sufficient to penetrate through duct wrap insulation.
5. Insulation Clips: Galvanized steel, minimum 1-1/2 in. (38 mm) round or square.
6. Through Penetration Firestop Sealants:
 - a. Packing Material: Remove encapsulation material from FireMaster FastWrap XL or Pyroscat Duct Wrap XL, use core blanket (white) as penetration packing material.
 - b. Firestop sealants per applicable building code report and/or laboratory design listings.

7. Grease and HVAC Duct Access Doors:
 - a. Thermal Ceramics FastDoor XL Access doors; Supplied in standard door sizes of 6 by10 in. (152 mm by 254 mm), 8 by12 in. (203 mm by 305 mm), 12 by12 in. (305 mm by 305 mm) 12 by16 in. (305 mm by 406 mm), and 20 by20 in. (508 mm by 508 mm).

2.8 HYDRONIC PIPING AND ACCESSORIES

- A. Manufacturer: Subject to compliance with requirements, provide piping system products from one of the following:
 1. Grooved Mechanical Joint Pipe, Fittings and Couplings:
 - a. Victaulic Company of America.
 - b. Anvil Gruvlok
 - c. Grinnell
 - d. Or equal
 2. Pump Discharge Valves (Triple-Duty Valve):
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Amtrol, Inc.
 - c. Armstrong Pumps, Inc.
 - d. Taco, Inc.
 - e. Victaulic (Tri-Service Assembly)
 - f. Or equal
 3. Safety Relief Valves:
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Amtrol, Inc.
 - c. Spirax Sarco.
 - d. Watts Regulator Co.
 - e. Or equal
 4. Pressure Reducing Valves:
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Amtrol, Inc.
 - c. Armstrong Pumps, Inc.
 - d. Taco, Inc.
 - e. Or equal
 5. Air Vents (Automatic):
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Armstrong Machine Works.
 - c. Hoffman Specialty ITT; Fluid Handling Div.
 - d. Spirax Sarco.
 - e. Or equal
 6. Air Separators:
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Amtrol, Inc.
 - c. Armstrong Pumps, Inc.
 - d. Taco, Inc.
 - e. Or equal
 7. Diaphragm-Type Compression Tanks:
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Amtrol, Inc.
 - c. Armstrong Pumps, Inc.
 - d. Or equal

8. Pump Suction Diffusers:
 - a. Bell & Gossett ITT; Fluid Handling Div.
 - b. Amtrol, Inc.
 - c. Armstrong Pumps, Inc.
 - d. Taco, Inc.
 - e. Victaulic (style 731-D / W731-D)
 - f. Or equal
 9. Chemical Feeder:
 - a. Dearborn USA.
 - b. Vulcan Laboratories, Subsidiary of Clow Corp.
 - c. York-Shipley, Inc.
 - d. Or equal
 10. Basket Strainers:
 - a. Crane Co.
 - b. Metraflex Co.
 - c. Spirax Sarco.
 - d. Victaulic Company of America. (732/W732/730/W730)
 - e. Or equal
- B. PIPE AND TUBING MATERIALS
1. Copper Tubing: ASTM grade B 88, Type L hard drawn temper copper tubing.
 2. Copper Tubing: ASMT grade B 88, Type K, annealed copper tubing.
 3. Steel Pipe: ASTM A-53 grade B, Schedule 40, seamless, black steel pipe, beveled ends.
 4. CPVC Plastic Pipe: ASTM D 2846, Chlorinated Poly (Vinyl Chloride) (CPVC) pipe.
- C. FITTINGS
1. Cast-Iron Threaded Fittings: ANSI B16.4, Class 125, standard pattern, for threaded joints. Threads shall conform to ANSI B2.1.
 2. Malleable-Iron Threaded Fittings: ANSI B16.3, Class 150, standard pattern, for threaded joints. Threads shall conform to ANSI B2.1.
 3. Steel Fittings: ASTM A 234, seamless or welded, for welded joints.
 4. Grooved Mechanical Fittings: ASTM A 106, or ASTM A 53/A53M, Type F, E or S, Grade B fabricated steel, or ASTM A 234, Grade WPB forged steel fittings with grooves or shoulders designed to accept grooved end couplings.
 5. Grooved Rigid Mechanical Couplings: Consist of a two- piece ductile iron housing per ASTM A536, a synthetic rubber gasket of a central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 - a. Rigid Couplings:
 - 1) Housings 12" and smaller cast with offsetting angled-pattern bolt pads to provide visual confirmation upon metal-to-metal pad contact with no torque requirement. Victaulic Style 107H and Style 07 or equal. Designs that permit spaces at bolt pads or require a torque per manufacturer's written installation instructions not permitted
 - 2) Housings 14" and larger cast with wedge-shaped groove profile, lead-in chamfer and flat pad design for metal-to-metal pad contact. Victaulic Style W07 or equal.

- b. Flexible Couplings:
 - 1) Use in locations where vibration attenuation and stress relief are required. Victaulic Style 177, 77 or W77 or equal. Three flexible couplings may be used in lieu of each flexible connector for vibration attenuation. Couplings shall be placed in close proximity to the vibrating source in accordance with published guidelines.
 - c. Flange Adapters: Ductile iron housing, flat face, for use with grooved end pipe and fittings, for mating directly with ANSI Class 125, 150, and 300 flanges. Victaulic Style 741, 743 or W741 or equal.
 - 6. Wrought-Copper Fittings: ANSI B16.22, streamlined pattern.
 - 7. CPVC Plastic Fittings: ASTM D 2846, Chlorinated Poly Vinyl Chloride (CPVC) socket-type fittings and solvent for solvent cemented joints.
 - 8. Cast-Iron Threaded Flanges: ANSI B16.1, Class 125; raised ground face, bolt holes spot faced.
 - 9. Cast Bronze Flanges: ANSI B16.24, Class 150; raised ground face, bolt holes spot faced.
 - 10. Steel Flanges and Flanged Fittings: ANSI B16.5, including bolts, nuts, and gaskets of the following material group, end connection and facing:
 - a. Material Group: 1.1.
 - b. End Connections: Butt Welding.
 - c. Facings: Raised face.
 - 11. Solder Filler Metals: ASTM B 32, 50-50, Tin-Lead, for condenser water, and make-up water and drain piping.
 - 12. Solder Filler Metals: ASTM B 32, 95-5 Tin-Antimony, for heating hot water and low pressure steam piping.
 - 13. Brazing Filler Metals: AWS A5.8.
 - 14. Gasket Material: EPDM Thickness, material, and type suitable for fluid to be handled, and design temperatures and pressures.
 - 15. Flexible Connectors: Stainless steel bellows with woven flexible bronze wire reinforcing protective jacket; minimum 150 psig working pressure, maximum 250° F. operating temperature. Connectors shall have flanged, grooved or threaded end connections to match equipment connected; and shall be capable of 3/4" misalignment.
 - a. Three (3) flexible couplings may be used in lieu of each flexible connector for vibration attenuation. Couplings shall be placed in close proximity to the vibrating source in accordance with published guidelines.
- D. PIPE SLEEVES AND ESCUTCHEONS
- 1. General: Provide schedule 40 black steel or 18 gage galvanized pipe sleeve large enough to accept pipe along with specified pipe insulation at each point where pipe penetrates a wall or floor. Sleeve shall be large enough to allow for free movement of pipe however minimized to prevent leakage of smoke and fire during a fire emergency. For all piping exposed to view provide a chrome plated escutcheon that will surround insulation where applicable on pipe for a neat finished appearance. Where piping is concealed above ceilings no escutcheons are required.

E. SPECIAL DUTY VALVES

1. General: General duty valves (i.e., gate, check, ball, and butterfly valves) are specified in Division 23 Section "Valves" Special duty valves are specified in this Article by their generic name; refer to the drawings for specific applications of these valves.
2. Pump Discharge Valves (Triple-Duty Valve): 175 PSIG working pressure, 300° F. maximum operating temperature, cast-iron body, bronze disc and seat, stainless steel stem and spring, and "Teflon" packing. Valves shall have flanged connections and straight or angle pattern as indicated. Features shall include non-slam check valve with spring-loaded weighted disc, and calibrated adjustment feature to permit regulation of pump discharge flow and shutoff.
 - a. In grooved installations, Tri-Service Assemblies may be used in lieu of Triple-Duty Valves. Straight pattern, (300-psi) pressure rating, combination shut-off, throttling, and non-slam check service in one unit. Victaulic Vic®-300 MasterSeal™ or equal, butterfly valve assembled with Series 779 Venturi Check valve or equal, with flow measurement capabilities and Victaulic or equal couplings (style to be determined by system requirements) for 2" through 12". Straight pattern, 230-psig pressure rating combination shut-off, throttling, and non-slam check service in one unit. Victaulic AGS-300 or equal butterfly valve assembled with Series W715 or equal check valve and Victaulic or equal couplings for 14" and larger.
3. Pressure Reducing Valves: Diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and non-corrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment.
4. Safety Relief Valves: 125 psig working pressure and 250° F. maximum operating temperature: designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast-iron, with all wetted internal working parts made of brass and rubber. Select valve to suit actual system pressure and BTU capacity.
5. Combined Pressure/Temperature Relief Valves: Diaphragm operated, cast-iron or brass body valve, with low inlet pressure check valve, inlet strainer removable without system shut-down, and non-corrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory-set at operating pressure and have the capability for field adjustment. Safety relief valve designed, manufactured, tested, and labeled in accordance with the requirements of Section IV of the ASME Boiler and Pressure Vessel Code. Valve body shall be cast-iron, with all wetted internal working parts made of brass and rubber; 125 psig working pressure and 250° F. maximum operating temperature. Select valve to suit actual system pressure and BTU capacity. Provide with fast fill feature for filling hydronic system.

F. HYDRONIC SPECIALTIES:

1. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150 psig working pressure, 240° F. operating temperature; and having 1/4" discharge connection and 1/2" inlet connection.
2. Diaphragm-Type Compression Tanks: Size and number as indicated; construct of welded carbon steel for 125 psig working pressure, 375° F. maximum operating temperature. Separate air charge from flexible diaphragm securely sealed into tank. Provide taps for pressure gage and air charging fitting, and drain fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Tank, with taps and supports, shall be constructed, tested, and labeled in accordance with ASME Pressure Vessel Code, Section VIII, Division 01.

3. Pump Suction Diffusers: Cast-iron or ductile iron body, with threaded connections for 2" and smaller, flanged or grooved connections for 2-1/2" and larger; 175 psig working pressure, 300° F. maximum operating temperature for flanged and 300 psig working pressure, 230F for grooved; and complete with the following features:
 - a. Inlet vanes with length 2-1/2 times pump suction diameter or greater.
 - b. Cylinder strainer with 3/16" diameter openings with total free area equal to or greater than 5 times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head.
 - c. Disposable fine mesh strainer to fit over cylinder strainer.
 - d. Permanent magnet, located in flow stream, removable for cleaning.
 - e. Adjustable foot support, designed to carry weight of suction piping.
 - f. Blowdown tapping in bottom; gage tapping in side.
4. Chemical Feeder: (Provide one (1) for each piping system). Bypass type chemical feeders of 5 gallon capacity, welded steel construction; 125 psig working pressure; complete with fill funnel and inlet, outlet, and drain valves.
5. Chemical Treatment
 - a. Furnish the necessary apparatus to provide water treatment to the hot water and chilled water piping systems as well as the boilers and chillers as furnished by New England Systems and Supply, Inc., GE Betz Water Technologies, or other fully capable water treatment organization approved by the Engineer.
 - b. A contract agreement satisfactory in form and substance shall be executed between this subcontractor and water treatment company to furnish supervisory service to assure the use of the proper chemical treatment thereof. The water treatment company shall perform the following specified services through its agent:
 - 1) Supervise the cleaning and flushing of all systems and the initial introduction of water treatment chemicals.
 - 2) Furnish all required chemicals for the cleaning and proper initial treatment of all systems hereinafter described, together with all necessary testing equipment and reagents for field analysis of the water.
 - 3) Submit a written report of test results of the field analyses to the Engineer when the systems are cleaned and treated with corrosion inhibitors. Submit certificate of completion for all systems indicating that all treatment systems are properly functioning and that the associated systems are properly treated.
 - c. The hot water and chilled water piping systems shall be cleaned with sufficient chemicals to ensure the removal of all cutting oil, compound, etc. These chemicals shall not be harmful to the various materials of the systems. The treatment company representative shall supervise this operation including the flushing of the system and shall test the final rinsed system to ensure that the remnants of the cleaning solution do not impart alkalinity to the water in excess of 300 PPM.
 - d. Hot water and chilled water systems shall be treated with sufficient amounts of the proper chemicals to conform to the Dianodic method for corrosion protection. Take various samples of water to assure proper level of chemical treatment.
 - e. Each boiler and chiller shall be treated with sufficient amounts of the proper chemicals to provide positive protection against corrosion, scale formation and carry over.
 - f. At the end of the first year of the contract agreement, the chemical treatment company shall provide to the owner and copy to Architect, a log of type, quantity and dosage of treatment and test results of treatment performed through the first year.

- g. Following the first year of service, chemical treatment company shall provide recommended maintenance and treatment schedule to owner and a copy to architect for testing and treating the water. This schedule shall be posted in the boiler room along with the testing and treatment log.
 - h. Upon completion of first year of service, the chemical treatment company shall instruct the owner to the owner's responsibility to test and treat water or to contract with chemical treatment company to perform testing and treatment services.
6. Y-Pattern Strainers: Cast-iron body (ASTM A 126, Class B), flanged ends for 2-1/2" and larger, threaded connections for 2" and smaller, bolted cover, perforated Type 304 stainless steel basket, bottom drain connections; 125 psig working pressure.
7. Basket Strainers: High tensile cast-iron body (ASTM A 126, Class B), flanged end connections, bolted cover, perforated Type 304 stainless steel basket, bottom drain connections; 125 psig working pressure.
8. Grooved-End Strainers:
 - a. Y-Pattern: Ductile iron body ASTM A536, grooved ends for 2" and larger, coupled cover, perforated Type 304 stainless steel basket, bottom drain, 300 psig working pressure.
 - b. T-Pattern: Ductile iron body ASTM A536, grooved ends for 2" and larger, coupled or T-bolt hinged cover, perforated 304 stainless steel basket, bottom drain, up to 750 psig working pressure.
9. Grooved-End Expansion for Steel Piping 2" and larger (Water Service):
 - a. 2" Through 6": Packless, gasketed, slip-type expansion joint with grooved end telescoping body for installation with Victaulic Style 107 or 07 rigid couplings. Provides axial end movement to 3", designed for water services up to 230°F and working pressure to 350 psi. Victaulic Style 150 Mover®.
 - b. 2" Through 24": Combination of short nipples and Victaulic Style 177 or 77 flexible couplings joined in tandem for increased expansion. Joint movement and expansion capabilities dependent on number of couplings/nipples used in the joint. Pressure rating dependent on size and style of flexible couplings used. Victaulic Style 155.
 - c. Expansion Loops: Pipe bends and loops in grooved piping systems shall consist of (8) Victaulic Style 177, 77 or W77 flexible couplings, (4) Victaulic 90° elbows, and (3) grooved end pipe spools provided in water systems to +250°F in accordance with the latest Victaulic recommendations for expansion compensation. Rigid couplings shall not be used on loop corners.
 - d. Expansion Joints: Provide pipe expansion joints at all building expansion joints. Utilize a seismic expansion fitting similar to Metra-Flex, Metra Loop Grooved ends or equal. The expansion fitting shall provide absorption in the lateral offset and angular movement.
10. Glycol/Make-up Pump: Provide a glycol fill pump with a capacity of 1.5 GPM @ 100 psi discharge. Pump shall be bronze gear driven design and shall have a standard 120Volt power electrical cord.

11. AIR and DIRT SEPARATORS - Air and dirt removal device shall be constructed of steel. It shall be designed, fabricated and stamped per ASME Section VIII Division 1 with a maximum working pressure of 125 psi at 270°F. Manufacturer shall be holder of ASME U stamp. Manufacturer to have optional 250 psi and 150 psi ASME units available. Units up to three 3-inch in size shall be provided with threaded connections as standard. Units four 4-inch and larger shall be provided with flanged system connections as standard. Inlet and outlet connections to be inline with piping system. Both inlet and outlet to be in the same horizontal and vertical planes. Each air and dirt removal device shall be equipped with a brass conical shaped air venting chamber designed to minimize system fluid from fouling the venting assembly. The air vent shall be able to be closed to allow flushing and purging of dirt via side port without dirt passing through vent on initial system fill. A brass flushing cock shall be located on the side of each separator to facilitate system fast-fill and removal of the floating impurities from the air system interface within the separator. A blow down valve shall be provided by the unit manufacturer on the bottom of each unit to allow blow down and cleaning. On units 2 ½" and smaller the valve and all of its fittings shall be 1". On units three 3" and larger the valve and all openings shall be 2".
12. Flexible Expansion Loop (seismic applications):
 - a. All equipment, either rigidly mounted or mounted on vibration isolators, shall be attached to the piping system using flexible loops designed for seismic movement. Flexible loops shall be capable of movement in the X, Y, and Z planes and must completely isolate the equipment from the piping.
 - b. All piping passing through building seismic joints shall contain a flexible expansion loop designed for seismic movement. Flexible loops shall be located at, or near the building seismic joint. A vertical support hanger, located within 4 pipe diameters, shall be installed on each side of the flexible loop. Each hanger to be transversely and longitudinally braced per local codes. Seismic bracing shall not pass through building seismic joint and shall not connect or tie together different sides or parts of building structure. Flexible loops shall be capable of move in the X, Y, and Z planes.
 - c. Flexible loops attached to fuel gas lines, shall be specifically manufactured for fuel gas applications and certified by the American Gas Association. Flexible loops connected to medical gas piping shall be specifically manufactured for medical gas and installed by a certified installer. Unless specified otherwise by system design engineer or governing codes, all flexible loop connections to medical gas piping shall be cleaned, installed, inspected, and tested in accordance with current NFPA-99 standards.
 - d. Flexible expansion/seismic loops shall consist of two flexible sections of hose and braid, two 90 elbows, and a 180 return assembled in such a way that the piping does not change direction, but maintains its course along a single axis. Flexible loops shall have a factory supplied, center support nut located at the bottom of the 180 return, and a drain/air release plug. Flexible loops shall impart no thrust loads to system support anchors or building structure. Flexible loops may be installed to accommodate both thermal and seismic motion. For steam service, loops must be installed with flexible legs horizontal to prevent condensate buildup. Materials of construction and end fitting type shall be consistent with pipe material and equipment/ pipe connection fittings. Movement capabilities and location, relative to seismic separation, shall be determined manufacturers recommendations.
 - e. Flexible expansion/seismic loops to be Metraloop(r) or approved equal

2.9 REFRIGERANT PIPING

- A. General: Provide piping materials and factory-fabricated piping products of sizes, types, pressure ratings, temperature ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. Provide materials and products complying with ANSI B31.5 Code for refrigeration piping where applicable, base pressure rating on refrigerant piping system maximum design pressures. Provide sizes and types matching piping and equipment connections; provide fittings of materials which match pipe materials used in refrigerant piping systems. Where more than one type of materials and products are indicated, selection is Installer's option.
- B. Material: Provide pipes and pipe fittings in accordance with the following listing:
1. Tube Size 4-1/8 in. and smaller: Copper tube; Type ACR, hard-drawn temper; wrought-copper, solder-joint fittings; brazed joints.
- C. Soldered Joints: Solder joints using silver-lead solder, ASTM B32, Grade 96 TS.
- D. Brazed Joints: Braze joints using American Welding Society (AWS) classification BCUO-4 for brazing filler metal.
- E. Piping Specialties: Provide piping specialties complying with Division 23 "Hydronic Piping" in accordance with the following listing:
1. Pipe escutcheons.
 2. Drip pans.
 3. Sleeves.
 4. Sleeve seals.
- F. Refrigerant Valves: Special valves required for refrigerant piping include the following types.
1. Globe Shutoff Valves: Forged brass, packed, back seating, winged seal cap, 300 degrees F (149 degrees C) temperature rating, 500 PSI working pressure.
 2. Check Valves: Forged brass, accessible internal parts, soft synthetic seat, fully guided piston and stainless steel spring, 250 degrees F (121 degrees C) temperature rating, 500 PSI working pressure.
 3. Manufacturer: Subject to compliance with requirements, provide globe and check valves of one of the following:
 - a. Henry Valve CO.
 - b. Parker Hannifin Corp.; Refrigeration & Air Cond. Div.
 - c. Sporlan Valve Co.
 - d. Or Equal
 4. 2-Way Solenoid Valves: Forged brass, designed to conform to ARI 760, normally closed, teflon valve seat, NEMA 1 solenoid enclosure, 24 volt, 60 Hz., UL-listed, 1/2 in. conduit adapter, 250 degrees F (121 degrees C) temperature rating, 400 PSI working pressure.
 5. Manufacturer: Subject to compliance with requirements, provide solenoid valves of one of the following:
 - a. Alco Controls Div.; Emerson Electric Co.
 - b. Automatic Switch Co.
 - c. Sporland Valve CO.
 - d. Or Equal
 6. Refrigerant Strainers: Brass shell and end connections, brazed joints, monel screen, 100 mesh, UL-listed, 350 PSI working pressure.
 7. Moisture-Liquid Indicators: Forged brass, single port, removable cap, polished optical glass, solder connections, UL-listed, 200 degrees F (93 degrees C) temperature rating, 500 PSI working pressure.

8. Refrigerant Filter-Driers: Steel shell, ceramic fired desiccant core, solder connections, UL-listed, 500 PSI working pressure.
 9. Refrigerant Filter-Driers: Corrosion-resistant steel shell, steel flange ring and spring, wrought copper fittings, ductile iron coverplate with steel cap screws, replaceable filter-drier core, 500 PSI working pressure.
 10. Evaporator Pressure Regulators: Provide corrosion-resistant, spring loaded, stainless steel springs, pressure operated, evaporator pressure regulator, in size and working pressure indicated, with copper connections.
 11. Refrigerant Discharge Line Mufflers: Provide discharge line mufflers as recommended by equipment manufacturer for use in service indicated, UL-listed.
 12. Manufacturer: Subject to compliance with requirements, provide refrigeration accessories of one of the following:
 - a. Alco Controls Div.; Emerson Electric CO.
 - b. Henry Valve CO.
 - c. Parker-Hannifin Corp.; Refrigeration & Air Conditioning Div.
 - d. Sporlan Valve Co.
 - e. Or Equal.
- G. Basic Vibration Control: Provide vibration control products as required in accordance with the following listing:
1. Isolation hangers.
 2. Riser isolators.
 3. Riser support isolators.
 4. Flexible pipe connectors.
- 2.10 HIGH EFFICIENCY, GAS-FIRED CONDENSING BOILER (Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 - COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)
- A. Construction:
1. The boiler shall bear the ASME "H" stamp for 160 psi working pressure and shall be National Board listed. The boiler shall have a fully welded 316L stainless steel, fire tube heat exchanger. There shall be no banding material, bolts, gaskets or "O" rings in the heat exchanger construction. The heat exchanger shall be designed for a single-pass water flow and will drain condensation to the bottom of the vessel. The complete heat exchanger assembly shall carry a ten (10) year limited warranty.
 2. The boiler shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.13 test standard for the U.S. and Canada. The boiler shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard and the minimum efficiency requirements of the latest edition of the AHRI BTS-2000 Standard. The BOILER shall operate at a minimum of 92% thermal efficiency at full fire as registered with AHRI. All models shall operate up to 99% thermal efficiency with return water temperatures at 90°F or below. The boiler shall be certified for indoor installation.

3. The boiler shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. Two burner/flame observation ports shall be provided. The burner shall be a premix design and constructed of high temperature stainless steel with a woven metal fiber outer covering to provide modulating firing rates. The boiler shall be supplied with a gas valve designed with negative pressure regulation and be equipped with a variable speed blower system, to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The boiler shall operate in a safe condition at a derated output with gas supply pressures as low as 4 inches of water column. The burner flame shall be ignited by direct spark ignition with flame monitoring via a flame sensor. Boiler manufacturer to provide neutralization kit and condensate trap for each boiler condensate.
- B. Controls:
1. The boiler shall utilize a 24 VAC control circuit and components. The control system shall have a liquid crystal touch screen display for boiler set-up, boiler status, and boiler diagnostics. All components shall be easily accessed and serviceable from the front and top of the jacket. The boiler shall be equipped with a temperature/pressure gauge; high limit temperature control with manual reset; ASME certified pressure relief valve set for 50 psi (standard); outlet water temperature sensor; return water temperature sensor; outdoor air sensor, flue temperature sensor; high and low gas pressure switches, low water cut off with manual reset, blocked drain switch and a condensate trap for the heat exchanger condensate drain.
 2. The boiler shall feature the "SMART TOUCH™" control with a liquid crystal touch screen display, password security, outdoor air reset, pump delay with freeze protection, pump exercise, domestic hot water prioritization and PC port connection. The boiler shall have alarm contacts for any failure, runtime contacts and data logging of runtime, ignition attempts, ignition failures, and modulation. The boiler shall have a built-in "Cascade" to sequence and rotate the while maintaining modulation of up to eight boilers without utilization of an external controller. The internal "Cascade" function shall be capable of lead-lag, efficiency optimization, front-end loading, and rotation of lead boiler every 24 hours. The boiler shall be capable of controlling isolation valves during heating operation and rotation of open valves in standby operation for full flow applications. The control must come with standard Modbus communication protocol. The boiler shall be provided with a gateway device which will allow integration with BacNet protocols. Boiler manufacturer to provide assistance and coordination with ATC Contractor for point mapping and programming from boiler controller to BMS system.
 3. The boiler shall be equipped with two terminal strips for electrical connection. A low voltage connection board with 30 data points for safety and operating controls, i.e., Alarm Contacts, Runtime Contacts, Louver Proving Switch, Tank Thermostat, Remote Enable/Disable, System Supply Sensor, Outdoor Sensor, Tank Sensor, Modbus Building Management System signal and Cascade control circuit. A high voltage terminal strip shall be provided for Supply voltage. Supply voltage shall be 120 volt / 60 hertz / single phase. The boiler may be factory trimmed for optional supply voltages, i.e. 208 volt / 60 hertz / 3 phase, 480 volt / 60 hertz / 3 phase and 600 volt / 60 hertz / 3 phase. The high voltage terminal strip plus integral relays are provided for independent pump control of the System pump, the Boiler pump and the Domestic Hot Water pump. Boiler manufacture to provide boiler pump circulator as scheduled, boiler manufacture to provide pump motor control panel/center with on/off/auto switch with pilot light. Pump power feed by electrical contractor.

- C. Gas Train:
 - 1. The gas train shall consist of a pressure regulating electro-hydraulic proportional air/gas main gas actuator providing a slow opening, fast closing shutoff valve and proportional 1:1 air/gas ration control, a fast closing safety shutoff as pressure regulator with 1 PSI allowable static pressure, and a low gas pressure switch. A factory pre-set combination metering valve and orifice shall be provided for setting combustion parameters. Boiler shall be capable of operating at 4.0" w.c.

 - D. Manufacturer: Subject to compliance with requirements, provide boilers of one of the following:
 - 1. Lochinvar
 - 2. Aerco
 - 3. Fulton
 - 4. Or Equal.
- 2.11 PUMPS (P) (Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 - COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)
- A. General: Provide factory-tested pumps, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment. Type, size, and capacity of each pump is listed in pump schedule. Provide pumps of same type by same manufacturer.

 - B. In-Line Circulator Pumps:
 - 1. General: Provide in-line circulator pumps where indicated, and of capacities as scheduled.
 - 2. Type: Horizontal mount, vertical split case, oil-lubricated, designed for 125 psi working pressure, and 225° F. (107° C) continuous water temperature.
 - 3. Body: Cast-iron, with suction and discharge gauge tappings.
 - 4. Shaft: Hardened alloy steel.
 - 5. Bearings: Oil-lubricated bronze journal bearings.
 - 6. Seal: Mechanical, with carbon seal ring and ceramic seat.
 - 7. Motor: Non-overloading at any point on pump curve, open, drip-proof, oil-lubricated journal bearings, resilient mounted construction, built-in thermal overload protection on single phase motors.
 - 8. Couplings: Self-aligning, flexible coupling.
 - 9. Impeller: Enclosed type hydraulically and dynamically balanced, and keyed to shaft.
 - 10. Install pumps on channel steel support stands with vibration isolators. Refer to pump piping drawing details for valve and accessory requirements.
 - 11. Manufacturer: Subject to compliance with requirements, provide in-line circulator pumps of one of the following:
 - a. Bell & Gosset ITT; Fluid Handling Div.
 - b. Armstrong Pumps, Inc.
 - c. Taco, Inc.
 - d. Or equal

 - C. Frame-Mounted End Suction Pumps:
 - 1. General: Provide frame-mounted end suction pumps where indicated, and of capacities and having characteristics as scheduled.
 - 2. Type: Horizontal mount, single stage, vertical split case, flexible coupling, base mounted, designed for 175 psi working pressure.
 - 3. Casing: Cast iron, 125 psi ANSI flanges, tappings for gage and drain connections.
 - 4. Shaft: Steel with replaceable shaft sleeve. Provide shaft grounding rings similar to Aegis or equal.
 - 5. Bearing: Regreasable ball bearings.

6. Seal: Mechanical, with carbon seal ring and ceramic seat.
7. Motor: Open, dripproof, regreasable ball bearings under motor, motor shall be premium efficiency inverted duty type. Provide AEGIS magnetic bearing protection ring for inverter rated motors that are controlled by variable speed drives. The bearing protection ring shall channel harmful shaft voltages to ground to protect bearing races from pitting.
8. Impeller: Enclosed type, hydraulically and dynamically balanced keyed to shaft and secured with locking screw.
9. Baseplate: Structural steel with welded cross members, and open grouting area.
10. Coupling: Flexible, capable of absorbing torsional vibration, equipped with coupling guard.
11. Manufacturer: Subject to compliance with requirements, provide frame-mounted end suction pumps of one of the following:
 - a. Bell & Gosset ITT; Fluid Handling Div.
 - b. Armstrong Pumps, Inc.
 - c. TACO
 - d. Or Equal.

2.12 AIR INTAKE AND EXHAUST BREECHING, CHIMNEYS AND STACKS

- A. The air intake and exhaust vents shall be of the double-wall, factory-built type for use on condensing appliances or pressurized venting systems serving Category II, III or IV appliances or as specified by the equipment manufacturer.
- B. Maximum temperature shall not exceed 550°F.
- C. Vent shall be listed for an internal static pressure of 6 in. w.g. and tested to 15 in. w.g.
- D. Vent shall be constructed with an inner and outer wall, with a 1 in. annular insulating air space.
 1. The inner wall (vent) shall be constructed of AL29-4C superferritic stainless steel, .015 thickness for 4 in.-12 in. diameters and .024 thickness for 14 in.-24 in. diameters.
 2. The outer wall (casing) shall be constructed of type 430 stainless steel, .018 thickness for 4 in.-12 in. diameters and .024 thickness for 14 in.-24 in. diameters.
 3. Inner and outer walls shall be connected by means of spacer clips that maintain the concentricity of the annular space and allow unobstructed differential thermal expansion of the inner and outer walls.
- E. All parts exposed to the weather shall be stainless steel.
- F. All supports, roof or wall penetrations, terminations, appliance connectors and drain fittings, required to install the vent system shall be included.
- G. Roof penetration pieces shall be UL listed and provided by the vent manufacturer.
- H. All inner vent connections shall be secured by means of profiled connector bands with gear clamp tighteners. Joints shall be sealed with waterproof sealant. Where exposed to weather, the outer closure band shall be sealed to prevent rainwater from entering the space between inner and outer walls.
- I. Vent shall terminate in accordance with installation instructions and local codes.

- J. Manufacturers: Subject to compliance with requirements, provide all steel, insulated, positive pressure double wall vents of one of the following:
1. Metal-Fab, Corr/Guard Model CG
 2. Selkirk Heat-Fab Saf-T Vent CI
 3. Schebler eVENTplus
 4. or equal

2.13 CONDENSATE NEUTRALIZING TUBES

- A. Contractor shall furnish and install condensate neutralizing tubes for new boilers and domestic water heater condensate drains and flue pipe condensate drains.
- B. Neutralizer tubes shall be as manufactured by JJM Boiler Works, or approved equal, and sized according to input rating of each piece of equipment.
- C. The boiler/water heater and flue condensate drains shall not be combined. Provide separate neutralizing tubes for boiler/water heater and flue condensates. All piping shall be per manufacturer's piping diagrams and directions. Secure neutralizing tubes to the floor.

2.14 ROOFTOP UNITS (RTU) (Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 - COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)

- A. Manufacturers
1. Subject to compliance with requirements specified here within provide rooftop units as manufactured by Daikin, Trane, York, or approved equal by the engineer. (Rooftop Unit must fit within the footprint shown on the drawings with manufacturer's recommended service clearances and code mandated airstream clearances being maintained)
 2. Any substitution or submitted equal unit that differs from the basis of design must fit within the equipment footprint shown on the Drawings. Any modifications to the design, as a result of approving a such equal or substitution from the basis of design equipment, shall be the responsibility of this subcontractor. Any additional cost to this subcontractor or any other contractor, directly or indirectly, as a result of such approval, shall be the responsibility of this subcontractor
- B. General
1. Units shall be of the configuration, capacity, and style as indicated on the drawings and Equipment Schedule and as specified herein. Through properly designed access; ease of maintenance, removability of components, and unit serviceability shall be assured.
 2. The unit shall be constructed for outdoor installation. Outdoor unit to be provided with weatherproofing outside air intake hood and shutoff dampers for supply, return and exhaust.
 3. The Rooftop unit as a whole and not individual components must be approved and on the New Hampshire Board of Registration of Plumbers and Gas Fitters as a listed and accepted manufacturer.

C. General Description

1. Furnish as shown on plans. Unit performance and electrical characteristics shall be per the job schedule.
2. Provide the unit with the following sections as a minimum:
 - a. Modulating exhaust fan/economizer section
 - b. Filter sections
 - c. Modulating supply fan section
 - d. Modulating gas-fired heating section
 - e. Access sections
 - f. Modulating cooling coil section
 - g. Diffuser (as required)
 - h. Discharge/intake plenums
 - i. Modulating condensing unit section
 - j. Modulating hot gas reheat coil
 - k. Modulating energy recovery wheel
 - l. Outside air weather hood with aluminum mesh screen
3. The complete unit shall be ETL listed. The burner and gas train for the unit furnace shall be IRI/FIA approved.
4. Each unit shall be specifically designed for outdoor rooftop application and include a weatherproof cabinet. Units shall be of a modular design with factory installed access sections available to provide maximum design flexibility.
5. Unit is to be shipped factory assembled in one complete section, when possible. Each unit shall be either completely factory assembled and shipped in one piece or split at the condensing section and/or split between the supply fan section and the heat section. Packaged units shall be shipped fully charged with Refrigerant R410A. Units split between the evaporator and the condensing sections are shipped with a nitrogen holding charge only. Unit manufacturer and subcontractor shall coordinate ship split and field installation, refrigerant charging, and all unit field inter-connection requirements.
6. The unit shall undergo a complete factory run test prior to shipment. The factory test shall include final balancing of the supply and return fan assemblies, a refrigeration circuit run test, a unit control system operations checkout (for controls provided with unit), test and adjustment of the gas furnace, a unit refrigerant leak test and a final unit inspection.
7. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.
8. The Rooftop unit shall be designed, manufactured, and independently tested, rated, and certified to meet the seismic standards of the 2009 International Building Code and ASCE 7-06.
 - a. Certificates of Compliance shall be provided with the submittal and include the manufacturer's identification, designation of certified characteristics, and the Independent Certifying Agency's name and report identification.
 - b. Clear installation instructions shall be provided including all accessory components.
9. Performance: All scheduled capacities and face areas are minimum accepted values. All scheduled amps, kW, and hp are maximum accepted values that allow scheduled capacity to be met.
10. Warranty: The manufacturer shall provide 12-month parts only warranty. The manufacturer will provide extended five year, parts only, warranty on the compressors. Defective parts shall be repaired or replaced during the warranty period at no charge. The warranty period shall commence upon project completion date.

D. Cabinet, Casing and Frame

1. Provide double-wall construction for all side wall access doors and floor areas shall be provided with 17 gauge exterior and 22-gauge interior, solid G60 galvanized steel construction. Inner liners shall protect insulation during service and maintenance. Unit cabinet shall be designed to operate at total static pressures up to 6.5 in. s w.g.
2. Insulation on ceiling and end panels shall be secured with adhesive and mechanical fasteners. Heavy gauge solid galvanized steel liners shall be provided throughout, allowing no exposed insulation within the air stream.
3. All cabinet insulation, except floor panels, shall be a nominal 2 in. thick, 1½-lb. density, R6.5, glass fiber. A combination of solid and perforated galvanized steel liners shall be provided throughout. Perforated liners to be used in the supply and return air plenums to provide improved sound attenuation. Insulation under perforated liners shall be coated with hospital grade liner rated in accordance with standard ASTM C-1071.
4. All floor panels shall include double wall construction and include a nominal 2 in. thick, 3 lb. density, R4.2 per in. glass fiber insulation.
5. Exterior surfaces shall be constructed of pre-painted galvanized steel for aesthetics and long term durability. Paint finish to include a base primer with a high quality, polyester resin topcoat, color to selected by architect, provide sample selection chart. Finished surface shall withstand a minimum 1000-hour salt spray test in accordance with ASTM B117 standard for salt spray resistance. Service doors shall be provided on both sides of each section in order to provide user access to all unit components.
6. Service doors shall be constructed of heavy gauge galvanized steel with a gauge, galvanized steel interior liner. All service doors shall be mounted on multiple, stainless steel hinges and shall be secured by a latch system that is operated by a single, flush-mounted handle. The latch system shall feature a staggered engagement for ease of operation. Removable panels, or doors secured by multiple, mechanical fasteners are not acceptable.
7. The unit base frame shall be constructed of 13-gauge pre-painted galvanized steel. The unit base shall overhang the roof curb for positive water runoff and shall have a formed recess that seats on the roof curb gasket to provide a positive, weather-tight seal. Lifting brackets shall be provided on the unit base with lifting holes to accept cable or chain hooks.

E. Supply and Exhaust Fans (As Scheduled)

1. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment. All fan assemblies shall employ solid steel fan shafts. Heavy-duty pillow block type, self-aligning, grease-lubricated ball bearings shall be used. Bearings shall be sized to provide an L-50 life at 200,000 hours. The entire fan assembly shall be isolated from the fan bulkhead and mounted on spring isolators with seismic restraints.
2. Adjustable pitch V-belt drives with matching belts or direct drive fans shall be provided. V-belt drives shall be selected at manufacturer's standard service factor of 1.5 times fan brake horsepower.
3. Fan motors shall be heavy-duty 1800 rpm open drip-proof (ODP) type with grease-lubricated ball bearings. Motors shall be premium efficiency inverter rated and meet applicable EPACT/NEMA requirements. Motors shall be mounted on an adjustable base that provides for proper alignment and belt tension adjustment. Provide AEGIS magnetic bearing protection ring for all inverter rated motors that are controlled by variable speed drives. The bearing protection ring shall channel harmful shaft voltages to ground to protect bearing races from pitting.

4. Airfoil type supply and return (exhaust) fans - supply fans shall be double width, double inlet (DWDI) airfoil centrifugal fan. All fans shall be mounted using shafts and hubs with mating keyways. Fans shall be Class II type and fabricated from heavy-gauge aluminum. Fan blades shall be continuously welded to the back plate and end rim. The supply air fan and return air fan sections shall be provided with an expanded metal belt guard.
- F. Variable Air Volume Control
1. Provide variable frequency drive for the supply and exhaust air fan. Two independent drives, one per fan, shall be provided. Each drive shall be factory installed downstream of the filters in a manner that the drive(s) are directly cooled by the filtered, mixed air stream. Drives shall meet UL Standard 95-5V and the variable frequency drive manufacturer shall have specifically approved them for plenum duty application. The completed unit assembly shall be listed by a recognized safety agency, such as ETL. Drives are to be accessible through a hinged door assembly complete with a single handle latch mechanism. Mounting arrangements that expose drives to high temperature, unfiltered ambient air is not acceptable.
 2. The unit manufacturer shall install all power/control wiring. A manual bypass contactor arrangement shall be provided. The arrangement will allow fan operation at full design cfm, even if the drive has been removed for service. 3% Line reactors shall be factory installed for each drive. Variable frequency drives shall be equipped with features as indicated in Division 260000 Variable Frequency Drive specification requirements.
 3. The supply air fan drive output shall be controlled by the factory installed main unit control system and drive status and operating speed shall be monitored and displayed at the main unit control panel. The supply and return/exhaust fan drive outputs shall be independently controlled in order to provide the control needed to maintain building pressure control. Supply and return/exhaust air fan drives that are slaved off of a common control output are not acceptable.
 4. All drives shall be factory run tested prior to unit shipment.
- G. Electrical
1. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with unit shall be numbered and color-coded and labeled according to the electrical diagram provided for easy identification. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a single point power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, high temperature sensor, and a 115-volt receptacle with a separate electrical connection shall also be provided with unit.
 2. Each compressor and condenser fan motor shall be furnished with contactors, current sensing manual motor and short circuit protection, and inherent thermal overload protection. Supply and return fan motors shall have Circuit breakers and built in overload protection with VFDs. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance. All 115–600 voltage wire shall be protected from damage by raceways or conduit.
 3. A factory installed and wired marine service light, with switch and receptacle, shall be provided in the supply air and return/exhaust fan section. The separate, main unit service receptacle electrical circuit shall also power the light circuit.
 4. A factory installed and wired 115 volt power supply shall be provided for the GFI receptacle. The power supply shall be wired to the line side of the disconnect so the receptacle is powered when the main unit disconnect is off. This option shall include a weather proof transformer and disconnect for the 115 volt GFI. The 115 volt GFI electrical circuit shall complete with primary fused short circuit protection.

5. Phase failure and under voltage protection on three-phase motors shall be provided to prevent damage from single phasing, phase reversal, and low voltage conditions.
 6. Ground fault protection shall be provided to protect against arcing ground faults.
 7. Smoke detectors shall be field installed as shown on the drawings. Smoke detectors shall be furnished and wired to the building Fire Alarm system by the Division 260000 Subcontractor and installed by the HVAC Subcontractor and ATC Sub-subcontractor shall wire to shut down unit upon activation.
 8. Disconnect switches shall be provided by Division 260000.
- H. Cooling Sections
1. The cooling coil section shall be installed in a draw through configuration, upstream of the supply air fan. The coil section shall be complete with factory piped cooling coil and sloped stainless steel drain pan. Hinged access doors on both sides of the section shall provide convenient access to the cooling coil and drain pan for inspection and cleaning.
 2. Submittals must demonstrate that scheduled unit leaving air temperature (LAT) is met, that fan and motor heat temperature rise (TR) have been considered, and scheduled entering air temperature (EAT) equals mixed air temperature (MAT). Draw-through cooling—Scheduled EAT equals cooling coil EAT and scheduled unit LAT equals cooling coil LAT plus TR.
 3. Direct expansion (DX) cooling coils shall be fabricated of seamless ½ in. diameter high efficiency copper tubing that is mechanically expanded into high efficiency aluminum plate fins. Coils shall be a multi-row, staggered tube design with a maximum of 12 fins per in. All units shall have two independent refrigerant circuits and shall use an interlaced coil circuiting that keeps the full coil face active at all load conditions. All coils shall be factory leak tested with high pressure air under water. Coils shall have a flexible epoxy polymer e-coat uniformly applied to all coil surface areas without material bridging between fins. Coating process shall ensure complete coil encapsulation and a uniform dry film thickness from 0.8 - 1.2 mil on all surface areas including fin edges. Superior hardness characteristics of 2H per ASTM D3363-92A and a cross-hatch adhesion of 4B-5B per ASTM B3359-93. Humidity and water immersion resistance shall be up to a minimum 1000 and 250 hours respectively (ASTM D2247-92 and ASTM D870-92). Corrosion durability shall be confirmed through testing to no less than 5,000 hours salt spray per ASTM B117-90.
 4. A stainless steel, positively sloped drain pan shall be provided with the cooling coil. The drain pan shall extend beyond the leaving side of the coil and underneath the cooling coil connections. The drain pan shall have a minimum slope of 1/8 in. per foot to provide positive draining. The drain pan shall be connected to a threaded drain connection extending through the unit base. Units with stacked cooling coils shall be provided with a secondary drain pan piped to the primary drain pan. Drain pan connections shall be field trapped per manufacturer's instructions and piped to the nearest roof drain to prevent ponding on the roof.
- I. Gas Heating Section
1. A natural gas fired furnace shall be installed in the unit heat section. The heat exchanger shall include a type 316 or 321 stainless steel cylindrical primary combustion chamber, a type 316 or 321 stainless steel header, type 316 or 321 stainless steel secondary tubes and type 321 stainless steel turbulators. Carbon and aluminized steel heat exchanger surfaces are not acceptable.
 2. The heat exchanger shall have a condensate drain.
 3. Clean out of the primary heat exchanger and secondary tubes shall be accomplished without removing casing panels or passing soot through the supply air passages.
 4. The furnace section shall be positioned downstream of the supply air fan.

5. The furnace will be supplied with a modulating forced draft burner. The burner shall be controlled for low fire start. The burner furnace shall be supplied with a forced draft burner capable of continuous modulation between eight percent and 100 percent (min 12:1 turn-down) of rated capacity, without steps. The burner shall have proven open damper low-high-low pre-purge cycle, and proven low fire start. The combustion air control damper shall be in the closed position during the off cycle to reduce losses. Provide refrigeration heat pump option and utilized in conjunction with the 10:1 turndown gas furnace. The burner shall operate efficiently at all firing rates.
6. The burner shall be specifically designed to burn natural gas and shall include a microprocessor based flame safeguard control, combustion air proving switch, prepurge timer and spark ignition. The gas train shall include redundant gas valves, regulators compatible with project gas pressure requirements, shutoff cock, pilot gas valve, pilot pressure regulator, and pilot cock. The burner shall be rated for operation and full modulation capability at inlet gas pressures down to 6.5 in. W.C. The gas burner shall be controlled by the factory installed main unit control system.
7. The burner shall have electric ignition, standing pilot lights are unacceptable.
8. The burner shall be fired, tested and adjusted at the factory. Final adjustments shall be made in the field at initial startup by a qualified service technician to verify that installation and operation of the burner is according to specifications.
9. Flue collector construction shall consist of type 409 stainless steel. Contractor shall provide flue discharge with weather cap shall discharge a minimum of two ft. higher than outdoor air intakes located closer than 25 ft. from flue discharge. Provide stainless steel flue extensions with weather cap for all units.

J. Filters

1. Unit shall be provided with filter sections. The filter sections shall be supplied complete with the filter rack as an integral part of the unit. The draw-through filter section shall be provided with panel and cartridge filters.
2. Filters shall be frame mounted and shall slide into galvanized steel racks contained within the unit. Filters shall be installed in an angular arrangement to maximize filter area and minimize filter face velocity. Filters shall be accessible from both sides of the filter section.
3. Four inch deep MERV 13, efficient, UL Std. 900, Class 1, AmericanAirFilter cartridge filters shall be provided. Two inch. panel, MERV-8 efficient pre-filters shall be included. Aluminum mesh outside air filter shall be provided at the outside air hood inlet. Cartridge filters shall consist of filter media permanently attached to a metal frame and shall slide into a gasketed, extruded aluminum rack contained within the unit. The filter rack shall have secondary gasketed, hinged end panels to insure proper sealing. Filters shall be accessible from both sides of the filter section. Filter set quantities shall be provided as indicated in Part III.
4. Clogged filter switches and magnehelic gauges shall be provided on all filter sections.

K. Outdoor / Return Air Section

1. Return Air Plenum- Unit shall be provided with a return air plenum capable of handling 100 percent re-circulated air. The 100 percent return air plenum shall allow return air to enter from the bottom of the unit. Low leak dampers shall be provided. Damper blades shall be fully gasketed and side sealed and arranged vertically in the hood. Damper leakage shall be less than 0.2 percent at 1.5 in. static pressure differential. Leakage rate to be tested in accordance with AMCA Standard 500. Damper blades shall be operated from multiple sets of linkages mounted on the leaving face of the dampers. Control of the dampers shall be from a field installed modulating actuator provided by the ATC Sub-subcontractor.
2. Provide re-circulation damper for all units.

- L. Energy Recovery Section and Components (As Scheduled)
1. Unit shall be provided with a modulating outdoor air economizer section with an ARI certified total energy recovery wheel with a minimum of 65% effectiveness. The economizer section shall include outdoor, return and return exhaust air dampers. Actuators shall be provided by the ATC contactor.
 2. Outdoor air shall enter at the back of the section through a factory-installed hood capable of handling 100 percent outdoor air. The outdoor air hood shall be factory installed and constructed from galvanized steel finished with the same pre-painted finish as the main unit. The hood shall include a bird screen to prevent infiltration of foreign material and a rain lip to drain water away from the entering air stream. Return air shall enter through the bottom of the unit.
 3. The entire section shall be double-wall construction.
 4. The enthalpy wheel shall be constructed of corrugated synthetic fibrous media, with a desiccant intimately bound and uniformly and permanently dispersed throughout the matrix structure of the media. Rotors with desiccants coated, bonded, or synthesized onto the media are not acceptable due to delamination or erosion of the desiccant material. Media shall be synthetic to provide corrosion resistance and resistance against attack from laboratory chemicals present in pharmaceutical, or hospital environments as well as attack from external outdoor air conditions. Coated aluminum is not acceptable. Face flatness of the wheel shall be maximized (+/-0.032 in.) in order to minimize wear on inner seal surfaces and to minimize cross leakage. Rotor shall be constructed of alternating layers of flat and corrugated media. Wheel layers should be uniform in construction forming uniform aperture sizes for airflow. Wheel construction shall be fluted or formed honeycomb geometry so as to eliminate internal wheel bypass. Wheel layers that can be separated or spread apart by airflow are unacceptable due to the possibility of channeling, internal bypass or leakage, and performance degradation. The media shall be in accordance with NFPA or UL guidelines. The desiccant material shall be a molecular sieve, specifically a 4A or smaller molecular sieve to minimize cross contamination. The wheel frames shall consist of evenly spaced steel spokes, galvanized steel outer band and rigid center hub. The wheel construction should allow for post fabrication wheel alignment. The wheel seals shall be brush seals, neoprene bulb seals, or equivalent. Seals should be easily adjustable. Cassettes shall be fabricated of heavy duty reinforced galvanized steel. Cassettes shall have a built-in adjustable purge section minimizing cross contamination of supply air. Bearings shall be in board, zero maintenance, permanently sealed roller bearings, or alternatively, external flanged bearings.
 5. Drive systems shall consist of fractional horsepower A.C. drive motors with multilink drive belts. The wheel shall be tested in accordance with NFPA or UL guidelines and shall be UL recognized or equivalent.
 6. The wheel capacity, air pressure drop, and efficiency shall be ARI certified by ARI and its testing agencies. Alternative independent performance testing must be pre-approved to be accepted.
 7. Wheel shall be provided with variable speed control shaft grounding rings for frost protection. Provide energy recovery wheel defrost controls and rotation detection controls.
 8. The wheel recovers energy from the factory-supplied return exhaust section and includes an airfoil fan and motor in accordance with construction already specified. Gravity relief dampers and fold-out exhaust hood shall be provided.
 9. All necessary exhaust fan motors, branch short circuit protection, and wiring shall be provided.

10. Two-in., 30 percent pleated filters shall be provided in both air inlets to protect the wheel from dust and dirt in both the outdoor and return/exhaust air paths. Dampers to be low-leak type, and shall be provided on outdoor or return dampers. Damper blades shall be fully gasketed and side sealed and arranged horizontally in the hood. Damper leakage shall be less than 0.2 percent at 1.5 in. static pressure differential. Leakage rate to be tested in accordance with AMC Standard 500. Damper blades shall be operated from multiple sets of linkages mounted on the leaving face of the dampers.
- M. Access Sections - Unit shall be provided with factory installed access sections located as shown/indicated on the drawings. Access sections shall have hinged access doors on both sides of the section and shall have the same construction features as the rest of the unit.
- N. Discharge and Return Plenum - A supply air discharge and return plenum shall be provided. The plenum section shall be lined with a perforated acoustic liner (rated per ASTM C1071 Standards) to enhance sound attenuation. The plenum section shall have a bottom discharge opening. Isolation dampers shall be provided in the bottom return air opening and bottom supply air openings. Actuators shall be provided by the ATC Sub-subcontractor to close the dampers when the fans are not running.
- O. Condensing Unit
 1. The condensing section shall be open on the sides and bottom to provide access and to allow airflow through the coils. Condenser coils shall be multi-row and fabricated from cast aluminum micro-channel coils. Each condenser coil shall be factory leak tested with high-pressure air under water. Coils are to be recessed so that the cabinet provides built in hail protection.
 2. Condenser fans shall be direct drive, ECM motor driven, propeller type designed for low tip speed, with low noise fan blades and vertical air discharge. Condenser fan rpm shall be 1140 rpm maximum. Fan blades shall be constructed of steel and riveted to a steel center hub. Condenser fan motors shall be heavy-duty, inherently protected, three-phase, non-reversing type with permanently lubricated ball bearing and integral rain shield. Provide condenser fan blades that reduce radiated sound levels.
 3. Each circuit shall have fan cycling of at least one condenser fan to maintain positive head pressure. An ambient thermostat shall prevent the refrigeration system from operating below 45° F.
 4. Liquid tight conduit shall be provided on exposed condensing section wiring.
 5. Compressors- Each unit shall have multiple, heavy-duty Copeland digital or staged scroll compressors. Each compressor shall be complete with crankcase heater, sight-glass, anti-slug protection, current sensing and motor temperature sensing, motor overload protection and a time delay to prevent short cycling and simultaneous starting of compressors following a power failure. Compressors shall be isolated with resilient rubber isolators to decrease noise transmission. At a minimum 50% of the quantity of compressors shall be a variable/digital scroll compressor.
 6. Refrigeration Controls - Each unit shall have two independent refrigeration circuits. Each circuit shall be complete with low pressure control, filter-drier, liquid moisture indicator/sight-glass, solenoid, thermal expansion valve, liquid line shutoff valve with charging port, discharge line shutoff valve, a manual reset high pressure safety switch and high pressure relief device. The thermal expansion valve shall be capable of modulation from 100 percent to 25 percent of its rated capacity. Sightglasses shall be accessible for viewing without disrupting unit operation. Each circuit shall be dehydrated and leak tested.

7. Capacity Control- Refrigeration capacity control shall be accomplished by staging of the unit's multiple compressors and modulating the scroll compressor utilizing a degree time staging method or modulating a digital scroll compressor. To maintain desired temperature control, the unit shall have a capacity control consisting of staged compressors of quantities indicated on schedules and a minimum of one digital scroll compressor or inverter driven compressors or control logic and staging methods for capacity modulating. The units condenser section fan speed shall be modulated based upon unit loading.
 8. All compressor capacity control staging shall be controlled by the factory installed main unit control system.
 9. Modulating hot gas reheat shall be provided on the lead circuit complete with modulating valves, micro-channel refrigerant reheat coil, and dehumidification control. Controls shall maintain $\pm .5$ deg. F control of the reheat coil leaving air temperature.
- P. Roof Curb – refer to Section 23 05 48
- Q. Controls
1. General – Automatic Temperature controls for Rooftop unit shall be DDC (direct digital control type). All sensors, actuators, controls (with exception of RTU gas-heating and DX cooling safety and internal refrigeration system controls) not provided by the RTU manufacturer shall be provided by the ATC/DDC controls Sub-subcontractor.
 2. Unit manufacturer shall provide terminal strips and/or BACNet MS/TP compatible controller for all control devices not furnished by ATC Sub-subcontractor. Including but not limited to modulating gas valve, compressor capacity controls, and hot gas reheat control.
 3. RTU manufacturer shall provide supply, return/exhaust air fan inlet airflow measuring stations and outdoor airflow grid-probe type air flow measuring stations.
 4. Refer to Specification 230000 ATC control specification requirements and Control Diagram Drawings for Rooftop unit control requirements and expanded sequence of operation and required points list.
 5. HVAC and ATC Contractors shall coordinate with unit manufacturer to ensure all sequence of operation and control points are achieved with the BMS to complete the specified sequence of operation and points lists.
 6. RTU manufacturer shall provide the necessary time and documentation to the ATC sub-subcontractor to provide seamless communication and points to achieve the desired sequence and BMS interface.

2.15 AIR COOLED CHILLER

- A. General: Unit panels, structural elements and control boxes shall be constructed of 12-gauge galvanized steel and mounted on a welded structural steel base. Unit panels and control boxes shall be finished with a baked on powder paint, and the structural base with an air dry paint. Units shall be leak and pressure tested at 450 psig high side, 300 psig low side, then evacuated and charged. Packaged units shall ship with a full operating charge of oil and refrigerant.
- B. Evaporator: The evaporator shall be a tube-in-shell heat exchanger design with internally finned copper tubes roller expanded into the tube sheet. The evaporator shall be designed, tested and stamped in accordance with ASME for a refrigerant side working pressure of 300 psig and a water side working pressure of 215 psig. The evaporator shall be one water pass with a series of internal baffles. Each shell shall have a vent, a drain and fittings for temperature control sensors and insulated with 3/4-in. Armaflex II or equal insulation ($K = 0.26$). Heat tape with thermostat is provided to protect the evaporator from freezing at ambient temperatures down to -20 F.

- C. Condenser and Fans: Air-cooled condenser coils shall have aluminum fins mechanically bonded to internally finned seamless copper tubing. The condenser coil shall have integral sub-cooling circuit and provide oil cooling for the compressor bearing and injection oil. Condensers shall be factory proof and leak tested at 506 psig. Direct-drive vertical discharge condenser fans shall be dynamically balanced. Three-phase condenser fans motors with permanently lubricated ball bearing and internal thermal overload protection shall be provided. Units will start and operate down to 15 F ambient.
- D. Compressor and Lube Oil System: The compressor shall be sealed hermetic, direct drive, 3600 rpm, with capacity control slide valve, rolling element bearings, differential refrigerant pressure oil pump and oil heater. The motor shall be suction gas cooled, hermetically sealed, two-pole squirrel cage induction motor. Oil separator and filtration devices shall be provided separate from the compressor. Check valves in the compressor discharge and lube oil system and a solenoid valve in the lube system shall be provided.
- E. Refrigeration Circuits: Each unit shall have two refrigerant circuits, with rotary screw compressors. Each refrigerant circuit shall include compressor suction and discharge service valve, liquid line shutoff valve, removable core filter drier, liquid line sight glass with moisture indicator, charging port and an electronic expansion valve. Provide fully modulating compressors and electronic expansion valves with variable capacity modulation over the entire operating range.
- F. Unit Controls: All unit controls shall be housed in a weather tight enclosure with removable plates for power wiring and remote interlocks. All controls, including sensors, to be factory mounted and tested prior to shipment. All units shall be UL listed. Microcomputer controls shall provide all control functions including start-up and shut down, leaving chilled water temperature control, compressor and electronic expansion valve modulation, fan sequencing, anti-recycle logic, automatic lead/lag compressor starting and load limiting. The unit control module microcompressor shall automatically take action to avoid unit shutdown due to abnormal operating conditions associated with low refrigerant temperature, high condensing temperature and motor current overload. If an abnormal operating condition shall continue, the unit will be shut down. Unit protective functions shall include loss of chilled water flow, evaporator freezing, loss of refrigerant, low refrigerant pressure, high refrigerant pressure, reverse rotation, compressor starting and running over current, phase loss, phase imbalance, phase reversal, and loss of oil flow.
- G. A menu driven digital display shall indicate operating data points including chilled water set-point, current limit set-point, leaving chilled water temperature, evaporator and condenser refrigerant pressures and temperatures. Standard power connections shall include main three phase power and two 115 volt single phase power connections for control power and heat tape.
 - 1. Starters: Starters shall be factory installed and housed in a weather tight enclosure with removable cover plate to allow for connection of power wiring.
 - 2. Chiller efficiency must meet the requirements of Advanced Building Core Performance Requirements for full load and IPLV.
 - 3. Accessories:
 - a. Louvers on upper and lower portions of unit.
 - b. Vibration isolators
 - c. Fused disconnect
 - d. Acoustic blanket on compressors (factory installed)
 - e. Single point power connection
 - f. Low ambient control
 - g. BAS interface (BAC Net/MS/TP)
 - h. VFDs on condenser fans.

4. Manufacturer: Subject to compliance with the above, provide air cooled liquid chiller of one of the following:
 - a. Trane
 - b. McQuay
 - c. York
 - d. Or equal
- 2.16 TERMINAL HEATING UNITS (HYDRONIC) (Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 - COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)
- A. Unit Heaters (UH) (Horizontal Type)
1. General: Provide horizontal unit heaters in locations as indicated, and of capacities, style, and having accessories as scheduled.
 2. Construction:
 - a. Casings: Construct of steel, phosphatized inside and out, and finished with baked enamel. Provide adjustable face air diffuser. Color by architect, provide sample selection chart.
 - b. Fans: Construct of aluminum and factory-balance. Design so motor and fan assembly is removable through fan outlet panel.
 - c. Coils: Construct of plate-type aluminum fins, mechanically bonded to copper tubes. Design coil for use in hot water applications.
 - d. Motors: Provide totally enclosed motors, with built-in overload protection, having electrical characteristics as scheduled.
 3. Manufacturer: Subject to compliance with requirements, provide horizontal unit heaters of one of the following:
 - a. Airtherm Mfg. Co.
 - b. Rittling
 - c. Trane (The) Co.
 - d. Modine
 - e. Vulcan Corp.
 - f. Or Equal.
- B. Unit Heaters (UH) (Cabinet Type)
1. General: Provide cabinet unit heaters having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coil, fanboard, fan wheels, housings, motor, and insulation.
 2. Construction:
 - a. Chassis: Galvanized steel wrap-ground structural frame with edges flanged.
 - b. Insulation: Faced, heavy density glass fiber.
 - c. Cabinet: 14-ga removable front panel, 18-ga top and side panels. Insulate front panel over entire coil section. Provide access door on coil connection side. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer and baked enamel finish paint with color as selected by Architect. Provide sample selection chart.
 - d. Water Coils: Construct of 5/8 in. seamless copper tubes mechanically bonded to configured aluminum fins. Design for 300 psi and leak test at 300 psi under water. Provide same end connections for supply and return.
 - e. Fans: Provide centrifugal, forward curved double width fan wheels constructed of non-corrosive, molded, fiberglass reinforced thermo-plastic material. Construct fan scrolls of galvanized steel.
 - f. Motors: Provide shaded pole motors with integral thermal over-load protection, and motor cords for plug-in to junction box in unit. Provide motor speed switch with auxiliary contacts capable of being remotely controlled by the DDC system.

- g. Filters: Provide 1 in. thick throwaway type filters in fiberboard frames.
 - 3. Manufacturer: Subject to compliance with requirements, provide cabinet heaters of one of the following:
 - a. McQuay Inc.
 - b. Trane (The) Co.
 - c. Vulcan Corp.
 - d. Rittling
 - e. Or Equal.
- C. Radiant Panels (RP)
 - 1. Modular Radiant Panels:
 - a. Modular radiant panels shall use heat sinks on the back of a rigid ceiling tile to transfer heat between copper tubes and the panel face. The modular radiant panels are to radiate or absorb heat from or to the zone below.
 - b. Water Tubes: Tubes shall consist of ASTM B75 ½" nominal copper tubing. Water connections shall be one end only. Water connections shall be suitable for solder, compression fittings, push-on fittings or threaded connection.
 - c. Heat Sinks: Heat sinks shall be extruded aluminum and copper pipe will be mechanically fastened to the heat sink. A nonhardening heat transfer paste is required between the tubing and the heat sink and between the heat sink and the panel.
 - d. Face: The panel face shall be constructed of 18 or 14 ga. Aluminum with a castellated face finish.
 - e. Paint Finish: All visible components shall be powdercoated with highly emissive powder coat polyester paint for optimal radiative properties as well as durability and easy cleaning. Manufacturer shall provide water pressure drop data as well as heat and cool output data derived from tests in accordance with DIN 14037 (heating) and DIN 14240 (cooling).
 - f. Standard Color: color to be chosen by the architect, provide sample selection chart.
 - g. Modular radiant panel capacity shall be tested and certified by manufacturer in accordance with DIN 14037 (heating) and DIN 14240 (cooling) to meet the performance listed on the schedule. Should any performance rating, hot water supply temperature, water pressure drop, etc. deviate from the schedule, manufacturer shall submit updated capacity as described in Section 1.3, as well as computational fluid dynamic modeling demonstrating that any changes do not impact the air distribution in a room that would cause a detriment to the PMV and ADPI rating from the design conditions. Manufacturer shall have factory testing facility available to perform performance test of units in accordance with said standard, as required. Upon request, up to 1% of units for the project can be tested in accordance with the standard. Request will be made with order and prior to shipment of chilled sails. Engineer will have the option of witnessing this test.
 - h. Water connections shall be shipped sealed to limit the introduction of dust and dirt during shipping and construction.
 - i. Accessories:
 - 1) Manufacturer shall supply upon request 12"/18" stainless steel braided hose with isolation ball valves as required.
 - j. Panel manufacturer shall provide all necessary inter-connectors, fittings, hanger brackets, installation kits, pipe headers, accessories, 1" foil-back insulation, trimmable panels and any other components as required for a complete radiant system.

2. Linear Radiant Panels
 - a. Linear radiant panels shall use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face. The linear radiant panel is to radiate or absorb heat from or to the zone below.
 - b. Water Tubes: Tubes shall consist of ASTM B75 ½" nominal copper tubing. Water connections shall be one end only. Water connections shall be suitable for solder, compression fittings, push-on fittings or threaded connection.
 - c. Heat Sinks: Heat sinks shall be extruded aluminum and copper pipe will be mechanically fastened to the heat sink. A non-hardening heat transfer paste is required between the tubing and the heat sink.
 - d. Extruded Aluminum Plank: The panel shall be constructed of 1.2 mm thick extruded aluminum with a castellated face finish.
 - e. Paint Finish: All visible components shall be powdercoated with highly emissive powder coat polyester paint for optimal radiative properties as well as durability and easy cleaning. Manufacturer shall provide water pressure drop data as well as heat and cool output data derived from tests in accordance with DIN 14037 (heating) and DIN 14240 (cooling).
 - f. Standard Color: color to be chosen by the architect, provide sample selection chart.
 - g. Linear radiant panel capacity shall be tested and certified by manufacturer in accordance with DIN 14037 (heating) and DIN 14240 (cooling) to meet the performance listed on the schedule. Should any performance rating, hot water supply temperature, water pressure drop, etc. deviate from the schedule, manufacturer shall submit updated capacity as described in Section 1.3, as well as computational fluid dynamic modeling demonstrating that any changes do not impact the air distribution in a room that would cause a detriment to the PMV and ADPI rating from the design conditions. Manufacturer shall have factory testing facility available to perform performance test of units in accordance with said standard, as required. Upon request, up to 1% of units for the project can be tested in accordance with the standard. Request will be made with order and prior to shipment of chilled sails. Engineer will have the option of witnessing this test.
 - h. Water connections shall be shipped sealed to limit the introduction of dust and dirt during shipping and construction.
 - i. Accessories:
 - 1) Manufacturer shall supply upon request 12"/18" stainless steel braided hose with isolation ball valves as required.
 - j. Panel manufacturer shall provide all necessary inter-connectors, fittings, hanger brackets, installation kits, pipe headers, accessories, 1" foil-back insulation, trimmable panels and any other components as required for a complete radiant system.
3. Exposed Linear Radiant Panels
 - a. Wall mounted exposed linear radiant panels shall use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face. The linear radiant panel is to radiate or absorb heat from or to the zone below.
 - b. Water Tubes: Tubes shall consist of ASTM B75 ½" nominal copper tubing. Water connections shall be one end only. Water connections shall be suitable for solder, compression fittings, push-on fittings or threaded connection.
 - c. Heat Sinks: Heat sinks shall be extruded aluminum and copper pipe will be mechanically fastened to the heat sink. A non-hardening heat transfer paste is required between the tubing and the heat sink.
 - d. Extruded Aluminum Plank: The panel shall be constructed of a minimum 1.2 mm thick extruded aluminum with castellated face finish and corner wall mount option.

- e. Paint Finish: All visible components shall be powdercoated with highly emissive powder coat polyester paint for optimal radiative properties as well as durability and easy cleaning. Manufacturer shall provide water pressure drop data as well as heat and cool output data derived from tests in accordance with DIN 14037 (heating) and DIN 14240 (cooling).
 - f. Standard Color: color to be chosen by the architect, provide sample selection chart.
 - g. Linear radiant panel capacity shall be tested and certified by manufacturer in accordance with DIN 14037 (heating) and DIN 14240 (cooling) to meet the performance listed on the schedule. Should any performance rating, hot water supply temperature, water pressure drop, etc. deviate from the schedule, manufacturer shall submit updated capacity as described in Section 1.3, as well as computational fluid dynamic modeling demonstrating that any changes do not impact the air distribution in a room that would cause a detriment to the PMV and ADPI rating from the design conditions. Manufacturer shall have factory testing facility available to perform performance test of units in accordance with said standard, as required. Upon request, up to 1% of units for the project can be tested in accordance with the standard. Request will be made with order and prior to shipment of chilled sails. Engineer will have the option of witnessing this test.
 - h. Water connections shall be shipped sealed to limit the introduction of dust and dirt during shipping and construction.
 - i. Accessories:
 - 1) Manufacturer shall supply upon request 12"/18" stainless steel braided hose with isolation ball valves as required.
 - j. Panel manufacturer shall provide all necessary inter-connectors, fitting, hanger brackets, installation kits, pipe headers, accessories, 1" foil-back insulation, trimmable panels and any other unit components as required for a complete radiant system.
4. Light Shelf Radiant Panels
- a. Linear radiant panels shall use extruded aluminum with integrated heat sinks on the back to transfer heat between copper tubes and the panel face. The linear radiant panel is to radiate or absorb heat from or to the zone below.
 - b. Water Tubes: Tubes shall consist of ASTM B75 5/8" nominal copper tubing. Water connections shall be one end only. Water connections shall be suitable for solder, compression fittings, push-on fittings or threaded connection.
 - c. Heat Sinks: Heat sinks shall be extruded aluminum and copper pipe will be mechanically fastened to the heat sink. A non-hardening heat transfer paste is required between the tubing and the heat sink.
 - d. Extruded Aluminum Plank: Panels shall be interlocked using tongue & groove connections and be held together using aluminum or steel cross channels with spring clips. The panels shall be installed utilizing the concealed method. The panel shall be constructed of a minimum 1.2 mm thick extruded aluminum with a castellated face finish and corner profile.
 - e. Paint Finish: All visible components shall be powdercoated with highly emissive powder coat polyester paint for optimal radiative properties as well as durability and easy cleaning. Manufacturer shall provide water pressure drop data as well as heat and cool output data derived from tests in accordance with DIN 14037 (heating) and DIN 14240 (cooling).
 - f. Standard Color: color to be chosen by the architect, provide sample selection chart.

- g. Light shelf radiant panel capacity shall be tested and certified by manufacturer in accordance with DIN 14037 (heating) and DIN 14240 (cooling) to meet the performance listed on the schedule. Should any performance rating, hot water supply temperature, water pressure drop, etc. deviate from the schedule, manufacturer shall submit updated capacity as described in Section 1.3, as well as computational fluid dynamic modeling demonstrating that any changes do not impact the air distribution in a room that would cause a detriment to the PMV and ADPI rating from the design conditions. Manufacturer shall have factory testing facility available to perform performance test of units in accordance with said standard, as required. Upon request, up to 1% of units for the project can be tested in accordance with the standard. Request will be made with order and prior to shipment of chilled sails. Engineer will have the option of witnessing this test.
 - h. Water connections shall be shipped sealed to limit the introduction of dust and dirt during shipping and construction.
 - i. Accessories:
 - 1) Manufacturer shall supply upon request 12"/18" stainless steel braided hose with isolation ball valves as required.
 - j. Panel manufacturer shall provide all necessary inter-connectors, fitting, hanger brackets, installation kits, pipe headers, accessories, 1" foil-back insulation, trimmable panels, mounting arm for installation and any other unit components as required for a complete radiant system.
5. Approved Manufacturers:
- a. Price
 - b. TWA
 - c. Sterling
 - d. Or Equal
- D. Radiation Wall Units (RWU)
1. Double Panel Radiators
- a. General: Provide steel double panel radiators of the lengths and in locations as indicated, and of capacities, style and having accessories as scheduled. The double heating panel radiation shall be of one-piece all-welded steel construction, consisting of a pair of flattened water tube panels welded to headers at each end. Welded to the inside of each panel shall be steel corrugated fins to increase the convective output of the radiator. The fins shall start at no less than 3" from the end of the radiator, and shall have no less than 32 fins per foot. A third set of fins shall be added to the backside of the radiator for maximum convective output. The radiators shall include an integral heavy gauge (0.09" minimum) all-welded perforated top grille, which will cover the top of all of the finned areas.
 - b. The headers shall include all necessary inlet, outlet and vent connections as required. Standard connection sizes are 1/2" NPT tapered thread for supply and return piping, and 1/8" for the vent connection. Internal baffling is provided where required for proper water flow.
 - c. The radiant heating panels shall be available in lengths from 2'-0" to 29'-6" in two inch even increments without the need for splicing. The panel radiation shall be capable of being mounted to typical stud wall construction without additional blocking or strapping. Appropriate wall mounting brackets shall be provided with the radiation.
 - d. The panel radiation shall be manufactured in the USA.
 - e. Panel radiation expansion shall not exceed 1/64" per foot of radiation at 215°F. The installer shall provide adequate expansion compensation for each radiator.

- f. Finishes: The panel radiation shall be cleaned and phosphatized in preparation for the powder coat finish. The radiation is then finish painted with a gloss powder coat finish, for a total paint thickness of 2-3 mils (0.002" - 0.003"). The color shall be selected by the Architect, provide sample selection chart. Provide ribbed pipe cover trims, finished to match the radiator.
 - g. Warranty: All radiators are covered by a 5-Year Limited Warranty.
 - h. Manufacturer: Subject to compliance with requirements, provide flat tube panel radiation as manufactured by:
 - 1) Runtal North America, Inc.
 - 2) Rittling
 - 3) Sterling
 - 4) Or equal
2. Single Panel Radiators
- a. General: Provide steel panel radiator elements of lengths and in locations as indicated, and of capacities, style and having accessories as scheduled. The wall hung heating panel radiation shall be of one-piece all-welded steel construction, consisting of flattened water tubes welded to headers at each end. The radiator shall include an integral heavy gauge (0.09" minimum) all-welded perforated top grille (for curved radiators the grille is omitted). RF models to have steel corrugated fins welded to the rear side of the water tubes to increase the convective output of the unit. There shall be no less than 32 fins per foot. Fins shall start within 1" of the headers, and shall be spotwelded three times per tube.
 - b. The radiator's headers shall include all necessary inlet, outlet and vent connections as required. Standard connection sizes are 1/2" NPT tapered thread for supply and return piping, and 1/8" for the vent connection. Internal baffling is provided where required for proper water flow. Optional 3/4" connections shall be available at an additional cost.
 - c. The radiant heating panels shall be available in lengths from 2'-0" to 29'-6" in two inch even increments without the need for splicing. The panel radiation shall be capable of being mounted to typical stud wall construction without additional blocking or strapping. Appropriate wall mounting brackets or optional floor post mounting shall be provided with the radiation. Panel radiation expansion shall not exceed 1/64" per foot of radiation at 215°F. The installer shall provide adequate expansion compensation for each radiator.
 - d. The panel radiation shall be manufactured in the USA.
 - e. Pressure Ratings: Standard: Working pressure-56 PSI maximum, Test Pressure-74 PSI maximum.
 - f. Finishes: The panel radiation shall be cleaned and phosphatized in preparation for the powder coat finish. The radiation is then finish painted with a gloss powder coat finish, for a total paint thickness of 2-3 mils (0.002" - 0.003"). The color shall be selected by the Architect, provide sample selection chart. Provide ribbed pipe cover trims, finished to match the radiator.
 - g. Warranty: All radiators are covered by a 5-Year Limited Warrant.
 - h. Manufacturer: Subject to compliance with requirements, provide flat tube panel radiation as manufactured by:
 - 1) Runtal North America, Inc.
 - 2) Ritting
 - 3) Sterling
 - 4) Or equal

E. HYDRONIC FAN-COIL UNITS (FC):

1. General: Provide fan-coil units having cabinet sizes, and in locations indicated, and of capacities, style, and having accessories as scheduled. Include in factory assembled unit, chassis, coils, freezestat, fanboard, fans, housing, ECM motor, filter, and insulation. All automatic controls and communication interface board shall be provided and field installed by ATC contractor.
2. Chassis: Construct chassis of galvanized steel with flanged edges.
3. Insulation: Faced, heavy density glass fiber.
4. Cabinet: Construct of 16-ga steel removable panels, 16-ga front. Provide insulation over entire coil section. Clean cabinet parts, bonderize, phosphatize, and flow-coat with baked-on primer and finish paint color as selected by architect.
5. Coils: Construct of 5/8" seamless copper tubes mechanically bonded to configured aluminum fins. Design for 300 psi working pressure, and leak test at 300 psi under water.
6. Fans: Provide centrifugal forward curved double width wheels of reinforced fiberglass, in galvanized steel fan scrolls.
7. Motors: Provide ECM motors with integral thermal overload protection. Run test motors at factory in assembled unit prior to shipping. Provide quickly detachable motor cords. Provide speed dial for speed control.
8. Filters: Provide 1" thick MERV 8 throwaway type filters in fiberboard frames.
9. Outside And Return Air Dampers: Provide 18-ga steel damper blades with polyurethane stop across entire blade length. Provide factory-mounted electronic operators.
10. Accessories: Provide the following accessories as indicated and/or scheduled:
 - a. Inlet Grille: Provide 18-ga black painted steel with 15° blade angle.
 - b. Recessing Flanges: Provide 18-ga steel flanges for recessing fan-coil units into ceiling.
11. Manufacturer: Subject to compliance with requirements, provide fan-coil units of one of the following:
 - a. Trane
 - b. Rittling
 - c. Carrier Corp.
 - d. McQuay Inc.
 - e. Or equal (AD1.01.24)

F. HYDRONIC COILS (RHC)

1. General: Provide coils of size and in location indicated, and of capacities and having performance data as scheduled. Certify coil capacities, pressure drops, and selection procedures in accordance with ARHI 410.
2. Heating Coils:
 - a. Fins: Construct of continuous aluminum or copper configured plate-fin type with full fin collars for accurate spacing and maximum fin-tube contact.
 - b. Tubes: Construct of copper tubing, expanded into fin collars for permanent fin-tube bond and expanded into header for permanent leaktight joint.
 - c. Headers: Hydrostatically test to 400 PSI before assembly. Construct of round seamless copper tube.
 - d. Casings: Construct of 16-ga. continuous coated galvanized steel with fins recessed into channels to minimize air bypass.
 - e. Testing: Proof test coils at 300 PSI, leak test at 200 PSI under water.
3. Manufacturer: Subject to compliance with requirements, provide coils of one of the following:
 - a. Greenheck
 - b. USA Coile and Air
 - c. Precision Coil
 - d. Or Equal. (AD2.01.172)

- 2.17 TERMINAL HEATING UNITS (ELECTRIC) (Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 - COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)
- A. Electric Propeller Unit Heaters (UH)
1. Materials and Equipment:
 - a. General: Except as otherwise indicated, provide manufacturer's standard electric propeller unit heater materials and components as indicated by published product information, designed and constructed as recommended by manufacturer, and as required for a complete installation.
 2. Heating Elements:
 - a. General: Except as otherwise indicated, provide manufacturer's standard heating elements of types, sizes, capacities, and ratings for duty indicated; consisting of resistance elements in steel sheath with extended fins, or with spirally finned sheath.
 - b. Heating Capacity: Size elements for indicated fan speed, CFM, room heating load (BTUH), entering air temperature, and electric inputs (watts, voltage, phase).
 3. Casings:
 - a. General: Provide casings braced and reinforced to provide required stiffness, and with adjustable heating element supports and brackets. Provide rounded corners. Phosphatize and paint casings inside and out with single coat of baked-on enamel; and zinc plate hardware. Architect to select color, provide sample selection chart. Include fan orifice (venturi) in casing, as well as threaded hanger connections (weld nuts). Fabricate from 18-gage galvanized steel.
 4. Air Deflectors:
 - a. General: Provide manufacturer's standard air deflectors of the following types:
 - 1) 4-way finned louvers.
 - 2) Cone diffusers.
 - 3) Vane outlets.
 - 4) Louver outlets.
 5. Motors:
 - a. General: Provide totally enclosed shaded-pole, or permanent-split capacitor motors, Class "B" insulation, resiliently mounted, tap wound with built-in thermal overload protection, and with sleeve type or permanently lubricated ball bearings.
 - b. Internal Electrical Wiring: Provide units with high temperature, heat-resistant electrical wiring enclosed in flexible metal conduit extending from terminal junction box to electrical devices. Provide fusing for motor and control circuit wiring.
 - c. Devices: Provide propeller unit heaters with the following devices:
 - 1) Thermally activated fan switch to keep fan motor operating until residual heat is dissipated.
 - 2) Disconnect switch.
 - 3) Automatic reset, high limit cut-out switch located in discharge air stream.
 - 4) Magnetic contactor.
 - 5) Transformer.
 6. Fans:
 - a. General: Provide aluminum propeller fans which are balanced statically and dynamically, of indicated capacity. Provide fans suitable for standard or sparkproof application.

7. Manufacturers: Subject to compliance with requirements, provide propeller unit heaters of one if the following:
 - a. Chromalox Div.; Emerson Electric Co.
 - b. Federal Pacific Electric Co.
 - c. Gould Inc.
 - d. Markel Nuton Div.; Scoville Inc.
 - e. TPI Corporation.
 - f. Qmark
 - g. Or Equal.
- 2.18 INDUCTION TERMINAL UNIT (ACTIVE CHILLED BEAMS) (Refer to Section 019113 - GENERAL COMMISSIONING REQUIREMENTS and Section 230800 – COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)
- A. General - Induction terminal units shall be constant volume primary air flow units designed to induce a secondary airflow within the conditioned space using the primary conditioned air supply. Units shall be designed for ceiling installation with factory supplied hanger supports.
 - B. Units shall be equipped with aerodynamic primary air intake, combination supply / return air grille for a full coanda effect room air distribution, air plenum and air induction nozzles (internal to the unit). The unit shall be capable of inducing the secondary airflow within the conditioned space using the velocity pressure of the primary airflow. This secondary air flow must be directly ducted to the unit and shall not use the ceiling as a return air plenum. Induction units using the ceiling plenum as a return air path are not acceptable.
 - C. Units shall consist of an induction air plenum and mixing chamber assembly with appropriate duct connections, a baffle plate provided for uniform air distribution and noise attenuation, air induction nozzles, water coils, water piping connections, supply/return air grille and all necessary accessories to complete the design installation. The return air chamber and baffle plates shall be lined with an open cell poly insulation for sound conditioning. A drainable condensate pan shall be provided by the induction unit manufacturer. Drain shall be an IBC (International Building Code) approved $\frac{3}{4}$ " deep design, a flat drip plate will not be acceptable.
 - D. Casings - The induction air plenum and mixing chamber assembly shall be constructed of 20 gauge galvanized sheet metal. A baffle plate, insulated with closed cell anti microbial poly foam insulation, shall be provided for uniform air distribution to the nozzles and low noise operation. Casings shall be furnished with bottom mounted access panels (removable central core of unit). Tee bar mounted air diffuser shall be removable for access to interior coil area for cleaning.
 - E. Induction Nozzles - Induction nozzles shall be aerodynamically designed and made of LDPE Petrothene food grade plastic having a tapered discharge diameter for low noise levels.
 - F. Water Coil Assembly - The water coil assembly shall consist of a two row coil with copper tubes and aluminum fins, and be equipped with a drainable condensate pan to collect any condensate that could temporarily form on system start up. Vent and drain connections for each coil shall be provided at the piping assembly for air evacuation during start up.
 1. Coils shall be of the hot water type utilizing aluminum fins and copper tubes. Coils shall be factory leak tested at 300 psig. Coil connections shall be $\frac{1}{2}$ " or $\frac{3}{4}$ " NPT type as indicated on the drawings.
 2. Coils shall be removable without interfering with the remainder of the unit. A special slide out flange shall contain the coil seal between the high and low pressure side of the unit.

3. A single control valve can control one or more terminal units. Control valves for the units shall be specified and supplied and installed by the Automatic Temperature Control Contractor.

G. Quality Assurance

1. Induction Units shall be tested by ETL Labs or equivalent testing facility for Performance, Throws, and Sound Levels. Units that have not be certified for these performance factors will not be accepted. Sound Rating of units shall not exceed NC35.
2. For 4 way blow units shown, alternate manufacturers shall provide (4) one way blow units and a return grid for field installation. Two way blow units will not be acceptable.

H. Execution - Follow manufacturer's installation instructions and recommendations for all equipment. Install Induction Terminal Units in T-bar ceiling or solid sheetrock in such a manner as to allow easy access to all controls and access panels and to allow for coil removal.

1. Support Induction Terminal Units to supporting structure using field supplied threaded rod.
2. Provide primary supply air connection and seal with duct sealer after installation.
3. Provide water supply/return connection and Install temperature control valve.

I. Manufacturers – Subject to compliance with project document requirements, Units shall be as manufactured of one of the following:

1. NuClimate Air Quality Systems
2. Titus
3. Flakt Woods
4. Price
5. Or equal.

2.19 POWER AND GRAVITY VENTILATORS (Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 - COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)

A. General: Except as otherwise indicated, provide standard prefabricated power and gravity ventilator units of type and size indicated, modified as necessary to comply with requirements, and as required for complete installation.

B. Refer to Division-23 automatic temperature control for control sequence.

C. Roof Fans (EF)

1. Type: Centrifugal fan, direct or belt driven as scheduled. Provide aluminum, or galvanized steel, weatherproof housings as scheduled. Provide square base to suit roof curb. Provide permanent split-capacitor type motor for direct driven fans; capacitor-start, induction-run type motor for belt driven fans.
2. Electrical: Provide factory-wired non-fusible type disconnect switch at motor in fan housing. Provide thermal overload protection in fan motor. Provide conduit chase within unit for electrical connection.
3. Bird Screens: Provide removable bird screens, ½ in. mesh, 16-ga. aluminum or brass wire.
4. Motor Operated Dampers: Provide louvered dampers with linkage below curb base (maximum of 6 in.). Provide hinged curb access with restraint cable for service.

5. Finish: Provide two coat 70 percent Kynar/Hylar finish in color selected by Architect. Dry film thickness shall be 1.23 mil. Provide 10 year finish warranty. Submit color selection chart to Architect as part of submittal package.
 6. Manufacturer: Subject to compliance with requirements, provide centrifugal roof ventilators of one of the following:
 - a. Carnes Co., Div. of Wehr Corp.
 - b. Cook Co., Loren.
 - c. Greenheck Fan Corp.
 - d. Penn Ventilator Co., Inc.
 - e. Power Line Fans; Div. of Torin Corp.
 - f. Twin City
 - g. Or equal
- D. Prefabricated Roof Curbs
1. Manufacturer of ventilating unit shall provide his standard 18 in. high roof curb compatible with unit being provided. Curb shall be insulated and sloped to allow for level installation of device. Provide all necessary nailers, and cants for a complete installation.
- E. Centrifugal In-Line Fans (EF)
1. General: Fans shall be of the centrifugal belt or direct driven in-line type. Units shall bear AMCA label.
 2. Fan Housing: Shall be of the square design constructed of heavy gauge galvanized steel and shall include square duct mounting collars. Unit shall include two removable access panels located perpendicular to the motor mounting panel. The access panels must be of sufficient size to permit easy access to all interior components.
 3. Fan Wheel: Shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.
 4. Motors: Shall be heavy duty ball bearing type, carefully matched to the fan load and furnished at the specified voltage, phase, and enclosure. Motors and drives shall be mounted out of the airstream. Motors shall be readily accessible for maintenance.
 5. Shafts and Drives: Precision ground and polished fan shafts shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor pulleys shall be adjustable for final system balancing. A NEMA 1 disconnect switch shall be provided, factory wired.
 6. Manufacturer: Subject to compliance with requirements, provide centrifugal in-line fans of one of the following:
 - a. Cook Co., Loren.
 - b. Greenheck Fan Corp.
 - c. Twin City
 - d. Or equal

- F. Laboratory Exhaust Fans
1. General
 - a. Base fan performance at standard conditions (density 0.075 Lb/ft³).
 - b. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.
 - c. Each fan shall be belt driven.
 - d. Fans to be equipped with lifting lugs.
 - e. Fan to be coated steel with a minimum of 4 mils of Hi-Pro Polyester Resin. Color to be gray.
 - f. Fasteners to be stainless steel.
 - g. Fan assembly shall be designed for a minimum of 125 MPH wind loading, without the use of guy wires.
 2. CORROSION RESISTANT COATING
 - a. All fan and system components (fan, nozzle, wind band, plenum) shall be corrosion resistant coated with LabCoat™, a two part electrostatically applied and baked, sustainable, corrosion resistant coating system; or Heresite P-413C. Standard finish color to be selected by architect, provide sample selection chart.
 - b. All parts shall be cleaned and chemically prepared for coating using a multi-stage wash system which includes acid pickling that removes oxide, increases surface area, and improves coating bond to the substrate.
 - c. The first powder coat applied over the prepared surface shall be a zinc rich epoxy primer (no less than 70% zinc) and heated to a gelatinous consistency (partial cure) at which the second powder coat of polyester resin shall be electrostatically applied and simultaneously be cured at a uniform temperature of 400°F.
 - d. The coating system shall not be less than a total thickness of 6 mils, is not affected by the UV component of sunlight (does not chalk), and has superior corrosion resistance to acid, alkali, and solvents. Coating system shall exceed 4000 hour ASTM B117 Salt Spray Resistance.
 - e. Note that 10-20 mil thick wet coating systems pollute the environment (air and water), and that these manually applied coatings are not uniform over the impeller surface and can cause fan imbalance and vibration.
 3. FAN HOUSING AND OUTLET
 - a. Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
 - b. Fan housing shall be welded steel with a minimum of 4 mils of Hi-Pro Polyester Resin. No uncoated metal fan parts shall be acceptable.
 - c. Fan housings that are fabricated of polypropylene or fiberglass that have lower mechanical properties than steel, have rough interior surfaces in which corrosive, hazardous compounds can collect, and / or which chalk and structurally degrade due to the UV component of the sunlight shall not be acceptable.
 - d. A high velocity conical discharge nozzle shall be supplied by the fan manufacturer and be designed to efficiently handle an outlet velocity of up to 6000 FPM. Discharge stack caps or hinged covers, impeding exhaust flow shall not be permitted.
 - e. Provide housing drain for removal of rain and condensation.
 - f. A bolted and gasketed access door shall be supplied in the fan housing allowing for impeller inspection or removal of impeller, shaft and bearings without removal of the fan housing.
 - g. Standard finish color to be selected by architect, provide sample selection chart.

4. FAN IMPELLER
 - a. Fan impeller shall be centrifugal, backward inclined, with non-stall characteristics. The impeller shall be electronically balanced both statically and dynamically per AMCA Standard 204.
 - b. Fan impeller shall be manufactured of aluminum (AMCA type B spark resistant), fully welded and meet specification section 2.15 for corrosion resistant coating.
5. FAN BYPASS AIR PLENUM
 - a. A bypass air plenum shall be provided. The plenum shall be equipped with a bypass air damper and intake air hood with bird screen for introducing outside air at roof level upstream of the fan.
 - b. The plenum shall be constructed of fully welded steel, meet specification section 2.15 for corrosion resistant coating, and mount on roof curb as shown on the project drawings. Plenums that are fabricated of plastics or resins that are combustible and have mechanical properties less than steel shall not be acceptable.
 - c. The bypass air plenum shall be mounted on factory fabricated roof curb provided by the fan manufacturer, as shown on the project drawings (see section 2.5)
 - d. Fan designs that use inlet flexible connectors that can leak causing loss of lab exhaust shall not be accepted.
 - e. Bypass air dampers shall be opposed-blade design, and coated with a minimum of 4 mils of Hi-Pro Polyester resin, electrostatically applied and baked.
 - f. A fan isolation damper, two position actuated, fabricated of steel and coated with minimum 4 mils of Hi-Pro Polyester resin, electrostatically applied and baked, shall be provided as shown on the project documents.
 - g. Blower / Plenum vibration isolation shall be limited to neoprene / cork vibration pads.
6. BYPASS AIR PLENUM CURB
 - a. Exhaust system manufacturer shall supply a structural support curb for the plenum, of specified height, as shown on the drawings.
 - b. Curb shall be fabricated of a minimum of 12 gauge corrosion resistant coated steel and structurally reinforced.
 - c. Curbs shall be insulated.
 - d. When properly anchored to the roof structure, the standard curb / plenum / blower assembly shall withstand wind loads of up to 125 mph without additional structural support.
7. FAN MOTORS AND DRIVE
 - a. Motors to be premium efficiency, standard NEMA frame, TEFC with a 1.15 service factor. A factory mounted NEMA 3R disconnect switch shall be provided for each fan. Motor maintenance shall be accomplished without fan impeller removal or requiring maintenance personnel to access the contaminated exhaust components.
 - b. Drive belts and sheaves shall be sized for 200% of the motor horsepower, and shall be readily and easily accessible for service, if required. Drive shall consist of a minimum of two belts under all circumstances.
 - c. Shaft to be polished and ground steel.
 - d. Fan shaft bearings shall be Air Handling Quality, ball or roller pillow block type and be sized for an L-10 life of no less than 100,000 hours. Bearings shall be fixed to the fan shaft using concentric mounting locking collars, which reduce vibration, increase service life, and improve serviceability. Bearings that use set screws shall not be allowed.
 - e. All shaft bearings shall have extended lube lines with zerk fittings.

8. INSTALLATION
 - a. Install fans as indicated, with flexible electrical leads.
 - b. Pipe housing drain to nearest drain.
 - c. Install fans in accordance with manufacturer's instructions.
9. ACCEPTABLE MANUFACTURERS
 - a. Greenheck Fan Corp, Model Vektor High Plume Laboratory Exhaust System (as scheduled)
 - b. Strobic Air
 - c. MK Plastics
 - d. Approved equal.

2.20 VEHICLE EXHAUST SYSTEM

- A. Vehicle Exhaust Plymovent:
 1. Exhaust Blower:
 - a. Exhaust Blower shall be TEV-559, 5 HP 208 Volt, 3 Phase, 3450 RPM TEFC direct drive motor. The inlet shall be 8" diameter and the outlet shall be 8" diameter. Construction shall be class B spark resistance with power coated steel housing and aluminum wheel with shaft seals.
 2. Hose Reel:
 - a. The hose reel shall be Plymovent SER-850 spring-operated type. This hose reel function is a latch and lock type with a spring cassette housing containing a high carbon steel drive spring to retract the hose. The necessary hose length is pulled from the reel and is latched and locked into position. To retract the hose, the hose is extended slightly and automatically retracted.
 - b. The hose reel shall be constructed of 11 gauge steel side mounting plates supported by steel channels. The hose reel drum shall be 33.5" wide galvanized steel rolled into an 18" diameter and supported by bearings that allow easy rotation of the drum. The hose reel drum shall be supplied with a hose-tracking bar to guide the hose during the recoiling function. The hose reel shall be protected with a polyester powder coating finish to resist corrosion.
 - c. The flexible hose shall be 5" diameter x 33' long and be high temperature fabric with coated galvanized spring steel helix. The hose shall be resistant to chemicals from gasoline and diesel fumes. The hose must be rated for 570 deg. F.
 - d. The safety disconnect coupling with adjustable tension release shall completely separate the lower nozzle section from the upper hose assembly in the unlikely event of the exhaust nozzle becomes entangled in the wheels or the under carriage of the vehicle. This is a mandatory requirement to prevent the hose reel supports from being pulled out of the ceiling caused by excessive mechanical tension and strain. The tension of the safety disconnect systems are not acceptable. The safety disconnect coupling must be reusable.
 - e. The nozzle shall be rubber coated galvanized steel with spring clamp to secure to the vehicle's tailpipe.
 3. Air Cleaner:
 - a. The air cleaner shall be Air King Model M30, ¾ hp, 115v/1/60 two speed direct drive motor with 10 x 10 blower. Constructed of 16 gauge welded steel cabinet with front load access to filters. Cabinet dimensions 24" high x 24" wide x 72" long and weighs 175 pounds. The outlet louver is four-way directional to create to most effective air pattern. Supplied with two (2) 4" pleated prefilter and two (2) 95% micro bead fiberglass filter with total of 132 sq. ft. of media area.

- 2.21 METAL DUCTWORK (Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 - COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)
- A. Reference Standards: Material, construction and installation shall meet requirements of most recent editions of the following standards and references, except for more stringent requirements specified or shown on Drawings:
- Standard As Applicable To:
 - SMACNA HVAC Duct Sheet Metal Ductwork;
 - Construction Standards Duct Liners; Adhesives;
 - Metal and Flexible Fasteners; Flexible Ductwork.

 - SMACNA HVAC Air Duct Leakage Duct Leakage Testing Test Manual

 - SMACNA Fibrous Glass Duct Fibrous Glass Ductwork; Tapes Construction Standards

 - SMACNA Thermaoplastic Duct (PVC) PVC Ductwork Construction Manual

 - ADC and TIMA Flexible Duct Flexible Ductwork Performance Standards

 - NFPA 96 Kitchen Hood Exhaust Ductwork

 - NFPA 45 Laboratories using chemicals

 - SMACNA Guidelines for Welding Welded Galvanized, Black Iron Sheet Metal and Stainless Steel Ductwork
- B. General
1. Provide supporting and hanging devices necessary to attach entire HVAC system including ductwork and equipment, and to prevent vibration.
 2. Provide vertical and horizontal supports as required by codes to meet minimum applicable earthquake resistance standards.
 3. Ductwork shall be free from vibration under all conditions of operation. Dimensions shown on Drawings for lined ductwork are net inside dimensions. Increase ductwork to accommodate lining requirements.
 4. Pipe or conduit crossing duct:
 - a. No pipe, conduit, hanger, Architectural element nor structural member shall pass through duct without Designer's written approval.
 - b. Where it is impossible to re route pipe or conduit and when written approval has been obtained, increase duct size to maintain constant cross sectional area at point of interference. Provide streamlined enclosure for pipe or conduit, as illustrated in SMACNA.
 5. When making offsets and transformations necessary to accommodate structural conditions, preserve full cross sectional area of ductwork shown on Drawings.

6. Ductwork shall have pressure velocity classifications as follow:

DUCT CONSTRUCTION CLASS	STATIC PRESSURE RATING	PRESSURE	SMACNA SEAL CLASS	SMACNA LEAKAGE CLASS	VELOCITY
4"	4"	Pos.*	A	3	4000 fpm or less
3"	3"	Pos. or Neg.	A	3	4000 fpm or less
2"	2"	Pos. or Neg.	A	6	2500 fpm or less
1"	1"	Pos. or Neg.	A	6	2500 fpm or less
½"	½"	Pos. or Neg.	A	6	2000 fpm or less

*for negative pressures over 3" w.g., refer to SMACNA Round and Rectangular Industrial Duct Construction Standards for joint and intermediate reinforcement requirements.

7. Ductwork shall have pressure velocity classifications as follow:

DUCT CONSTRUCTION CLASS	STATIC PRESSURE RATING	PRESSURE	SMACNA SEAL CLASS	SMACNA LEAKAGE CLASS	VELOCITY
4"	4"	Pos.*	A	6	4000 fpm or less
3"	3"	Pos. or Neg.	A	6	4000 fpm or less
2"	2"	Pos. or Neg.	B	12	2500 fpm or less
1"	1"	Pos. or Neg.	B	12	2500 fpm or less
½"	½"	Pos. or Neg.	B	12	2000 fpm or less

*for negative pressures over 3" w.g., refer to SMACNA Round and Rectangular Industrial Duct Construction Standards for joint and intermediate reinforcement requirements.

- a. Unless otherwise specified or shown on the drawings, the following pressure classifications shall be used for the construction of the ductwork listed below:
- 1) 4" Class: All supply ductwork from discharge of air units to inlets of VAV boxes.
 - 2) 3" Class: All kitchen hood exhaust ductwork, fume hood, klin exhaust, all return air ductwork, ductwork between VAV outlet and displacement diffuser inlet, supply ductwork from discharge of air units to duct mounted or ceiling/wall mounted diffusers.
 - 3) 2" Class: All other ductwork.

8. Sealing Requirements for Class A, Leakage Class 3, Galvanized, Non-Welded Aluminum or Non-Welded Stainless Steel Ductwork:
 - a. Transverse Joints
 - 1) During assembly seal all flanged transverse joints with sealing tape of quality equal to Hardcast Inc. 1902-FR. Corners shall be sealed as described by SMACNA and when applicable per manufacturer's published procedures. After sealant has cured, seal entire joint with Hardcast Inc. RTA-50 adhesive on to Hardcast Inc. DT tape or approved equal.
 - 2) Seal all non-flanged transverse joints with Hardcast Inc. RTA-50 adhesive on to Hardcast Inc. DT tape or approved equal.
 - b. Longitudinal Seams
 - 1) Seal all longitudinal seams during ductwork fabrication with Hardcast Inc. Cold Seal 1001 or approved equal.
 - c. Joints and Ductwall Penetrations
 - 1) Seal all duct joints at takeoffs, access doors, damper bearing penetrations, flexible duct connections etc., with Hardcast Inc. Versa Grip 102 or approved equal.
 - 2) Note, access doors and damper rod penetrations shall be equipped with proper hardware for sealing.
9. Sealing Requirements for Class A, Leakage Class 6, Galvanized, Non-Welded Aluminum or Non-Welded Stainless Steel Ductwork.
 - a. Transverse Joints
 - 1) During assembly seal all flanged transverse joints with sealing tape of quality equal to Hardcast Inc. 1902-FR. Corners shall be sealed as described by SMACNA and when applicable per manufacturer's published procedures.
 - 2) Seal all non-flanged transverse joints with Hardcast Inc. Versa Grip 102 or approved equal.
 - b. Longitudinal Seams
 - 1) Seal all longitudinal seams during ductwork fabrication with Hardcast Inc. Cold Seal 1001 or approved equal.
 - c. Joints and Ductwall Penetrations
 - 1) Seal all duct joints at takeoffs, access doors, damper bearing penetrations, flexible duct connections etc., with Hardcast Inc. Versa Grip 102 or approved equal.
10. Sealing Requirements for Class B, Leakage Class 12, Galvanized, Non-Welded Aluminum or Non-Welded Stainless Steel, Ductwork.
 - a. Transverse Joints
 - 1) During assembly seal all flanged transverse joints with sealing tape of quality equal to Hardcast Inc. 1902-FR. Corners shall be sealed as described by SMACNA and when applicable per manufacturer's published procedures.
 - 2) Seal all non-flanged transverse joints with Hardcast Inc. Versa Grip 102 or approved equal.
 - b. Longitudinal Seams
 - 1) Seal all longitudinal seams during ductwork fabrication with Hardcast Inc. Cold Seal 1001 or approved equal.
11. Support
 - a. Space hangers as required by SMACNA (8 ft max) for horizontal duct on 8 ft. centers, unless concentrated loadings require closer spacing.
 - b. Support vertical duct on each floor or slab it penetrates.
 - c. Supports for ductwork and equipment shall be galvanized unless specified otherwise.

12. Connections
 - a. Connect inlets and outlets of air handling units and fans to ductwork with flexible connections unless fan has vibration isolator mounts inside unit with flexible connections and no external vibration isolators. Exception: Do not use flex on life safety smoke exhaust fans.
 - b. Indoors, flexible connections shall be neoprene coated fibrous glass fire retardant fabric, by Ventfabrics, or Durodyne. Outdoors, flexible connections shall be Dupont hypalon coated fibrous glass fire, weather, and UV resistant by Ventfabrics or Durodyne.
 - c. Secure flexible connections tightly to air handlers with metal bands. Bands shall be same material as duct construction.
 - d. Connections from trunk to branch ducts shall be as detailed on Drawings.
13. Construction
 - a. No sharp metal edges shall extend into air streams.
 - b. Install drive slips on air leaving side of duct with sheet metal screws on 6" centers.
 - c. Spin in collars shall NOT be used for branch connections in 3" or higher pressure class ductwork.
14. Joints
 - a. Longitudinal lock seams shall be double locked and flattened to make tight joints.
 - b. Make transverse joints, field connections, collar attachments and flexible connections to ducts and equipment with sheet metal screws or bolts and nuts. Do not use rivets and staples.
15. Prefabricated Transverse Duct Joints
 - a. Transverse joints in galvanized sheet metal ductwork may be made with galvanized gasketed frame and angle duct joint system by Ductmate, TDF, TDC or approved equal. Angles shall be at least 20 gauge. Prefabricated transverse duct joints shall not be used for duct 16 GA. and heavier, nor for duct 23 GA. or lighter.
 - b. Secure angles to duct with screws (using clutched arbor) or spot welds spaced as recommended by manufacturer for duct pressure class.
16. Elbows and Bends
 - a. Elbows and bends for rectangular ducts shall have centerline radius of 1 1/2 times duct width wherever possible. Elbows for grease exhaust and fume hood exhaust shall be full radius. Vanes or mitered duct are not allowed.
 - b. Where centerline radius is less than 1 1/2 times duct width (on supply, return and exhaust ductwork), elbows shall be radius throat (square throat allowed when turning around column or other close objects) with radius heel. For elbows whose width is greater than 48 inches and/or where shown on plans, provide splitter vanes. Install vanes in accordance with SMACNA. Where multiple elbows are separated by less than ten duct diameters use splitter (full length) vanes.
 - c. For round ductwork provide stamped elbows, with centerline radii equal to 1 1/2 times duct diameter, or gored elbows as follows:

Elbow Angle	No. of Gores
0° - 36°	2
37° - 72°	3
73° - 90°	5
 - d. Elbows for flat oval ducts shall have centerline radii equal to 1 1/2 times duct diameter in plane of bend, or gored elbows with gores as specified for round ducts.

17. Access Panels/Doors
 - a. Provide proper pressure and leakage rated, gasketed, duct mounted access panels/doors for the following items with minimum sizes, as indicated. Access doors shall be of double wall construction doors in insulated ducts shall be insulated. Gauges of door materials, no. of hinges, no. and type of door locks shall be as required by the SMACNA Duct Construction Standards. Hinged doors are not acceptable, screwed or bolted access panels are not acceptable. Doors shall be chained to frame with a minimum length of 6" to prevent loss of door. For seal Class A, access doors shall be leakage rated, neoprene gasketed UL 94 HF1 listed, DUCTMATE "sandwich" or approved equal. Door metal shall be the same as the attached duct material. For grease and high temperature ducts, door assembly shall be rated for 2300°F. The minimum sizes are:
 - 1) Fire dampers 12" x 12", or larger.
 - 2) Combination Fire/Smoke dampers 12" x 12", or larger.
 - 3) Smoke dampers 6" x 6" minimum.
 - 4) Automatic control dampers 6" x 6" minimum.
 - 5) Manual volume dampers 2 sq. ft. and larger 6" x 6" minimum.
 - 6) Inlet side to all coils 12" x 12", or larger.
 - 7) Suction and discharge sides of inline fans 24" x 24" minimum.
 - 8) At additional locations indicated on drawings, or specified elsewhere 12" x 12" minimum.
 - b. Generally access doors are not shown on the drawings, but shall be provided in accordance with the above.
18. Extractors shall have adjusting rod and locknut on outside of duct.
19. Connections to roof fans:
 - a. Shall be at least 22 ga. galvanized steel soldered watertight.
 - b. Solder side seams at least 12" up from bottom.
 - c. Provide suitable dielectric gaskets to join dissimilar materials.
20. Plenums and connections to louvers:
 - a. Shall be 18 ga. minimum cross broken and properly reinforced with galvanized angle irons to SMACNA requirements.
 - b. Shall have bottom and corner seams soldered watertight at least 12" up from bottom.
 - c. Shall have neoprene gaskets or other non corrosible material to make connections to louvers watertight.
 - d. Shall pitch connection back towards the louver. Provide half coupling drain connection at bottom of plenum unless noted otherwise Pipe drain to nearest floor drain.
 - e. Shall have unused portions of louvers blocked-off with sheet metal; sealed air and water tight; insulated with 2" thick 6 lb. density rigid or board insulation.
21. Duct Pressure Tests
 - a. Pressure test all duct classes after takeoffs and wall penetrations are in place and before applying exterior insulation. Correct any leaks.
 - b. Pressure and leak test 100% of all duct work with a pressure class of 3" or higher as specified in paragraph 2.16.B.7.a. Duct shall be constructed so there is no joint or structural failure at the test pressure.

22. Duct Leakage Tests
 - a. Leak testing method shall be performed as outlined in the SMACNA HVAC Air Duct Leakage Test Manual. As specified in paragraph 2.16.B.7 & a, utilize Sealing Requirements for Class A and Leakage Class 6 for all ductwork. Provide orifice assembly including straightening vanes, orifice plate mounted in straight tube with properly located pressure taps, and U tube manometer or other device as specified by SMACNA. Orifice assembly shall be calibrated accurately and shall come with calibration curve. Leakage classes shall be as previously specified. Submit leak test report (per SMACNA format) for Designer review. Drawings of ductwork tested shall also be submitted with report, indicating presence of takeoffs, wall penetrations, joints, etc.
23. Materials
 - a. Sheet metal ducts shall be constructed of hot dipped galvanized sheet metal with G90 Commercial coating according to ASTM 527 unless specified otherwise.
 - b. Stainless steel (SS) ductwork shall be 18 gauge for kitchen hoods; and as required by SMACNA for other ducts. Materials shall be 316/No. 4 finish for exposed duct, 304/No. 1 finish for concealed ducts. Joints and seams shall be welded as required by SMACNA Guidelines for Welding Sheetmetal.
 - c. Aluminum ductwork for dishwashers and locker rooms shall be Alclad 3003 1414 or alloy 5052 H32, of thickness required by the SMACNA duct construction standards with Alloy 6061 bracing angles, and Pittsburgh lock longitudinal corner and double side seaming.
 - d. Flexible Ductwork
 - 1) Flexible ductwork, connecting to uninsulated or unlined duct, shall be polyester core with corrosion resistant helical wire reinforcing. The polyester core shall be minimum two ply and shall have a minimum thickness of 0.0017". Flex duct shall be U.L. rated for 6" W.C. positive pressure, 2" W.C. negative pressure with a maximum velocity of 4000 FPM. Flexduct must be listed as a Class 1 Connector according to UL 181 and shall meet the requirements of NFPA 90A maximum ASTM E 84 fire hazard rating shall be 25 flame spread, 50 fuel contributed and 50 smoke developed. Uninsulated flexible duct shall be equivalent to Wiremold, Type WB, or Flexmaster Types 2 and 4 (not type 9).
 - 2) Flexible duct connected to insulated or lined duct shall also be insulated and shall be equivalent to Wiremold Type WK or Flexmaster Types 2 or 4 (not type 9), with 1 1/2", 3/4 lb. density fiberglass insulation and an aluminized reinforced vapor barrier.
 - 3) Submittals shall include data on no. of polyester plies and minimum thickness of polyester core, in addition to other data listed above required to ensure that submitted product meets the requirements of these specifications.
 - 4) If flexduct other than the model numbers of the vendors listed above is submitted, a sample of the flex shall be submitted to the Designer. The Designer shall have sole discretion in determining whether the submitted flex is equivalent to that of the named vendors above.
 - 5) Unless otherwise indicated, flexible duct shall not exceed 5'-0" long.
 - e. Rigid PVC ductwork shall be thermally formed ASTM D 1784 69 Class 12454 B with 3/16" thick wall.
- C. 2" and Lower Pressure Class Ductwork, Rectangular:
 1. Ducts wider than 19" with more than 10 square feet of unbraced panel shall be beaded or cross broken.
 2. Internal stiffening struts shall only be used upon prior written approval of the Designer.

3. Make changes in duct size with tapered connections as required by SMACNA. Changes shall NOT exceed 30° from line of air flow. Take off to the diffusers shall be 45° leading edge type or Bellmouth type.
 4. Transverse joints shall be TDF/TDC or slip joints; use flat or standing seam according to SMACNA. Where duct size requires standing seam but space restrictions dictate flat seam, notify Designer prior to fabrication.
- D. 2" and Lower Pressure Class Ductwork, Round:
1. Joints
 - a. Longitudinal joints shall be spiral seam, butt welded, lap and seam welded, or ACME lock grooved seam. Snap lock seams shall be used on ½" w.g. pressure class duct only.
 - b. Transverse joints shall be beaded sleeve joint or other approved joints listed in SMACNA. Use three or more sheet metal screws at 15" uniform intervals along circumference of joints.
 2. Branch fittings shall be conical tee (Buckley or equal) or combination tee as shown in SMACNA.
- E. 3" and 4" Pressure Class Ductwork Rectangular
1. Joints
 - a. Joints shall be prefabricated type by TDC, TDF or Ductmate. See Prefabricated Joints paragraph for specific requirements.
 2. Duct reinforcement spacing and type shall comply with SMACNA.
 3. Ductwork on both sides of transitions shall be run in same horizontal axis.
 4. Diverging section slope shall be 1 1/2" per foot or less if possible.
 5. Contraction section slope shall not exceed 7" per foot.
 6. Takeoffs shall be 45° leading edge type except that Bellmouths (Buckley or equal) may be used for takeoffs to terminal boxes if the distance between the box and point of takeoff is less than 8 ft.
 7. Ducts with an aspect ratio greater than 3:1 shall be minimum of 18 gauge unless a thicker gauge is required by SMACNA.
- F. 3" and 4" Pressure Class Ductwork, Flat Oval, Single Wall
1. Joints
 - a. Ducts shall have spiral lock seams or longitudinal seams. Seams and joints in fittings shall be continuously welded. If coating is damaged during welding, repair joints to prevent corrosion.
 - b. Transverse joints shall be slip or flanged.
- G. 3" and 4" Pressure Class Ductwork, Round, Single Wall
1. Joints
 - a. Longitudinal seams shall be lock spiral, lock longitudinal or butt welded longitudinal.
 - b. Transverse joints shall be slip joints. Draw band joints shall be used on longitudinal seam duct only. Loose flange Vanstone joints may be used on ducts over 36" in diameter.
 - c. Seams and joints in fittings shall be continuously welded. If coating is damaged during welding, repair joints to prevent corrosion.
 2. Branch fittings shall be conical tee or combination tee as detailed in SMACNA.

H. Double Wall Ductwork

1. Duct and fitting shall be United Sheet Metal Co., Acousti K27, type P, Pro-Fab Sheet Metal, HRANEC Sheet Metal or equal consisting of:
 - a. External pressure tight shell of zinc coated steel.
 - b. Uniformly packed, 1-1/2" layer of fire resistant fibrous glass acoustic insulation with R-6 value with mylar or foil liner meeting 25/50 flame spread/smoke developed rating.
 - c. Internal perforated protective metal liner of zinc coated steel, with holes sized and spaced to give acoustic impedance of noise reduction characteristic of Acousti K27 duct.
2. Pressure shell of round duct shall be United or approved equal spiral pipe and pressure shell of fittings shall be zinc coated steel, as follows:

Item	Size	Gauge of Pressure Shell
Duct	3" to 6"	26
	7" to 20"	24
	21" to 34"	22
	36" to 48"	20
Fitting	3" to 34"	20
	36" to 48"	18

3. Fittings shall be continuous, corrosion resistant welds made by certified welders.
4. Joints between straight duct sections shall be made with pre fabricated couplings with 4" shoulder inserted into duct.

I. Flexible Rigid Duct

1. Flexible ductwork shall be Flexmaster Triple Lock Buck Duct Flexible Air Duct (insulated) as manufactured by Buckley Associates or equal (617 878 5000). Flexible duct, non insulated, shall be Underwriters Laboratory Listed UL 181 Class 0 air duct and constructed in accordance with NFPA Standards 90A and 90B. It shall have a smoke/flame spread rating of 50/25.
2. Duct shall be made from a tape of dead soft aluminum sheet, spiral wound into a tube and spiral corrugated to provide strength and stability. The joint shall consist of a triple lock mechanically performed without the use of adhesives to make a durable airtight seam. A double lock is not acceptable.
3. Flexible duct connected to insulated or lined duct shall also be insulated. Flexmaster insulated flex shall have a gray Fire Retardant Polyethylene outer jacket with a 1/2 lb. density, 1 1/2" thick fiberglass insulation blanket, factory wrapped. Flexible Duct, insulated, shall be Underwriters Laboratory Listed and constructed in accordance with NFPA standards 90A and 90B. It shall have a smoke/flame spread rating of 50/25.
4. The flexible duct shall be supported as required.
5. Flexible duct work shall be rated at 12" positive pressure. Duct from 3 to 16" shall have a negative pressure of 12", 8" for duct work 18 and 20.
6. All flexible duct shall be individually cartoned and labeled for delivery to the job site for maximum protection.
7. Submittals shall include data on minimum thickness of aluminum core, in addition to other data listed above, required to ensure that submitted product meets the requirements of these specifications.
8. Provide sealing compound for installation. See further paragraphs in this specification and details for other installation requirements.

- J. Thermoplastic Ductwork (PVC)
1. PVC duct installation shall be as recommended by SMACNA Thermoplastic (PVC) Duct Construction Manual.
 2. Butt weld longitudinal and transverse joints with hot gas filter rod welding. Rods shall be compatible with material specified for duct. Stagger longitudinal seams. Weld transverse seams on 8 foot centers.
 3. Taper transition pieces 5" in length for each 1" change in diameter.
 4. Provide welded 4" wide reinforcing sleeve straps where recommended by SMACNA.
 5. Provide expansion joints where recommended and as specified by SMACNA.
 6. Provide suitable hangers and supports on eight foot centers that coincide with transverse joints as recommended by SMACNA.
- K. Volume Dampers
1. Provide Young Regulator manual adjustable rectangular opposed blade dampers for duct heights less than 12" with factory installed locking hand quadrants extended 2" for all dampers installed in externally insulated duct:
 - a. On each supply, return and general exhaust duct take off.
 - b. At each take off to register, grille or diffuser (not all are shown on Drawing).
 2. Dampers are manufactured approximately 5/16" smaller in width and 1/8" smaller in height than size of duct in which they are installed; e.g., nominal damper size is 24" x 10"; actual size is approximately 23 11/16" x 9 7/8".
 3. Damper frame shall be constructed of #6063 extruded aluminum reinforced channel with minimum thickness of .050". Opposed damper blades shall be #6063 extruded aluminum with minimum thickness of .050" and shall include reinforcing ribs. Each blade shall be supported in the damper frame by individual Teflon axle bearings, and shall be driven by stainless steel connecting slide linkage controlled by 3/8" square steel control shaft.
 4. Note: All required volume dampers may not be indicated on drawings but dampers shall be provided as necessary for systems balancing.
 5. Dampers 12" and larger in height shall be opposed multi blade equal to Greenheck, Nailor, or Vent Products.
 6. Where dampers are inaccessible, use Young Regulator locking type ceiling regulators and miter gear or worm gear for all horizontal dampers. Bearing coupling for bottom duct control may be used for shaft on vertical blade dampers. The 3/8" rod between ceiling regulator and damper shall be provided by contractor.
 7. Damper blades shall be two gauges heavier than adjoining ductwork, and shall be riveted to supporting rods. Hem over edges parallel to rods.
 8. Brackets shall be galvanized metal, secured to ductwork with sheet metal screw with locking quadrant arms (see seal class section for additional requirements). Provide 2" handle extension for all dampers on externally insulated ductwork.
 9. Note: All required volume dampers may not be indicated on Drawings but dampers shall be provided as necessary for system balancing.
- L. Automatic Dampers: Install automatic dampers furnished under Automatic Temperature Control Paragraph of this Section, as shown on Drawings, and as specified. Provide sealed wall penetrations for Seal Class A ductwork.
- M. Locker Room Exhaust or Return Ductwork
1. Ductwork shall be aluminum, of types as detailed in this specification above and constructed in accordance with SMACNA except that Seal Class shall be "A" regardless of duct pressure rating.

N. Branch Duct Take off Fittings

1. Contractor shall provide Buckley Bellmouth Take offs at all branch duct locations.
2. Bellmouth Fitting shall be Model BMD with damper. In areas where sufficient duct height is not available, the contractor shall provide the Buckley Mini mouth fitting, Model M BMD with damper or the flat oval Bellmouth, Model FOBMD with damper.
3. Bellmouths shall be constructed of heavy duty galvanized steel. Bellmouths shall include an air tight Neoprene gasket to ensure a tight fitting with minimal leakage. Pre drilled holes shall be provided for quick mounting. Bellmouth shall be as manufactured by Buckley Associates or equal (617 878 5000).
4. Standard damper hardware to be constructed of 26 gauge galvanized material with a quadrant damper and tight fitting gasketing to ensure minimal leakage at damper pivot points.
5. Optional heavy duty hardware shall be provided at locations of higher static pressure where shown on the drawings.
6. Ninety degree take offs are not permitted on this project.

2.22 DUCTWORK ACCESSORIES (Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 - COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)

A. Dampers:

1. Low Pressure Manual Dampers: Provide dampers of single blade type or multi-blade type, constructed in accordance with SMACNA "HVAC Duct construction Standards".
2. Automatic Control Dampers: Refer to Division 23 section "Automatic Temperature Control" for control dampers; not work of this section.
3. Backdraft Relief Dampers: Provide dampers with parallel blades, counterbalanced and factory-set to relieve at .05 in. static pressure. Construct blades of 16-ga. aluminum; provide ½ in. diameter ball bearings, 1/2 in. diameter steel axles spaced on 9 in. centers. Construct from 2 in. x 1/2 in. x 1/8 in. steel channel for face areas 25 sq. ft. and under: 4 in. x 1-1/4 in. x 16 ga. channel for face areas over 25 sq. ft. Provide galvanized steel finish on frame with aluminum touch-up. Provide felted or rubber trim to assure tight, leak-proof seal when closed.
4. Manufacturer: Subject to compliance with requirements, provide dampers of one of the following:
 - a. Air Balance, Inc.
 - b. Airguarde Corp.
 - c. American Warming & Ventilating, Inc.
 - d. Arrow Louver and Damper; Div. of Arrow United Industries, Inc.
 - e. Louvers & Dampers, Inc.
 - f. Penn Ventilator Co.
 - g. Ruskin Mfg. Co.
 - h. Or Equal.

B. Fire Dampers:

1. Fire Dampers: Provide fire dampers, of types and sizes indicated. Construct casings of 11-ga. galvanized steel. Provide fusible link rated at 160 to 165 degrees F (71 to 74 degrees C) unless otherwise indicated. Provide out of air stream type damper in open position and with positive lock in closed position with stainless steel heat treated type 301 closure spring, and with the following additional features:
 - a. Damper Blade Assembly: Curtain type.
 - b. Blade Material: Steel, match casing.
 - c. Blade Material: Stainless steel.

2. Combination Fire/Smoke Dampers: Provide fire/smoke dampers, of types and sizes indicated. Construct casing of 11-ga. galvanized steel with bonded red acrylic enamel finish. Provide fusible link rated at 160 to 165 degrees F (71 to 74 degrees C) unless otherwise indicated. Provide additional frangible link containing explosive charge, connected in series with fusible link. Provide stainless steel spring loaded leakage seals in sides of casing, and 36 in. long wire leads for connecting smoke link to smoke detector, and the following additional features:
 - a. Damper Blade Assembly: Single-blade type.
 - b. Damper Blade Assembly: Multi-blade type.
 - c. Damper Blade Assembly: Curtain type.
 - d. Blade Material: Steel, matching casing.
 - e. Blade material: Stainless steel.
 3. Motor-Driven Fire/Smoke Dampers: Provide motor-driven fire/smoke dampers in types and sizes indicated, with casing constructed of 11-ga. galvanized steel with bonded red acrylic enamel finish, fusible link 160 to 165 degrees F (71 to 74 degrees C), unless otherwise indicated, and curtain type stainless steel interlocking blades, with electric motor equipped with instant closure clutch, stainless steel cable damper blade linkage, motor mounting bracket, and 32 in. long wire leads for connecting to smoke detector, and with the following construction features:
 - a. Unit Assembly: Motor mounted outside air stream.
 4. Manufacturer: Subject to compliance with requirements, provide fire and smoke dampers of one of the following:
 - a. Air Balance, Inc.
 - b. American Warming & Ventilating, Inc.
 - c. Arrow Louver and Damper; Div. of Arrow United Industries, Inc.
 - d. Louvers & Dampers, Inc.
 - e. Penn Ventilator Co.
 - f. Phillips-Aires
 - g. Ruskin Mfg. Co.
 - h. Or Equal.
- C. Model: FSD-200 series combination fire smoke dampers.
1. Ratings:
 - a. HVAC Contractor shall verify wall ratings utilizing the architectural code plan.
 - b. Fire Closure Temperature: Each combination fire smoke damper shall be equipped with a factory installed heat responsive device rated to close the damper when the temperature at the damper reaches 165°F
 - c. Leakage: Dampers shall have a UL555S leakage rating of Leakage Class I or II.
 - d. Differential Pressure: Dampers shall have a minimum UL 555S differential pressure rating of 4 in. wg.
 - e. Velocity: Dampers shall have a minimum UL 555S velocity rating of 2000 fpm.
 2. Construction:
 - a. Frame: Damper frame shall be 16 ga. galvanized steel formed into a 5" x 1" structural hat channel. Top and bottom frame members on dampers less than 17" high shall be low profile design to maximize the free area of these smaller dampers. Frame shall be 4-piece construction with 1 1/2" (minimum) integral overlapping gusset reinforcements in each corner to assure square corners and provide maximum resistance to racking.
 - b. Blades: Damper blades shall be 16 ga. galvanized steel strengthened by three longitudinal 1" deep Vee grooves running the entire length of each blade. Each blade shall be symmetrical relative to its axle pivot point, presenting identical performance characteristics with air flowing in either direction through the damper. Provide symmetrical blades of varying size as required to completely fill the damper opening.

- c. Blade Stops: Each blade stop (at top and bottom of damper frame) shall occupy no more than ½" of the damper opening area to allow for maximum free area and to minimize pressure loss across the damper.
 - d. Seals:
 - 1) Blade Edge: Blade seals shall be extruded silicone rubber permanently bonded to the appropriate blade edges.
 - 2) Jamb: Flexible stainless steel compression type.
 - 3. Linkage: Concealed in jamb.
 - a. Axles: Minimum ½ inch dia. plated steel. Frame: Galvanized steel (in gauges required by manufacturer's UL listing).
 - b. Sleeves: Damper shall be supplied as a single assembly with an integral factory sleeve.
 - c. Retaining Angles: Damper shall be supplied with factory retaining angles sized to provide installation overlap in accordance with the manufacturer's UL listing.
 - d. Bearings: Axle bearings shall be sintered bronze sleeve type rotating in polished extruded holes in the damper frame.
 - 4. Actuators:
 - a. Type: Electric, 120V AC, 2-position
 - b. Mounting: External
 - 5. Source quality control
 - a. Factory Tests: Factory cycle damper and actuator assemblies to assure proper operation.
 - 6. Manufacturer: Subject to compliance with requirements, provide fire and smoke dampers of one of the following:
 - a. Air Balance, Inc.
 - b. American Warming & Ventilating, Inc.
 - c. Arrow Louver and Damper; Div. of Arrow United Industries, Inc.
 - d. Louvers & Dampers, Inc.
 - e. Penn Ventilator Co.
 - f. Phillips-Aires
 - g. Greenheck
 - h. Or Equal.
- D. Turning Vanes:
- 1. Manufactured Turning Vanes: Provide double thickness airfoil turning vanes constructed of 1-1/2 in. wide curved blades set at ¾ in. o.c., supported with bars perpendicular to blades set at 2 in. o.c, and set into side strips suitable for mounting in ductwork.
 - 2. Manufacturer: Subject to compliance with requirements, provide turning banes of one of the following:
 - a. Aero Dyne Co.
 - b. Airsan Corp.
 - c. Anemostat Products Div.; Dynamics Corp. of America.
 - d. Barber-Colman Co.
 - e. Duro Dyne Corp.
 - f. Environmental Elements Corp.; Subs, Koppers Co., Inc.
 - g. Hart & Cooley Mfg. Co.
 - h. Register & Grille Mfg. Co., Inc.
 - i. Southern, Inc.
 - j. Or Equal.

- E. Duct Hardware:
1. General: Provide duct hardware, manufactured by one manufacturer for all items on project, for the following:
 - a. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated, duct test holes, consisting of slot and cover, for instrument tests.
 - b. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12 in.. Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.
 2. Manufacturer: Subject to compliance with requirements. Provide duct hardware of one of the following:
 - a. Ventfabrics, Inc.
 - b. Young Regulator Co.
 - c. Ductmate Industries, Inc.
 - d. Or Equal.
- F. Duct Access Doors:
1. General: Provide duct access doors of a size as required to service and maintain device in duct. All access doors to be a minimum of 12 in.x12 in. and to be gasketed and installed air tight. Provide one access door at each control damper, humidifier, coil, fire damper, and any device that requires attention.
 2. Construction: Construct of same or greater gage as ductwork served, provide insulated doors for insulated ductwork. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. Provide one side hinged, other side with one handle-type latch for doors 12 in. high and smaller, 2 handle-type latches for larger doors.
 3. Manufacturer: Subject to compliance with requirements, provide duct access doors of one of the following:
 - a. Air Balance, Inc.
 - b. Duro Dyne Corp.
 - c. Register & Grille Mfg. Co., Inc.
 - d. Ruskin Mfg. Co.
 - e. Ventfabrics, Inc.
 - f. Zurn Industries, Inc.; Air Systems Div.
 - g. Or Equal.
- G. Flexible Connectors:
1. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibration of connected equipment.
 2. Manufacturer: Subject to compliance with requirements, provide flexible connections of one of the following:
 - a. American/Elgen Co.; Energy Div.
 - b. Duro Dyne Corp.
 - c. Flexaust (The) Co.
 - d. Ventfabrics, Inc.
 - e. Or Equal.

2.23 ACOUSTIC DUCT LINING

- A. Lining for Rectangular Metal Ducts: All ducts, where shown or noted on the drawings, shall be lined with 1-1/2 in. (R-6) thick hospital grade liner similar to "Permacotge Linacoustic RC" fiberglass duct liner with factory-applied surface and edge coating. The liner shall meet the Life Safety Standards as established by NFPA 90A and 90B, FHC 25/50 and Limited Combustibility and the airstream surface coating should contain an immobilized, EPA-registered, anti-microbial agent so it will not support microbial growth as tested in accordance with ASTM G21 and G22. The duct liner shall conform to the requirements of ASTM C 1071 and C1104, with an NRC not less than .75 as tested per ASTM C 423 using a Type "A" mounting, and a thermal conductivity no higher than .24 at 75EF mean temperature.
- B. Material Handling and Storage: Liner shall be kept clean and dry during transportation, storage and installation. Care should be taken to protect the liner from exposure to the elements or damage from mechanical abuse.
- C. Manufacturer: Subject to compliance with the above, provide duct sound lining in accordance with the above performance criteria description.

2.24 SOUND ATTENUATORS (SA)

- A. General: Provide factory-fabricated and tested duct silencers as indicated, select with performance characteristics which match, or exceed those indicated on schedule.
- B. Casings: Construct of sheet metal, with gage and seam construction equal or greater than that recommended by SMACNA-Duct Construction Standards for ductwork of same size and pressure class; but not less than gauge dimension recommended by manufacturer to meet the DIL requirements based upon application (or 16-gage for outer casing and 20-gage for inner casing, refer to schedule for further info and requirements).
- C. Acoustic Fill: Provide inorganic mineral or mold blocking cloth lining material, inert, vermin and moisture proof, of sufficient density to obtain specified acoustic performance. Pack under not less than 5 percent compression to eliminate voids due to vibration and settling. Acoustic fill shall be covered and protected with hospital grade film type liner.
- D. Acoustic Performance: Provide silencer ratings that have been determined in such to reverberative room test facility. Test silencer with air flow in both directions through silencer, in accordance with ASTM E477, "Methods of Testing Duct Liner Materials and Prefabricated Silencers for Acoustical and Airflow Performance."
 - 1. For acoustic ratings, include Dynamic Insertion Loss and Self Noise Power Levels for both forward flow (air and noise in same direction) and reverse flow (air and noise in opposite directions) with airflow of at least 2,000 FPM face velocity.
- E. Aerodynamic Performance: Provide silencers with static pressure loss equal to or less than that scheduled.
- F. Certification: Provide certified test data on Dynamic Insertion Loss, Self-Noise Power Levels, and Aerodynamic Performance. Conduct all rating tests at same facility. Open testing facility for inspection by Architect/Engineer if requested.

- G. Manufacturers: Subject to compliance with requirements, provide duct silencers of one of the following:
1. Kinetics
 2. Vibro-Acoustics
 3. Price
 4. Or Equal.
- 2.25 AIR OUTLETS AND INLETS (Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 - COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)
- A. Ceiling Air Diffusers:
1. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation. Stamped face diffusers will not be acceptable.
 2. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw, drop and noise criteria ratings for each size device as listed in manufacturer's current data.
 3. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.
 4. Types: Provide ceiling diffusers of type, capacity, throw, blow and with accessories as listed on diffuser schedule.
 - a. Ceiling Diffusers shall be of the restricted multi-orificed jet induction and air mixing type consisting of louver sections with built-in diffusing vanes. The vanes shall be arranged to discharge air from adjacent louvers at an angle of 45 degrees in opposite directions to insure rapid mixing of primary and room air. Diffusing vanes shall be welded and mechanically fastened to the adjacent louver sections to make a rigid unit. The vanes shall extend to the discharge edges of the louvers. Where louver sections join the core frame, the louver ends shall be welded to the core frame. The leaving edge of each louver shall be hemmed and the louver ends shall be rounded and hemmed before welding to the core frames.
 - b. Diffusers shall be fabricated of aluminum or steel-welded construction, and shall be provided with a removable core permitting easy access to the neck connection. The diffuser neck shall extend no less than 1 in. above the core to accommodate an internal duct connection to prevent leakage into the ceiling space.
 - c. Finish shall be baked enamel. Color as selected by architect, provide sample selection chart.
 - d. Plaque diffuser shall be one piece seamless back cone with round inlet color and inner removable plaque assembly.
 5. Diffuser Dampers:
 - a. Opposed Blade: Adjustable opposed blade damper assembly, key operated from face of diffuser. Provide in each ceiling diffuser.

6. Manufacturer: Subject to compliance with requirements, provide diffusers of one of the following:
 - a. Tuttle & Bailey Agitair Series
 - b. Metalaire – “5000 IV”
 - c. Price
 - d. Nailor
 - e. Or Equal
- B. Wall Registers and Grilles:
1. General: Except as otherwise indicated, provide manufacturer's standard registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
 2. Performance: Provide registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device and listed in manufacturer's current data.
 3. Compatibility: Provide registers and grilles with border styles that are compatible with adjacent systems, and that are specifically manufactured to fit into wall and ceiling construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of construction which will contain each type of register and grille.
 4. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as listed on register and grille schedule:
 5. Pattern: Register and grille patterns shall have style as identified on Drawings:
 6. Dampers: Opposed Blade adjustable assembly, key operated from face of register.
 7. Accessories:
 - a. Plaster Frame: Perimeter frame designed to act as plaster stop and register or grille anchor. Provide where required.
 - b. Operating Keys: Tools designed to fit through register or grille face and operate volume control device and/or pattern adjustment.
 8. Finish: Register and Grille Finishes shall be baked enamel. Color as selected by architect, provide sample selection chart.
 9. Manufacturer: Subject to compliance with requirements, provide registers and grilles of one the following:
 - a. Agitair (Air Devices)
 - b. Metalaire
 - c. Price
 - d. Nailor
 - e. Or Equal.
- C. Ceiling Registers and Grilles:
1. General: Except as otherwise indicated, provide manufacturer's standard "Egg-Crate" type registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
 2. Compatibility: Provide registers and ceiling grilles with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling construction.
 3. Types: Provide registers and grilles of type, capacity, and with accessories and finishes as listed on register and grille schedule.
 4. Register and Grille Materials:
 - a. Aluminum Construction: Manufacturer's standard extruded aluminum frame and core.
 5. Register and Grille Faces:
 - a. 1/2 in. x 1/2 in. "Egg-Crate" with one in. border frame.

6. Register and Grille Dampers:
 - a. Opposed Blade: Adjustable opposed blade damper assembly, key operated from face of register (provide for registers only).
 7. Register and Grille Finishes shall be baked enamel. Color as selected by architect, provide sample selection chart.
 8. Manufacturer: Subject to compliance with requirements, provide registers and grilles of one of the following:
 - a. Agitair (Air Devices)
 - b. Metalaire
 - c. Price
 - d. Nailor
 - e. Or Equal.
- D. In Wall Displacement Diffuser
1. Description: Furnish and install in wall displacement diffusers with the sizes and capacities indicated on the plans and air outlet schedule.
 2. Performance: Air shall be delivered to the space at low noise levels and low velocities that are even across the diffuser face, in all ducting configurations and without the use of nozzles.
 3. Diffuser Manufacturer shall provide sound and pressure drop data derived from tests in accordance with ASHRAE Standard 70-2006. Performance data for Draft Rate (%DR) shall be provided based on tests in accordance with ASHRAE Standard 55-2004. A manufacturer software program that allows room comfort evaluation for specific operating conditions and diffuser locations shall be available to aid in performance assessment. If such a computer program is not available from the manufacturer, the manufacturer shall supply, free of charge, a CFD model of the representative spaces completed by a modeling contractor who has demonstrable qualifications to model such spaces. These shall include no less than 10 years of experience in the modeling of displacement ventilation systems, thorough validation of the code through comparison to empirical data as well as a list of references.
 4. Construction: The 1 way flat faced in-wall displacement diffuser, shall be constructed with an equalization baffle behind the operative diffuser face for uniform, low velocity, distribution of supply air. Both the equalization baffle and face shall be securely retained in the diffuser frames. Plastic nozzle arrays or any plastic components are unacceptable. The diffuser frames shall be constructed of 20 gauge steel for rigidity and protection of the operative face. The operative face shall be constructed of painted 18 gauge perforated steel, and the frame shall be provided in painted 20 gauge steel. The plenum shall be 24 gauge steel. The internal baffling elements shall be constructed of aluminum. The diffuser shall be available for duct connection at the top. The paint shall be powder coat polyester, color as selected by architect, provide sample selection chart. Epoxies and their derivatives are unacceptable. Visible non-metallic components are unacceptable.
 5. Mounting/Fastening: The diffuser front panel shall be bolted to the plenum through the wall with factory provided fasteners.
 6. Manufacturer: Subject to compliance with requirements, provide flat faced displacement diffusers of one of the following:
 - a. Price
 - b. Metalaire
 - c. Trox
 - d. Nailor
 - e. Or Equal.

E. Flat Face Displacement Diffusers

1. Description: Furnish and install flat face displacement diffuser with the configurations and mounting types indicated on the plans and air outlet schedule.
2. Performance: Air shall be delivered to the space at low noise levels and low velocities that are even across the diffuser face, in all ducting configurations and without the use of nozzles. Diffuser Manufacturer shall provide sound and pressure drop data derived from tests in accordance with ASHRAE Standard 70-2006. Performance data for Draft Rate (%DR) shall be provided based on tests in accordance with ASHRAE Standard 55-2004. A software program that allows room comfort evaluation for specific operating conditions and diffuser locations shall be available to aid in performance assessment. If such a computer program is not available from the manufacturer, the manufacturer shall supply, free of charge, a CFD model of the representative spaces completed by a modeling contractor who has demonstrable qualifications to model such spaces. These shall include no less than 10 years of experience in the modeling of displacement ventilation systems, thorough validation of the code through comparison to empirical data as well as a list of references.
3. Construction: The 1 way flat faced recessed displacement diffuser shall be constructed with an equalization baffle behind the operative diffuser face for uniform, low velocity, distribution of supply air. Both the equalization baffle and face shall be securely retained in the diffuser frames. Plastic nozzle arrays or any plastic components are unacceptable. There shall be no visible fasteners on the front panel. The operative face shall be constructed of painted 18 gauge perforated steel. The installation frame shall be constructed of 24 gage steel. The internal baffling elements shall be constructed of aluminum. The paint shall be powder coat polyester, color as selected by architect, provide sample selection chart.. Epoxies and their derivatives are unacceptable. Visible non-metallic components are unacceptable. The diffuser shall be supplied with an installation frame for recessed installation that is not visible from the room. (The diffuser shall be supplied with an installation frame for recessed installation which allows the diffuser to be installed in areas where plaster is required).
4. Mounting/Fastening: The diffuser shall be installed within the manufacture provided plenum, refer to details sheet M2.4 for further information. Plenum to be provided with mounting clips, all by diffuser manufacture. The diffuser shall have no visible fasteners or framing, and shall be held within the supplied plenum via secure mounting clips.
5. Manufacturer: Subject to compliance with requirements, provide flat faced displacement diffusers of one of the following:
 - a. Price
 - b. Metalaire
 - c. Trox
 - d. Nailor
 - e. Or Equal.

F. Ceiling Mounted Displacement Diffusers

1. Description: Furnish and install ceiling mounted displacement diffuser with the sizes and capacities indicated on the plans and air outlet schedule.

2. Performance: Air shall be delivered to the space at low noise levels and low velocities that are even across the diffuser face in all ducting configurations and without the use of nozzles. Diffuser Manufacturer shall provide sound and pressure drop data derived from tests in accordance with ASHRAE Standard 70-2006. Performance data for Draft Rate (%DR) shall be provided based on tests in accordance with ASHRAE Standard 55-2004. A manufacturer software program that allows room comfort evaluation for specific operating conditions and diffuser locations shall be available to aid in performance assessment. If such a computer program is not available from the manufacturer, the manufacturer shall supply, free of charge, a CFD model of the representative spaces completed by a modeling contractor who has demonstrable qualifications to model such spaces. These shall include no less than 10 years of experience in the modeling of displacement ventilation systems, thorough validation of the code through comparison to empirical data as well as a list of references.
 3. Construction: The 1 way flat faced ceiling mounted Displacement diffuser shall be constructed with an equalization baffle behind the operative diffuser face for uniform, low velocity, distribution of supply air. Both the equalization baffle and face shall be securely retained in the diffuser frames. Plastic nozzle arrays or any plastic components are unacceptable. The diffuser frames shall be constructed of high strength aluminum extrusion for rigidity and protection of the operative face and side panels. There shall be no visible fasteners on the front or side panels. The operative face shall be constructed of painted 18 gauge perforated steel, and the frame shall be provided in painted 20 gauge steel. The internal baffling elements shall be constructed of Aluminum. The diffuser shall be available for duct connection at the top, bottom, side or rear of the diffuser with a factory inlet. The paint shall be powder coat polyester, color as selected by architect, provide sample selection chart. Epoxies and their derivatives are unacceptable. Visible non-metallic components are unacceptable.
 4. Mounting/Fastening: The diffuser shall integrate into standard T-Bar ceilings and shall have no visible fasteners.
 5. Manufacturer: Subject to compliance with requirements, provide flat faced displacement diffusers of one of the following:
 - a. Price
 - b. Metalaire
 - c. Trox
 - d. Nailor
 - e. Or Equal.
- G. Linear Diffusers
1. Linear slot diffusers shall be furnished and installed as indicated on the drawings.
 2. Provide shop drawings accompanied by itemized list indicating units' location and appropriate product submittal drawings provided by the manufacturer.
 3. Exact dimensions of walls and ceiling are as per the architectural drawings. Install diffusers so they fit properly in the ceiling system with suspension wire (48 in. o/c MAX.) and/or attachment plates — as required.
 4. Coordinate installation with General Contractor and other sub-contractors.
 5. The linear slot diffuser shall utilize heavy wall extruded aluminum air deflector frames. These frames shall be designed to accommodate notched compressible space bars, complete with integral hanger, spaced approximately 24 in. on center. The steel air pattern controllers are fully adjustable and can be moved from side to side to create various air pattern configurations. These dual pattern controllers shall be fully adjustable to allow shut-off without adding any blank-off devices. The spacer bars and pattern controllers shall be removable for on-site modification and trimming.
 6. The Linear slot diffuser shall be complete with factory end conditions as shown or indicated.
 7. Supply air engineered plenums shall be provided and manufactured of heavy gauge wipe coat steel. These units shall be insulated with a side inlet collar.

8. When engineered plenum end caps cannot be positioned directly over the linear spacer bar due to field conditions, install MB Blank-Off from plenum end cap to next spacer bar.
9. MB Blank-Off shall be manufactured of heavy gauge steel painted black.
10. Linear Bar Grilles: Furnish and install extruded bar supply/return grilles of the sizes and mounting types indicated on the plans and outlet schedule.
 - a. Construction: Grilles shall have fixed degree blades, spaced 7/16 in. on center. The outlet core shall have extruded aluminum receiving bar. Blades shall run parallel to the long dimension of the grille. The grille border shall be heavy duty extruded aluminum construction with factory mitered corners and reinforcing support bars for extra support for the core receiving bar. The support and receiving bars shall not exceed 8 in. on center. The core shall be held into the border with removable core clips allowing the removal of the core without special tools.
 - b. Finish: The grille shall be finished, color as selected by architect, provide sample selection chart. Paint finish shall pass 500 hours of salt spray exposure with no measurable creep in accordance with ASTM D1654 and 1000 hours with no rusting or blistering as per ASTM D610 and ASTM D714.
 - c. Manufacturer: Subject to compliance with requirements, provide linear bar grilles of one of the following:
 - 1) Agitair
 - 2) Tuttle & Bailey
 - 3) Metalaire
 - 4) Price
 - 5) Nailor
 - 6) Or equal

2.26 DUCTLESS COOLING UNITS (Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 - COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)

A. Evaporator:

1. General: The unit shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board, and fan motor. The unit in conjunction with the wired, wall mounted controller shall have a self-diagnostic function, three-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry nitrogen before shipment from factory.
2. Cabinet: The casing shall be ABS plastic factory finish. Cabinet shall be designed for suspension mounting and horizontal operation. The rear cabinet panel shall have provisions for a field installed filtered outside air intake connection.
3. Fan: The evaporator fan shall have three high performance, double inlet, forward curve sirocco fans driven by a single motor. The fans shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The indoor fan shall consist of four speeds: Low, M1, M2 and Hi.
4. Vane: There shall be a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction for uniform air distribution. The horizontal vane shall provide a choice of five vertical airflow patterns selected by remote control. There shall also be a set of vertical vanes to provide horizontal swing airflow movement selected by remote control.
5. Filter: Return air shall be filtered by means of an easily removable washable filter.

6. Coil: The evaporator coil shall be of nonferrous construction with pre-coated aluminum strake fins on copper tubing. The multi-angled heat exchanger shall have a modified fin shape that reduces air resistance for a smoother, quieter airflow. All tube joints shall be brazed with PhosCopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil.
 7. Control: The control system shall consist of two microprocessors, one on each indoor and outdoor unit, interconnected by a single non-polar two-wire cable. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. For A-Control, a three conductor 14 ga. AWG wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units. Where separate power is supplied to the indoor and outdoor units, a two 20 ga. AWG wire shall be run between the units to provide forbid-directional control communication. The system shall be capable of automatic restart when power is restored after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostics codes for indoor and outdoor units shall be displayed on the wired controller panel.
- B. Condensing:
1. General: The outdoor unit shall be equipped with a control board that interfaces with the indoor unit to perform all necessary operation functions. The outdoor unit shall be capable of operating at 0 degrees F, (-18 degrees C) ambient temperature without additional low ambient controls. The outdoor unit shall be able to operate with a maximum height difference of 100 ft. and have maximum refrigerant tubing length of 165 ft. between indoor and outdoor units without the need for line size changes, traps or additional oil. The outdoor unit shall be completely factory assembled, piped, and wired. Each unit must be test run at the factory.
 2. Cabinet: The casing shall be constructed from galvanized steel plate, coated with a finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection and have a factory finish. The fan grille shall be of ABS plastic.
 3. Fan: The fan motor shall be of aerodynamic design for quiet operation, and the fan motor bearings shall be permanently lubricated. The outdoor unit shall have horizontal discharge airflow. The fan shall be mounted in front of the coil, pulling air across if from the rear and dispelling it through the front. The fan shall be provided with a raised guard to prevent contact with moving parts.
 4. Coil: The L shaped condenser coil shall be of copper tubing with flat aluminum fins to reduce debris build up. The coil shall be protected with an integral metal guard. Refrigerant flow from the condenser shall be controlled by means of linear expansion valve (LEV) metering orifice. The LEV shall be control by a microprocessor controlled step motor.
 5. Compressor: The compressor shall be a scroll compressor with variable speed inverter technology. The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system which results in vast energy savings. To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be intermittently applied to the compressor motor to maintain enough heat. The outdoor unit shall have an accumulator and high pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration.
 6. Electrical: The electrical power of the unit shall be as indicated on the drawings. The outdoor unit shall be controlled by the microprocessor located in the indoor unit. The control signal between the indoor unit and the outdoor unit shall be pulse signal 24 volts DC. The unit shall have Pulse Amplitude Modulation circuit to utilize 98 percent of input power supply.
 7. Provide BMS interface for system status monitoring.

8. Warranty: Provide a five year parts warranty for all components.
9. Manufacturer: Subject to compliance with requirements provide DCU AC Units of one of the following:
 - a. LG
 - b. Mitsubishi
 - c. Daikin
 - d. Or Equal

2.27 CONDENSATE DISCHARGE PUMPS (Refer to various equipment schedules for locations and Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 – COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)

- A. General: Provide where indicated, condensate pumps of capacity as scheduled, to be field installed in various air handling equipment drain pans, consisting of ABS housing, pump, check valve, safety switch, and thermal overload protection. Factory assembled unit must be UL/CSA listed.
- B. High-Capacity Pumps
 1. Reservoir: Construct of ABS plastic with a 3/10 capacity volume.
 2. Pump: 25 GPH at 15TDH vertical type pump with stainless steel motor shaft, rustproof, ABS volute, with safety switch.
 3. Housing and Cover: Each shall be ABS plastic.
 4. Manufacturers: Subject to compliance with requirements, provide high-capacity condensate pump of Little Giant, Sauermann, Hartell, or approved equal:
- C. Low-Capacity Pumps
 1. Pump: 8 GPH at 33TDH reciprocating piston pump direct discharge with no storage reservoir.
 2. Detection Unit: Low-maintenance filter free with a three level float (on/off/alarm).
 3. Pump Housing and Detection Unit: Each shall be ABS plastic.
 4. Manufacturers: Subject to compliance with requirements, provide low-capacity condensate pump of Sauermann, Hartell (Nano), Little Giant, or approved equal.

2.28 VARIABLE AIR VOLUME BOX (VAV)

- A. General: Provide factory-fabricated and tested air terminals as shown on drawings, selected with performance characteristics which match or exceed those indicated on schedule.
- B. Casings: Construct of die-cast aluminum or sheet metal of the following minimum thicknesses:

	Steel	Aluminum
1. Upstream Pressure Side:	22-ga.	0.032 in.
2. Downstream Pressure Side;	22-ga.	0.025 in.

 3. Provide hanger brackets for attachment of supports.
 4. Linings: Line inside surfaces of casings with hospital grade lining material meeting ASTM Standard C1071 to provide acoustic performance, thermal insulation, and to prevent condensation on outside surfaces of casing. Provide minimum thickness of 1 in. Secure lining to prevent delamination, sagging or settling. Seal edges of lining to prevent fraying.
 - a. Cover liner surfaces and edges with mylar, foil or perforated metal.

5. Leakage: Construct casings such that when subjected to 0.5-in w.g. pressure for low pressure units, and 3.0-in w.g. pressure for high pressure units, total leakage does not exceed 4 percent of specified air flow capacity with outlets sealed and inlets wide open. Construct air dampers such that when subjected to 6.0-in w.g. inlet pressure with damper closed, total leakage does not exceed 10 percent of specified air flow capacity.
- C. Air Dampers: Construct of materials that cannot corrode, do not require lubrication, nor require periodic servicing. Provide maximum volume dampers, pressure independent that are calibrated in cfm, factory-adjusted, and marked for specified air capacities. Provide mechanism to vary air volume thru damper from minimum to maximum, in response to signal from thermostat.
- D. Controls: Provide controls accurate to 1.5 deg. F (0.8 deg. C) and adjustable from 65 deg. F (22 deg. C) to 85 deg. F (29 deg. C).
 1. ATC Contractor to provide and field install DDC controls, compatible with automatic temperature control system specified in other Division-23 sections. All testing and commissioning shall be completed in field.
- E. Identification: Provide label on each unit indicating Unit Number, cfm range, cfm factory-setting, and calibration curve (if required).
- F. Coils: Provide the following coils as indicated on Drawings and schedule:
 1. Hot Water Heating Coils: Provide heating coils constructed of copper tubes and aluminum fins with galvanized steel casing.
- G. Silencer:
 1. Silencer section shall consist of a three foot 22ga solid metal casing, 22ga perforated liners, and absorptive acoustic fiberglass liner.
 2. Acceptable methods of silencer construction shall be button lock, Pittsburgh lock, and welds. In situations where these methods are not feasible, rivets can be used. Screws or other mechanical fasteners on the silencer will not be acceptable.
 3. The silencer noses and perforated liners shall be rigidly fastened to the casing of the silencer on both the top and bottom.
 4. The silencer section acoustic media shall be shot free inorganic glass fiber with long, resilient fibers, bonded with thermosetting resin, and contain 50 percent recycled media. Glass fiber shall be packed with a minimum 10 percent compression to eliminate voids and settling; density shall consistent with that used to generate catalog test data. Combustion ratings for acoustical media shall be equal to or less than the combustion ratings noted below when tested in accordance with ASTM E84, UL713, and NFPA 255:
 - a. Flame Spread Classification: 25
 - b. Smoke Development Rating: 50
 5. Silencer shall be Price model SUDQ.
- H. Manufacturer: Subject to compliance with requirements, provide variable air volume boxes of one of the following:
 1. Nailor
 2. Price
 3. Metalaire
 4. Or equal

2.29 DUST COLLECTOR SYSTEM

- A. Housing
 - 1. Housing construction is 12 gauge steel, rated for + or -20 in. wg, and designed in compliance with IBC2003 International Building Codes. The tube sheet is 3/16 in. (7 gauge) steel.
- B. Finish
 - 1. Exterior surfaces are painted with a blue finish. Interior surfaces are primed gray.
- C. Discharge Hopper
 - 1. Hopper is 12 gauge steel with side panel and valley angles exceeding 60 deg. Bottom discharge is a ~~44.25~~ **10** in. square opening. Discharge hopper attaches to a 55 Gallon Drum provided by other.
- D. Support Leg Structure
 - 1. Legs provide 48" clearance below the hopper discharge flange and are designed per the IBC 2003 Bldg. code for 90 mph, Exposure C wind loads, seismic spectral response accelerations of $S_s = 1.5g$ and $S_1 = 0.6g$, and ground snow loads of 40 psf. Cross bracing is included on three sides.
- E. Dust Laden Air Inlet
 - 1. A Directed Flow inlet properly distributes the dust laden air throughout the dirty air plenum, keeps the underside of the filters clean, prevents filter abrasion, maximizes dust drop-out and eliminates hopper sweeping and dust re-entrainment. Side inlet locations are standard.
- F. Powercore Filter Packs
 - 1. Each compact PowerCore Filter Pac incorporates multiple layers of Ultra-Web media packaged in flutes that intercept even the smallest particles . Laboratory testing has determined that PowerCore Filter Pacs produce 60% fewer emissions than standard 16 oz polyester bags.
 - 2. Each PowerCore Filter Pac contains 63 square feet of effective Ultra-Web media.
- G. Filter Cleaning
 - 1. PowerCore Filter Pacs are automatically cleaned by periodic pulses of compressed air. The patented compact Oblique Pulse Cleaning System matches the pulse shape to the PowerCore Filter Pac providing maximum cleaning effectiveness.
- H. Cleaning Controls
 - 1. The proprietary solid-state Torit® Delta P Plus Control Board, featuring a digital read-out display, includes a choice of two cleaning modes, continuous or after-shift. The after-shift cleaning mode pulse cleans the filter cartridges in a unique shutdown sequence to eliminate direct worker exposure to pulse noise. It provides filter restriction and cleaning control; starting and stopping the cleaning process at user selected set points. No battery backup required.
- I. Prewired Solenoids
 - 1. Solenoids will be factory wired to a Terminal Strip in a NEMA 4 Enclosure. A single wire per solenoid and a common will be routed through conduit to the enclosure (1), located on the right and left side of Collector. All conduit and fittings are PVC. Wiring from Control Panel to Collector Solenoids requires (6) Low voltage (115v) wires and one (1) common, for Pulsing, provided by electrical contractor.

- J. Pulse Mufflers
1. Solenoid Mufflers will be installed on the exhaust side of each solenoid valve, to reduce the filter cleaning pulse noise.
- K. Electrical Control Panel
1. Includes motor starter (1), circuit protection for each motor (1), a transformer, pulse cleaning controls, a Torit® Delta P Plus control mounted in the panel door, start/stop buttons, and a flange mounted disconnect switch. All components are IEC rated; the enclosure is rated NEMA 12 with 460 primary voltage. Pneumatic tubes (2) must be run from Collector to Control Panel to operate pulse cleaning timer board, this will be provided by the HVAC contractor.
- L. Filter Access
1. PowerCore Filter Pacs are easily accessed from the exterior clean side of the collector via an access door on top of the collector. Filter removal and replacement can be accomplished from outside the collector without the need for tools.
- M. Torit® Direct Drive Fan
1. ~~TBI 10 BACKWARD INCLINED Direct drive fan designed to deliver 4,200 acfm at 10.0" wg total static pressure. Fan field mounts to the side of the collector. Fan motor is 15 hp 3450 rpm 208/460/60/3 TEFC. Exterior surfaces are painted with a blue finish.~~
 1. **BACKWARD INCLINED direct drive fan designed to deliver 7,500 acfm at 10.0" wg total static pressure. Fan field mounts to the side of the collector. Fan motor is 25 hp, 3450 rpm, 208/460/60/3 TEFC. Exterior surfaces are painted with a blue finish.**
- N. Fan Transition With Guard
1. The fan transition with guard provides an installation bracket for mounting the above TBI fan. The transition also provides a guard to keep objects from accessing the fan wheel from the clean air plenum of the collector.
- O. Damper
1. Volume control damper, parallel blade, is shipped loose for field installation on the fan outlet to control system airflow. Damper is manually operated with handle and locking quadrant.
- P. Exhaust Silencer
1. The exhaust silencer for TBI fans is fabricated of painted galvanized steel and lined with absorbing materials. Noise level with a standard exhaust silencer and a 15 hp fan assembly is approximately 70 dBA measured at 1 meter at AMCA position #3, and under free field conditions. The actual measured sound level will be dependent on background noise and installation conditions
- Q. Explosion Relief Vents
1. Quantity (1) ~~12 in. x 24~~ **36 in. x 49** in. explosion relief vent is located on the side of unit. Explosion vents limit overpressure in the event of a deflagration in order to maintain the structural integrity of the collector.
- R. Ductwork (Manuf. EHG Transfer System or equal)
1. Material
 - a. Galvanized steel conforming to ASTM standards A653 and A924
 2. Surface Finish
 - a. G-60 galvanized steel (standard)

3. Thickness
 - a. 22 gauge nominal (0.0296 inch minimum)
 4. Construction
 - a. Duct is of non-corrugated, spiral lock seam construction with a mechanically formed seam locking indentation evenly spaced along the spiral seam.
 - b. Fittings shall be manufactured using one or more of the following construction methods:
 - 1) Overlapped edges stitch welded along the entire length of the fitting
 - 2) Standing seam gore locked and internally sealed
 - 3) Button punched and internally sealed
 - 4) Elbows 3 in. through 12 in. diameter will be die stamped and continuously stitch welded.
 - c. Available in diameters 3 in. – 20 in.
 5. Connections
 - a. All duct and fitting ends shall be provided with factory formed 300° rolled edge and joined externally by means of an integral latching/locking barrel clamp with custom form fitting EPDM sealing gasket to ensure no duct penetrations or protrusions into the airstream.
 6. Joint Sealing
 - a. Connections are sealed by means of the Transfer barrel clamp. No additional field sealant is necessary.
 7. Provide specifically designed flexible hoses to connect the hard duct to each piece of equipment. Provide all necessary fitting, transitions, offsets, elbows and components for a complete connection to each piece of equipment.
 8. Provide blast gates at each piece of equipment and at each floor sweep, locate at 6'-0" above the finished floor.
- S. Manufacturer: Subject to compliance with requirements, provide dust collection systems of one of the following
1. Donaldson/Torit
 2. American Air Filter
 3. AQC Dust Collector
 4. Approved equal
- T. **Spark Detection and Extinguishment System:**
1. **The spark detection and extinguishing system shall be a micro-processor based system designed to detect and extinguish a spark before it reaches other downstream processes or filtration equipment, thus eliminating the potential for fires and explosions.**
 2. **System must be Factory Mutual Approved, and approval report number must be listed.**
 3. **Control Cabinet:**
 - a. **Control cabinet shall be fully microprocessor based with an event recorder capable of memory of at least 2,500 events. This memory shall be a circular memory so as to feed out the old and input the new when the memory is full. Control Console shall be equipped with RS-485 Serial Port for interface to a remote printer or computer. Control Console shall also be equipped for optional built-in event printer.**
 - b. **Control cabinet shall have a user-friendly operating menu with critical operation parameters password protected for security.**

- c. The control cabinet shall receive the alarm signal from the spark sensor and immediately activate the existing assembly and relay contacts. An LCD readout shall be provided to indicate the affected zone, date of the alarm, time of the alarm, the number of sparks, the length of extinguishment and whether the threshold setting of number of sparks or length of extinguishment has been exceeded. A visual light for alarm and water flow will also be indicated.
 - d. The control cabinet shall be programmed to allow the extinguishing system to function without interrupting production, provide minimum volume of water necessary for extinguishment and be capable of activating two separate dry relay contacts; i.e., from a first spark alarm or when exceeding a pre-set number of sparks in a preset time frame. The extinguishing threshold and the spark threshold shall be adjustable to the customer's requirements.
 - e. The control cabinet shall provide a constant visual readout of extinguishments during a specific period of time. A battery back-up emergency power supply will be provided to assure continued operation upon main power failure.
 - f. The control cabinet shall have a NEMA 12 rating, non-ventilated and microprocessor based with solid-state circuitry. Terminal connection should have easy access, and all components should be plug-in type. The internal components should be easily removable and replaceable if maintenance is required.
 - g. The control cabinet shall provide powered terminals for an external horn or light device, summation alarm and trouble dry contacts, trouble contacts for system disabled and alarm contacts to monitor for water flow and low water pressure.
 - h. The control cabinet shall be either wall mounted or free standing, and require 120 volt AC power supply with all working voltage, internal and external, to be 15/24 volt DC and a wire requirement of no more than three (3) wires for the sensors and two (2) wires for the valve. No AC voltage is to be run next to sensor or valve wiring or within the conduit.
 - i. Testing of each sensor shall be automatic at four (4) hour intervals. In addition, the system shall have the capability of manual testing of the sensors and water flow. System integrity shall be monitored at all times by the control console components and shall produce an alarm in case of any system troubles.
4. **Spark Sensors:**
- a. The standard spark sensors are to be located in ducts susceptible to sparks. Sensor shall be an infrared type sensor responsive to radiation in the 800 to 1,100 nanometer range with a mean temperature of 600 °C (1,112 °F) and operate in an air stream temperature not to exceed 158 °F. An optional high temperature sensor will be available to operate in an air stream temperature from 158 °F up to 660 °F and with optional adapters allowing operation up to 1,800 °F. The optional high temperature sensor will be fitted with three (3) individual fiber-optic cables to allow the sensor to be mounted away from the duct and will be attached to the duct with the use of a stainless steel cable mounting adapter.
 - b. If sensors are required to operate in ambient light, then a daylight type sensor must be furnished that must not be responsive to this condition and should respond to radiation in the 1,650 - 3,000 nanometer range.
 - c. Sensor shall be infrared type of the highest sensitivity electronic photo diode type to detect the tiniest of sparks.

- d. **Sensors shall be electronically stable with the longest possible time exposure of the spark signal to the photo diode, providing confirmation of signal. Shielded cable shall not be a requirement.**
 - e. **Spark detection sensors must not be responsive to VHF and UHF radio frequencies or other electrical interferences.**
 - f. **Sensors must have the ability to detect individual sparks in an air stream up to 10,000 FPM.**
 - g. **No more than two (2) sensors shall be required in ducts up to 79"(2,000 mm) in diameter.**
 - h. **Spark sensors shall be mounted on the pipe or duct with a stainless steel adapter for pipes 9" diameter or larger and a mounting band for pipes 8" diameter or smaller. The adapter shall be installed from the outside of the pipe or duct with the use of a special tool kit to be supplied with the sensors and will mount in such a manner as to prevent build-up of materials on the lens cover.**
5. **Extinguishing Assembly:**
- a. **The automatic extinguishing assembly shall use a finely atomized water spray as the extinguishing agent. The duration of atomized water spray is to be regulated by the microprocessor based control cabinet. Pressurized water at 75 PSI minimum static pressure or 60 PSI at flow condition will be used as the extinguishing agent.**
 - b. **The extinguishment assembly shall be furnished completely assembled with a 100 mesh Y-strainer and ball valve, 1" solenoid valve with coil and wire connecting plug, contamination-free 3/4" nozzle, either brass or stainless steel, and a stainless steel nozzle mounting adapter or mounting band and intermediate galvanized piping.**
 - c. **The spring loaded spray nozzles are to be flush mounted inside the pipe or duct with the use of a stainless steel nozzle mounting adapter.**
 - d. **The system shall have the capability to establish the water spray pattern in the pipe within 0.3 seconds from time of detection, which will include a 50% safety factor.**
6. **Pressure Booster Pump System:**
Extinguishing water pressure booster system consisting of: pressure tank, centrifugal pump, 230/460V pump motor, pressure relief valve, pressure gauges, switches, flow switch, control panel with motor starter and circuit breaker. All items are assembled on a common steel base, pre-plumbed, pre-wired and water tested.
7. **Abort Gate:**
A high speed abort gate activated by the spark detector shall divert any burning material to atmosphere before it can enter the building. The abort gate shall have a manual reset so that after it has aborted, it can be reset to the normal position. Support for abort gate is by others."

2.30 FIRESTOP SYSTEMS

- A. **General: Provide firestopping at all new and existing construction where penetrated by the Work of this Section. Also provide smoke sealing at all smoke barrier and smoke partition construction where penetrated by the work of this section.**

- B. Refer to Section 078400 - Firestopping, for all product requirements for maintaining integrity of fire-rated and smoke-rated construction at penetrations.

2.31 WALL AND CEILING ACCESS DOORS

- A. General: Furnish and install access panels, at all new construction where required for access to the Work of this Section. Furnish access doors for access to all concealed control valves, motor operated dampers, fire doors, and all other concealed parts of the HVAC system that require accessibility for the proper operation and maintenance of the system.
- B. Refer to Section 083100 - ACCESS DOORS AND FRAMES, for all product requirements for furnishing access panels.
- C. Coordinate locations and schedule with the work of trades involved with construction in which access panels will be installed.

2.32 AUTOMATIC TEMPERATURE CONTROLS (DDC) (Section 019113 - COMMISSIONING REQUIREMENTS and Section 230800 - COMMISSIONING OF HVAC SYSTEMS for additional contract requirements)

- A. Basic Components and Systems:
 - 1. General: Provide control products in sizes and capacities indicated, consisting of dampers, thermostats, clocks, sensors, controllers, and other components as required for completed installation. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information, designed and constructed as recommended by manufacturer and as required for application indicated. All equipment and systems shall be installed by certified factory trained contractors with the following functional and construction features.
 - 2. The building automation system shall be provided with a Tridium Niagara AX front-end platform. Tridium provides an open automation infrastructure that integrates diverse systems and devices (regardless of manufacturer, communication standard or software) into a unified platform that can be easily managed in real time using a standard Web browser. Systems not provided with the Tridium Niagara AX platform are unacceptable. The building automation system shall not require licensing fees and shall be licensed indefinitely to the Owner for use at the project site.
 - 3. Prior to the BAS system being approved for construction, as part of the submittal submit sample operator workstation graphics for typical systems for approval. Print and submit the graphics that the operator will use to view the systems, change set points, modify parameters and issue manual commands. Programming shall not commence until typical graphics are approved.
 - 4. Provide all required control wiring including CAT6 Ethernet wiring for any controllers requiring Ethernet connectivity. Terminate Ethernet cable in MDF and IDF closets on patch panels proceed under Technology Section 270000.
 - 5. Install an open-protocol (BACNet) energy management system (EMS) to monitor and trend the energy consumed by the following systems throughout the school:
 - a. HVAC systems
 - b. Hot, chilled and cold domestic water systems
 - c. Main electric service meter
 - d. Gas Main-meter
 - 6. The ATC control and building EMS system shall have the following attributes with characteristics and performance as specified within this Specification section, related Electrical and Plumbing section specifications and the Control Diagram drawings:
 - a. Sensors and components as follows:

- 1) Weather station to trend outdoor air temperature, humidity, barometric pressure, wind speed and wind direction.
- 2) Indication and trending of damper and valve commanded positions.
- 3) Sensors to monitor building electrical and natural gas consumption. Main service electrical meters shall be provided by the Electrical Contractor and control wiring from the meter to the BMS including conduits, programming and graphics display shall be provided by the ATC contractor. Gas sub-meters shall be furnished and installed by the Plumbing contractor and control wiring from the meter to the BMS including conduits, programming and graphics display shall be provided by the ATC contractor. Flow meters for building cold water consumption will be installed by the Plumbing Contractor and control wiring from the meter to the BMS including conduits, programming and graphics display shall be provided by the ATC contractor. Domestic hot water consumption shall utilize relays on each domestic water heater burner and through BMS programming utilizing burner on/off operation domestic hot water consumption will be determined, all provided by the ATC Contractor.
- 4) Sensors to monitor indoor and outdoor CO₂.
- 5) Sensors to monitor and trend (create trend logs) controlled variables at the operator interface. Control variables may include air and/or water flow, temperature, pressure, CO₂, humidity and pump or fan speed. Relevant multiplexed data from microprocessors located in chillers, boilers, variable speed drives and other equipment with multiplexing capabilities may be used in lieu of specifying separate sensors.
- b. Points matrix – including all hardwired input and output devices connected to the automation system, all set points, upper and lower control limits.
- c. Trend capabilities – including a trend point list and preprogrammed sample of point (performed by controls contractor), sample rate, storage interval, upload interval, custom trend abilities, alarms, and automated trend data review and notification (automated diagnostics).
- d. System architecture – capable of allowing sampling of these points to facilitate building commissioning and diagnostics without significantly affecting system performance.
- e. Data storage system – with adequate capacity to record trend data for use by building operators. Data export requirements must facilitate user-friendly data access and manipulation.
- f. Operator interface – designed for remote/web access, monitoring requirements, trend-log reporting and diagnosing building problems through a user-friendly interface. This includes providing a visual (non text based) operations and reporting interface to facilitate rapid system assessment that utilizes color-coding, diagrams of floor plans and graphing capabilities.
- g. The remote access shall use a web browser only and not require a VPN with remote desktop application.
7. Electric Wiring: All electric wiring and wiring connections, either line voltage or low voltage, from the emergency electric panels to the ATC panels, and from the ATC related panels to the individual control devices i.e. rooftop units, exhaust fans, boilers, chillers, valves, and dampers required for the installation of the control system, as herein specified shall be provided by the control contractor unless specifically shown on the electrical drawings or called for in the electrical specifications.
 - a. The wiring installation shall be in accordance with National and Local Codes and with the Electrical portion of these specifications. All wiring shall be run concealed wherever possible. Exposed wiring in occupied areas shall be run in raceways. Raceways shall be Wiremold 200 series with all elbows, raceways, covers, mounting stops, box extensions and wiring for a complete and neat

- installation. All wiring located in mechanical spaces, boiler rooms, and fan rooms shall be installed in metal conduit
- b. All wiring above ceilings, in boiler rooms, and all mechanical spaces shall follow routing of piping and where not possible shall be in conduit. All exposed wire shall be bundled and wire tied and shall be supported to adjacent piping. Draped and free floating wire will not be allowed.
 - c. All terminations of wire at control devices shall be looped and supported adequately.
 - d. All wiring shall comply with the requirements of the electrical section of the specification.
- B. Controls Systems Wiring
1. All conduit raceways, wiring, accessories and wiring connections required for the installation of the Controls Systems shall be provided by the Controls Contractor except as shown on the Electrical Drawings. All wiring shall comply with the requirements of applicable portions of the Electrical Section 260000 and all local and national electric codes and the requirements of the AHJ.
 2. All Controls Systems wiring materials and installation methods shall comply with the original equipment manufacturer recommendations and standards.
 3. The sizing type and provision of cable, conduit, cable trays and raceways shall be the design responsibility of the Controls Contractor.
 4. Class 2 Wiring
 - a. All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
 - b. Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5ft. from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines.
 5. Class 2 signal wiring and 24VAC power may be run in the same conduit. Power wiring 120VAC and greater shall not share the same conduit with Class 2 signal wiring.
 6. Perform circuit tests using qualified personnel only. Provide necessary instruments and equipment to demonstrate that:
 - a. All circuits are continuous and free from short circuits and grounds.
 - b. All circuits are free from unspecified grounds; that resistance to ground of all circuits is no less than 50 megaohms.
 - c. All circuits are free from induced voltages.
 7. Provide complete testing for all cables and wiring. Provide all equipment, tools, and personnel as necessary to conduct these tests.
 8. Provide for complete grounding of all signal and communication cables, panels and equipment so as to ensure integrity of Controls Systems operation. Ground cabling and conduit at panel terminations. Do not create ground loops.
- C. Line Voltage Power Sources
1. 120-volt AC circuits for the Controls Systems shall be taken by the Controls Contractor from electrical emergency panelboards and circuit breakers as designated on the electrical drawings.
 2. Circuits used for the Controls Systems shall be dedicated to these Controls Systems and shall not be used for any other services.
 3. Controls DDC terminal unit controllers may use 120-volt AC power from motor power circuits.
- D. Controls Systems Raceways
1. All wiring shall be installed in conduit or raceway except as noted elsewhere in the Specification. Minimum conduit size 3/4 in.

2. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.
 3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the supporting surface.
 4. UL/ULC Listed Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 ft. in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls and for final connection to equipment.
- E. Penetrations
1. Firestopping for all penetrations used by dedicated Controls Systems conduits and raceways shall be by other trades.
 2. All openings in fire proofed or fire stopped components shall be closed by other trades using approved fire resistive sealant.
 3. All wiring passing through penetrations, including walls, shall be in sleeves, conduit or enclosed raceway.
 4. No penetrations through building structural elements, slabs, ceilings and walls shall be made before receipt of written approval from the Architect.
- F. Controls Systems Identification Standards
1. Node Identification: All nodes shall be identified by a permanent label fastened to the outside of the enclosure. Labels shall be suitable for the node environmental location.
 2. Cable shall be labeled at every termination with cross-referencing to record documentation.
 3. Raceway Identification: Exposed covers to junction and pull boxes of the FMS raceways shall be identified at primary points.
 4. Wire Identification: All low and line voltage wiring shall be identified by a number, as referenced to the associated shop and record drawing, at each termination.
 5. Wires and cabling shall not be spliced between terminations. Cable shields shall be single end grounded – typically at the panel end outside the panel.
 6. Suggested color coding, for use at the Contractors option, are:
 - a. Analog Input Cable Yellow
 - b. Analog Output Cable Tan
 - c. Binary Input Cable Orange
 - d. Binary Output Cable Violet
 - e. 24 VAC Cable Gray
 - f. General Purpose Cable Natural
 - g. Tier 1 Comm Cable Purple
 - h. Other Tier Comm Cable Blue
 - i. Ethernet cable Blue
 7. Provide permanent identification labels at all valve and damper actuators to indicate open and closed positions.
- G. Field Panel And Device Installations And Locations
1. The Controls Systems panels, enclosures and cabinets shall be located as coordinated with the Architect at an elevation of not less than 2 ft. from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
 2. All field devices shall be installed per the manufacturer recommendation and in accessible locations as coordinated with the Architect.
 3. Panels to be located in damp areas or areas subject to condensation shall be mounted with wall standoffs.
 4. Conduit configurations entering or leaving panels and devices shall be such as to preclude condensation traps.

H. Networking Communications

1. The design of the BAS shall network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of multiple levels for communication efficiency, a campus-wide (Management Level Network) Ethernet network based on TCP/IP protocol, high performance peer-to-peer building level network(s) and DDC Controller floor level local area networks with access being totally transparent to the user when accessing data or developing control programs.
2. System shall communicate with a BACnet network over Ethernet or BACnet/IP (according to Annex J). The intent is to use the system provided under this contract to communicate with control systems and/or devices provided by other vendors. A PICS must be provided describing the BACnet, ANSI/ASHRAE 135-95, implementation. The product shall be Network Application Engine level 1 controllers with field equipment controller for level 2 controllers no substitutions. Minimum system functionality must include monitoring, commanding, and alarming for daily operator functions from a common workstation.
 - a. System shall have the capability to be an OPC Client and Server for dynamic communication with OPC Clients or Servers over an Ethernet network. At a minimum, the following must be supported:
 - 1) Data Access 1.0 (96), 1.0A (97) and 2.0 (11/98)
 - 2) Alarms & Events 1.0 (1/99)
3. Network Switches
 - a. Provide HP ProCurve 2910 al series 2910-48G al 48 ports network switch Brocade, Cisco or equal in MDF/IDF rooms as required.
4. Ethernet Wiring
 - a. Ethernet wiring shall be CAT6 UTP cable plenum rated. CAT6 UTP cables shall conform to ANSI/TIA/EIA-568-B1, B2, B3 Commercial Building Telecommunications Cabling Standard (latest amendment and including all applicable addenda) and ISO/IEC 11801 (International) Generic Cabling for Customer Premises standard (latest amendment and including all applicable addenda).
5. Building Data Network:
 - a. All operator devices either network resident shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the network. No hardware or software limits shall be imposed on the number of devices with global access to the network data at any time.
 - b. The network shall support a minimum of 100 DDC controllers and PC workstations
 - c. The system shall support integration of third party systems (fire alarm, security, lighting, PLC, chiller, boiler) via panel mounted open protocol processor. This processor shall exchange data between the two systems for interprocess control. All exchange points shall have full system functionality as specified herein for hardwired points.
 - d. Field panels must be capable of integration with open standards including Modbus, BACnet, and Lonworks as well as with third party devices via existing vendor protocols.
 - e. The Building Network shall use the TCP/IP over Ethernet. All devices must:
 - 1) Auto-sense 10/100/1000 Mbps networks.
 - 2) IP Address will be assigned by Owner's IT staff.
 - 3) DNS and Gateway IP address will be provided by Owner's IT staff. A VLAN will be setup by Owner's IT staff.
 - 4) Allow access using Telnet.
6. Internet access
 - a. Web Based Operator Interface
 - 1) The BAS shall provide a web based graphical interface that allows users to access the BAS data via the Internet. The interface shall use HTML

- based ASP pages to send and receive data from the BAS to a web browser.
- 2) All information exchanged over Internet shall be encrypted and secure via SSL.
 - 3) Access to the web interface will be password protected. A users rights and privileges to points and graphics will be the same as those assigned at the BAS workstation. An option will exist to only allow users “read” access via the web browser, while maintaining “command” privileges via the BAS workstation.
 - 4) Commissioning of the Web interface shall not require modification or creation of HTML or ASP pages. All graphics available at the BAS graphical workstation shall be available to users via a web browser.
 - 5) The web-based interface shall provide the following functionality to users, based on their access and privilege rights:
 - a) Logon Screen – allows the user to enter their user name, password and Domain name for logging into the web server.
 - b) Alarm Display – a display of current BAS alarms to which the user has access will be displayed. Users will be able to acknowledge and erase active alarms, and link to additional alarm information including alarm messages, and informational and memo text. Any alarm acknowledgements initiated through the web interface will be written to the BAS central workstation activity log.
 - c) Graphic Display – Display of system graphics, including animated motion, available in the BAS workstation will be available for viewing over the web browser. Software that requires creation of dedicated “web” graphics in order to display them via the browser interface will not be acceptable. A graphic selector list will allow users to select any graphics to which they have access. Graphic displays will automatically refresh with the latest change of values. Users will have the ability to command and override points from the graphic display as determined by their user accounts rights.
 - d) Point details – users will have access to point detail information including operational status, operational priority, physical address, and alarm limits, for point objects to which they have access rights.
 - e) Point Commanding – users will be able to override and command points they have access to via the web browser interface. Any commands or overrides initiated via the web browser interface will be written to the BAS central workstation activity log.
 7. The web server licensing options will allow concurrent access by 10 browser connections.
 8. Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the Owner as required to support the web access feature.
- I. DDC Controller Floor Level 2 Network
1. This level communication shall support a family of application specific controllers and shall communicate with the network through DDC Controllers for transmission of global data.
- J. DDC & HVAC Mechanical Equipment Controllers
1. The DDC and HVAC Mechanical Equipment Controllers shall reside on the Building Level Network.

2. DDC and HVAC Mechanical Equipment Controllers shall use the same programming language and tools. DDC and HVAC Mechanical Equipment Controllers which require different programming language or tools on a network are not acceptable.
 3. DDC and HVAC Mechanical Equipment Controllers which do not meet the functions specified are not acceptable.
- K. DDC Controller
1. DDC Controllers shall be a 16-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point I/O schedule. Each controller shall support a minimum of three Floor Level Application Specific Controller Device Networks.
 2. Each DDC Controller shall have 72 Megabytes of memory to support its own operating system and databases, including:
 - a. Control processes
 - b. Energy management applications
 - c. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
 - d. Historical/trend data for points specified
 - e. Maintenance support applications
 - f. Custom processes
 - g. Operator I/O
 - h. Dial-up communications
 - i. Manual override monitoring
 3. Each DDC Controller shall support firmware upgrades without the need to replace hardware.
 4. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
 5. DDC Controllers shall provide a serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.
 6. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points.
 - a. Switches shall be mounted either within the DDC Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.
 - b. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.
 7. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.
 8. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
 9. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

- a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V
 - b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
 - c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
 - d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)
 - e. Isolation shall be provided at all peer-to-peer panel's AC input terminals to suppress induced voltage transients consistent with:
 - 1) IEEE Standard 587-1980
 - 2) UL 864 Supply Line Transients
 - 3) Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)
10. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 60 days.
- a. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.
 - b. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.
11. Provide a separate DDC Controller for each AHU or other HVAC system as indicated in Section 3.02. It is intended that each unique system be provided with its own point resident DDC Controller.
- L. HVAC Mechanical Equipment Controllers
1. HVAC Mechanical Equipment Controllers shall be a 12-bit stand-alone, multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors.
 2. Each HVAC Mechanical Controller shall have 72 Megabytes of memory to support its own operating system and databases, including:
 - a. Control processes
 - b. Energy management applications
 - c. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
 - d. Historical/trend data for points specified
 - e. Maintenance support applications
 - f. Custom processes
 - g. Operator I/O
 - h. Remote communications
 3. HVAC Mechanical Equipment Controllers shall provide a serial data communication port for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals.
 4. HVAC Mechanical Equipment Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.
 5. Each HVAC Mechanical Equipment Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all components. The HVAC Mechanical Equipment Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
 6. In the event of the loss of normal power, there shall be an orderly shutdown of all HVAC Mechanical Equipment Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

- a. Upon restoration of normal power, the HVAC Mechanical Equipment Controller shall automatically resume full operation without manual intervention.
 - b. Should HVAC Mechanical Equipment Controller memory be lost for any reason, the user shall have the capability of reloading the HVAC Mechanical Equipment Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.
- M. DDC and HVAC Mechanical Equipment Controller Resident Software Features
1. General:
 - a. The software programs specified in this Section shall be provided as an integral part of DDC and HVAC Mechanical Equipment Controllers and shall not be dependent upon any higher level computer for execution.
 - b. All points shall be identified by up to 30 character point name and 16 character point descriptor. The same names shall be used at the PC workstation.
 - c. All digital points shall have user defined two-state status indication (descriptors with minimum of eight characters allowed per state (i.e. summer/winter).
 2. Control Software Description:
 - a. The DDC and HVAC Mechanical Equipment Controllers shall have the ability to perform the following pre-tested control algorithms:
 - 1) Two-position control
 - 2) Proportional control
 - 3) Proportional plus integral control
 - 4) Proportional, integral, plus derivative control
 - 5) Automatic tuning of control loops
 3. DDC and HVAC Mechanical Equipment Controllers shall provide the following energy management routines for the purpose of optimizing energy consumption while maintaining occupant comfort.
 - a. Start-Stop Time Optimization (SSTO) shall automatically be coordinated with event scheduling. The SSTO program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by time of occupancy. The SSTO program shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period, and still maintain desired comfort conditions.
 - 1) The SSTO program shall operate in both the heating and cooling seasons.
 - a) It shall be possible to apply the SSTO program to individual fan systems.
 - b) The SSTO program shall operate on both outside weather conditions as well as inside zone conditions and empirical factors.
 - 2) The SSTO program shall meet the local code requirements for minimum outside air while the building is occupied.
 - b. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or groups of points according to a stored time.
 - 1) It shall be possible to individually command a point or group of points.
 - 2) For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start or stop within that group.
 - 3) The operator shall be able to define the following information:
 - a) Time, day
 - b) Commands such as on, off, auto, and so forth.
 - c) Time delays between successive commands.
 - d) There shall be provisions for manual overriding of each schedule by an appropriate operator.

- 4) It shall be possible to schedule events up to one year in advance.
 - a) Scheduling shall be calendar based.
 - b) Holidays shall allow for different schedules.
 - c) Enthalpy switchover (economizer) The Energy Management Control Software (EMCS) will control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover set point the EMCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly changeover to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.
 - d) Temperature-compensated duty cycling.
 - The DCCP (Duty Cycle Control Program) shall periodically stop and start loads according to various patterns.
 - The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.
 - e) Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.
 - f) Night setback control: The system shall provide the ability to automatically adjust setpoints for night control.
 - g) The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.
 - PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.
 - PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.
 - If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.
 - Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.
4. DDC and HVAC Mechanical Equipment Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
 - a. A single process shall be able to incorporate measured or calculated data from any and all other DDC and HVAC Mechanical Equipment Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC and HVAC Mechanical Equipment Controllers on the network. Database shall support 30 character, English language point names, structured for searching and logs.
 - b. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

- c. DDC and HVAC Mechanical Equipment Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task orientated information from the user manual.
 - d. DDC and HVAC Mechanical Equipment Controller shall be capable of comment lines for sequence of operation explanation.
 5. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC and HVAC Mechanical Equipment Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC and HVAC Mechanical Equipment Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
 - a. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
 - b. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller) to provide full flexibility in defining the handling of system alarms. Each DDC and HVAC Mechanical Equipment Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
 - c. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after hours destinations) or based on priority.
 - d. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
 - e. In dial-up applications, operator-selected alarms shall initiate a call to a remote operator device.
 6. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for points as specified in the I/O summary.
 - a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC and HVAC Mechanical Equipment Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of 1 minute to seven days shall be provided. Each DDC and HVAC Mechanical Equipment Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a sufficient number of data samples. All trend data shall be available for transfer to a Workstation without manual intervention.
 - b. DDC and HVAC Mechanical Equipment Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary.
 - 1) Loop tuning shall be capable of being initiated either locally at the DDC and HVAC Mechanical Equipment Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.
 7. DDC and HVAC Mechanical Equipment Controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O schedule.

8. The peer to peer network shall allow the DDC and HVAC Mechanical Equipment Controllers to access any data from or send control commands and alarm reports directly to any other DDC and HVAC Mechanical Equipment Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC and HVAC Mechanical Equipment Controllers shall send alarm reports to multiple workstations without dependence upon a central or intermediate processing device. The peer to peer network shall also allow any DDC and HVAC Mechanical Equipment Controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.
 9. The network shall allow the DDC and HVAC Mechanical Equipment Controllers to assign a minimum of 50 passwords access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control the points that the operator is authorized for. All other points shall not be displayed on the PC workstation or portable terminal (e.g. all base building and all tenant points shall be accessible to any base building operators, but only tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.
- N. Floor Level Network Application Specific Controllers (FEC)
1. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (FECs) through Floor Level LAN Device Networks.
 2. Each FEC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each FEC shall be a microprocessor-based, multi-tasking, real-time digital control processor. Each FEC shall be capable of control of the terminal device independent of the manufacturer of the terminal device.
 3. Terminal Equipment Controllers:
 - a. Provide for control of each piece of equipment, including, but not limited to, the following:
 - 1) Variable Air Volume Terminal Boxes (with and without heating coils)
 - 2) Heating Coils
 - 3) Fin Tube Radiation
 - 4) Convectors
 - 5) Radiant Heating Panels
 - 6) Unit Heaters, Cabinet Unit Heaters
 - 7) Unit Ventilators
 - b. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, 3-15 psi pneumatic, 0-10v, allowing for interface to a variety of modulating actuators.
 - c. All controller sequences and operation shall provide closed loop control of the intended application. Closing control loops over the FLN, BLN or MLN is not acceptable.

O. Local User Display

Where specified in the sequence of operation or points list, the controllers on the peer to peer building level network shall have a display and keypad for local interface. A keypad shall be provided for interrogating and commanding points in the controller.

1. The display shall use the same security password and access rights for points in the display as is used in the associated controller.
2. The LCD display shall be a minimum of a 2 line 40 character display.
3. The LCD display shall include the full point name, value (numeric, digital or state text), point priority and alarm status on one screen.
- 4.

5. The LCD shall dynamically update the value, priority, and alarm status for the point being displayed.
 6. The display shall be mounted either on the door of the enclosure or remote from the controller.
- P. Personal Computer Operator Workstation Hardware
1. Personal computer operator workstations shall be provided for command entry, information management, system monitor, alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater distribution, fault tolerance and reliability of the building automation control.
 - a. Provide workstation(s): Manufactured by Dell, HP, Lenovo or equal.
 - b. Workstation shall consist of a personal computer with minimum 8.0GB RAM, hard drive with 1 TB available space, video card capable of supporting 1024 x 768 resolution with a minimum of 32 Bit color (Windows 10), DVD-ROM Drive, mouse and 101-key enhanced keyboard. Personal computer shall be a Windows 10 Compatible PC and shall include a minimum latest generation Intel Core i7 3.40 GHz processor.
 - c. The PC monitor shall support a minimum display resolution of no less than 1900 X 1280 pixels and shall be minimum 19 in. LCD display. Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective.
 - d. Also provide separate file server with available storage capacity to accommodate trending 15 min. interval of each control point for a period of one year for data archives, minimum 1 TB capacity.
 2. Provide an HP LaserJet Pro 400 Color M451dn, Cannon, Brother or equal printer at each workstation location or on the network (Ethernet) for recording alarms, operator transactions and systems reports.
 3. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.
 4. Intranet/Internet access
 - a. Web Based Operator Interface
 - 1) The BAS shall provide a web based graphical interface that allows users to access the BAS data via the Internet, extranet, or Intranet. The interface shall use HTML based ASP pages to send and receive data from the BAS to a web browser.
 - 2) A web server computer will be supplied. The web server shall support browser access via Microsoft Internet Explorer 9.0 (or higher), or Navigator Netscape 6.0 (or higher).
 - 3) All information exchanged over Internet shall be optionally encrypted and secure via SSL (provided by Owner).
 - 4) Access to the web interface may be password protected. A users rights and privileges to points and graphics will be the same as those assigned at the BAS workstation. An option will exist to only allow users "read" access via the web browser, while maintaining "command" privileges via the BAS workstation.
 - 5) Commissioning of the Web interface shall not require modification or creation of HTML or ASP pages. All graphics available at the BAS graphical workstation shall be available to users via a web browser.
 - 6) The web-based interface shall provide the following functionality to users, based on their access and privilege rights:
 - a) Logon Screen – allows the user to enter their user name, password and Domain name for logging into the web server.

- b) Alarm Display – a display of current BAS alarms to which the user has access will be displayed. Users will be able to acknowledge and erase active alarms, and link to additional alarm information including alarm messages, and informational and memo text. Any alarm acknowledgements initiated through the web interface will be written to the BAS central workstation activity log.
 - c) Graphic Display – Display of system graphics, including animated motion, available in the BAS workstation will be available for viewing over the web browser. Software that requires creation of dedicated “web” graphics in order to display them via the browser interface will not be acceptable. A graphic selector list will allow users to select any graphics to which they have access. Graphic displays will automatically refresh with the latest change of values. Users will have the ability to command and override points from the graphic display as determined by their user accounts rights.
 - d) Point details – users will have access to point detail information including operational status, operational priority, physical address, and alarm limits, for point objects to which they have access rights.
 - e) Point Commanding – users will be able to override and command points they have access to via the web browser interface. Any commands or overrides initiated via the web browser interface will be written to the BAS central workstation activity log.
- 7) The web server licensing options will allow concurrent access by a minimum of 10 browser connections.
 - 8) Internet connections, ISP services, as well as necessary firewalls or proxy servers shall be provided by the Owner as required to support the web access feature.

Q. Operators Laptop

- 1. A Lap Top Operators Terminal shall be provided for operator readout of system variables, override control and adjustment of control parameters and display graphics as called for in paragraphs following. Computer specification shall be similar to fixed station computer in Paragraph P.
- 2. Functionality to include ability to automatically display a sequential all point summary and a sequential alarm summary. The Lap Top shall also allow display and/or changing of digital point state, analog point value, time and date, application and DDC parameters, analog limits, time schedules, runtime counts and limits, daylight savings time changeover, time/event initiation, and programmable offset values. The Lap Top shall allow access into DCP initialization routines and diagnostics and enable/disable of points, initiators and programs, all similar to the fixed computer. Laptop shall have a minimum 15 in. color screen, 4GB ram, 500GB hard drive and Windows 10 Professional operating system.

R. Workstation Operator Interface

- 1. Basic Interface Description
 - a. Operator workstation interface software shall minimize operator training through the use of user-friendly and interactive graphical applications, 30-character English language point identification, on-line help, and industry standard Windows application software. Interface software shall simultaneously communicate with existing system and share data between the dedicated, modem autodial, and Ethernet-connected building level networks. The software shall provide, as a minimum, the following functionality:
 - 1) Real-time graphical viewing and control of the BAS environment
 - 2) Reporting

- 3) Scheduling and override of building operations
 - 4) Collection and analysis of historical data
 - 5) Point database editing, storage and downloading of controller databases.
 - 6) Utility for combining points into logical Point Groups. The Point Groups shall then be manipulated in Graphics, trend graphs and reports in order to streamline the navigation and usability of the system.
 - 7) Alarm reporting, routing, messaging, and acknowledgment
 - 8) "Collapsible tree," dynamic system architecture diagram application:
 - a) Showing the real-time status and definition details of all workstations and devices on a management level network
 - b) Showing the real-time status and definition details of all DDC and HVAC Mechanical Controllers at the building level
 - c) Showing the status and definition details of all field-level application controllers
 - 9) Definition and construction of dynamic color graphic displays.
 - 10) Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.
 - 11) On-screen access to User Documentation, via online help or PDF-format electronic file.
 - 12) Automatic database backup at the workstation for database changes initiated at DDC Controller operator interface terminals.
- b. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a "point and click" approach to menu selection and a "drag and drop" approach to inter-application navigation. Selection of applications within the workstation software shall be via a graphical toolbar menu – the application toolbar menu shall have the option to be located in a docked position on any of the four sides of the visible desktop space on the workstation display monitor, and the option to automatically hide itself from the visible monitor workspace when not being actively manipulated by the user.
- c. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BAS software shall run on a Windows 10 Professional bit operating system. System database parameters shall be stored within an object-oriented database, which is compliant with the Open Database Connectivity (ODBC) or Structured Query Language (SQL) standards. Standard Windows applications shall run simultaneously with the BAS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BAS alarms and monitoring information
- 1) Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via adjustable user-sized windows. Operator shall be able to drag and drop information between the following applications, reducing the number of steps to perform a desired function (e.g., Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend on the desired point):
 - a) Dynamic color graphics application
 - b) Alarm management application
 - c) Scheduling application
 - d) Dynamic trend graph data plotter application
 - e) Dynamic system architecture diagram application

- f) Control Program and Point database editing applications
- g) Reporting applications
- 2) Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.
- d. Operator-specific password access protection shall be provided to allow the administrator/manager to limit users' workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported). The administrator/manager shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BAS workstation application. And each BAS workstation user account shall use a Windows 10 user account as a foundation.
- e. Dynamic Color Graphics application shall include the following:
 - 1) Must include graphic editing and modifying capabilities
 - 2) A library of standard control application graphics and symbols must be included
 - 3) Must be able to command points directly off graphics application
 - 4) Graphic display shall include the ability to depict real-time point values dynamically with animation, picture/frame control, symbol association, or dynamic informational text-blocks.
 - 5) Navigation through various graphic screens shall be optionally achieved through a hierarchical "tree" structure
 - 6) Graphics viewing shall include zoom capabilities
 - 7) Graphics shall automatically display the HAND status of points that have been overridden by a field HAND switch, for points that have been designed to provide a field HAND override capability.
 - 8) Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls), internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.
- f. Reports shall be generated on demand or via pre-defined schedule, and directed to CRT displays, printers or file. As a minimum, the system shall allow the user to easily obtain the following types of reports:
 - 1) A general listing of all or selected points in the network
 - 2) List of all points currently in alarm
 - 3) List of all points currently in override status
 - 4) List of all disabled points
 - 5) List of all points currently locked out
 - 6) List of user accounts and access levels
 - 7) List all weekly schedules and events
 - 8) List of holiday programming
 - 9) List of control limits and deadbands
 - 10) Custom reports from 3rd party software
 - 11) System diagnostic reports including, list of DDC panels on line and communicating, status of all DDC terminal unit device points
 - 12) List of programs
 - 13) List of point definitions
 - 14) List of logical point groups
 - 15) List of alarm strategy definitions
 - 16) List of DDC Control panels
 - 17) Point totalization report
 - 18) Point Trend data listings
 - 19) Initial Values report
 - 20) User activity report

- g. Scheduling and override
 - h. Provide a calendar type format for simplification of time and date scheduling and overrides of building operations. Schedule definitions reside in the PC workstation, DDC Controller, and HVAC Mechanical Equipment Controller to ensure time equipment scheduling when PC is off-line -- PC is not required to execute time scheduling. Provide override access through menu selection, graphical mouse action or function key. Provide the following capabilities as a minimum:
 - 1) Weekly schedules
 - 2) Zone schedules
 - 3) Event schedules – an event consists of logical combinations of equipment and/or zones
 - 4) Report schedules
 - 5) Ability to schedule for a minimum of up to 365 days in advance
 - 6) Additionally, the scheduling application shall:
 - a) Provide filtering capabilities of schedules, based on name, time, frequency, and schedule type (event, zone, report)
 - b) Provide sorting capabilities of schedules, based on name, time and type of schedule (zone, event, report)
 - c) Provide searching capabilities of schedules based on name – with wildcarding options
 - i. Collection and Analysis of Historical Data
 - 1) Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals (up to four time-based definitions per point) or change of value, both of which shall be user-definable. Trend data shall be collected stored on hard disk for future diagnostics and reporting. Automatic Trend collection may be scheduled at regular intervals through the same scheduling interface as used for scheduling of zones, events, and reports. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.
 - 2) Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of selected points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel. DDC contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. DDC contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.
 - j. The ATC contractor shall provide an additional 40 hours of ATC/BMS system programming time to assist the owner/engineer with customized programming due to changes and/or modifications of the ATC/BMS system.
2. Dynamic Color Graphic Displays
- a. Create color graphic floor plan displays with construction room number designations. Create system schematics for each piece of mechanical equipment, including air handling units and hot water boiler systems, and room level terminal units, all shall be provided by the BAS contractor as indicated in the point I/O schedule of this specification to optimize system performance, analysis and speed alarm recognition. Also include with the equipment number the construction room name associated with that piece of equipment.
 - b. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu

- selection, point alarm association, or text-based commands. Graphics software shall permit the importing of Autocad or scanned pictures for use in the system.
- c. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations within the system schematics or graphic floor plan displays, and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
 - 1) Provide the user the ability to display real-time point values by animated motion or custom picture control visual representation. Animation shall depict movement of mechanical equipment, or air or fluid flow. Picture Control shall depict various positions in relation to assigned point values or ranges. A library (set) of animation and picture control symbols shall be included within the workstation software's graphics application. Animation shall reflect, ON or OFF conditions, and shall also be optionally configurable for up to five rates of animation speed.
 - 2) Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.
 - 3) Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.
 - 4) Equipment state or values can be changed by clicking on the associated point block or graphic symbol and selecting the new state (on/off) or setpoint.
 - 5) State text for digital points can be user-defined up to eight characters.
 - d. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
 - e. Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls), internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.
 - f. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
 - g. Off the shelf graphic software, html web-based graphic software shall be provided to allow the user to add, modify or delete system graphic background displays.
 - h. A clipart library of HVAC application and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams. The user shall have the ability to add custom symbols to the clipart library. The clipart library shall include a minimum of 400 application symbols. In addition, a library consisting of a minimum of 700 graphic background templates shall be provided.
 - i. The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a selected Terminal Equipment controller's control values and parameters, without the need to create separate and individual graphic files for each controller.
3. System Configuration & Definition
- a. A "Collapsible tree," dynamic system architecture diagram/display application of the site-specific BAS architecture showing status of controllers, PC workstations and networks shall be provided. This application shall include the ability to add and configure workstations, DDC Controllers or HVAC

- Mechanical Equipment controllers, as well as 3rd-party integrated components. Symbols/Icons representing the system architecture components shall be user-configurable and customizable, and a library of customized icons representing 3rd-party integration solutions shall be included. This application shall also include the functionality for real-time display, configuration and diagnostics of dial-up modems to DDC Controllers.
- b. Network wide control strategies shall not be restricted to a single DDC Controller or HVAC Mechanical Equipment controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.
 - c. Provide automatic backup and restore of all DDC controller and HVAC Mechanical Equipment controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller or HVAC Mechanical Equipment Controller. Changes made at the user-interface of DDC Controllers or HVAC Mechanical Equipment Controllers shall be automatically uploaded to the workstation, ensuring system continuity.
 - d. System configuration, programming, editing, graphics generation shall be performed on-line. If programming and system back-up must be done with the PC workstation off-line, the BAS contractor shall provide at least 2 operator workstations.
 - e. Point database configuration shall be available to the user within a dedicated point database editor application included in the workstation software. The editor shall allow the user to create, view existing, modify, copy, and delete points from the database. The point editor shall also allow the user to configure the alarm management strategy for each point. The editor shall provide the option for editing the point database in an online or offline mode with the DDC Controllers.
 - 1) The workstation software shall also provide the capability to perform bulk modification of point definition attributes to a single or multiple user-selected points. This function shall allow the user to choose the properties to copy from a selected point to another point or set of points. The selectable attributes shall include, but are not limited to, Alarm management definitions and Trend definitions.
4. Alarm Management
- a. Alarm Routing shall allow the user to send alarm notification to selected printers or workstation location(s) based on time of day, alarm severity, or point type.
 - b. Alarm Notification shall be presented to each workstation in a tabular format application, and shall include the following information for each alarm point: name, value, alarm time and date, alarm status, priority, acknowledgement information, and alarm count. Each alarm point or priority shall have the ability to sound a discrete audible notification.
 - c. Alarm Display shall have the ability to list and sort the alarms based on alarm status, point name, ascending or descending alarm time.
 - d. Directly from the Alarm Display, the user shall have the ability to acknowledge, silence the alarm sound, print, or erase each alarm. The interface shall also have the option to inhibit the erasing of active acknowledged alarms, until they have returned to normal status. The user shall also have the ability to command, launch an associated graphic or trended graphical plot, or run a report on a selected alarm point directly on the Alarm Display.
 - e. Each alarm point shall have a direct link from the Alarm Display to further user-defined point informational data. The user shall have the ability to also associate real-time electronic annotations or notes to each alarm.

- f. Alarm messages shall be customizable for each point, or each alarm priority level, to display detailed instructions to the user regarding actions to take in the event of an alarm. Alarm messages shall also have the optional ability to individually enunciate on the workstation display via a separate pop-up window, automatically being generated as the associated alarm condition occurs.
 - g. Alarm Display application shall allow workstation operators to send and receive real-time messages to each other, for purposes of coordinating Alarm and BAS system management.
 - h. Remote notification of messages
 - 1) Workstation shall be configured to send out messages to numeric pagers, alphanumeric pagers, phones (via text to speech technology), SMS (Simple Messaging Service, text messaging) Devices, and email accounts based on a point's alarm condition.
 - 2) There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit on the number of remote devices which can receive messages from the system.
 - 3) On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.
 - 4) Remote devices may be scheduled as to when they receive messages from the system to account for operators' work schedules.
 - 5) System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to the next device after a configurable time has elapsed.
 - 6) Message detail shall be configurable on a per user basis.
 - 7) During a "flood" of alarms, remote notification messages shall have the ability to optimize several alarms into an individual remote notification message.
 - 8) Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.
 - 9) Workstation shall have a feature to send a heartbeat message to periodically notify users that they have communication with the system.
- S. Field Devices
- 1. Provide instrumentation as required for monitoring, control or optimization functions.
 - 2. Room Temperature Sensors
 - a. Office and classroom spaces shall be provided with digital room sensors with day / night override button, and setpoint slide adjustment. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment. Public areas such as corridors, entry areas, vestibules, restrooms and storage rooms shall have chrome cover plate without adjustment or occupied/unoccupied capability. Temperature sensors located in gymnasiums and locker rooms shall be provided with tamper proof guard. All temperature sensors shall be BACnet compatible network type. All areas/spaces including but not limited to offices, classroom spaces, common learning or gathering areas, dining areas, gym, locker rooms, band chorus & movement studio shall be provided with digital combination room sensors for temperature, humidity & CO2 and shall have day / night override button, and setpoint slide adjustment. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment. Public areas such as corridors, entry areas, vestibules, restrooms and storage rooms shall have chrome cover plate temperature sensors without adjustment or occupied/unoccupied capability. Sensors located in gymnasiums and locker rooms shall be provided with tamper proof guard. All temperature sensors shall be BACnet compatible network type.

- Temperature monitoring range +20/120 deg. F -13 deg. to 49 deg. C)
- Output signal Changing resistance
- Accuracy at Calibration point +0.5 deg. F (+/- 0.3 deg. C)
- Set Point and Display Range 55 deg. to 95 deg. F (13 deg. to 35 deg. C)
- b. Liquid immersion temperature:
 - Temperature monitoring range +30/250 deg. F (-1 deg. /121 deg. C)
 - Output signal Changing resistance
 - Accuracy at Calibration point +0.5 deg. F (+/-0.3 deg. C)
- c. Duct (single point) temperature:
 - Temperature monitoring range +20/120 deg. F (-7 deg. /49 deg. C)
 - Output signal Changing resistance
 - Accuracy at Calibration point +0.5 deg. F (+/-0.3 deg. C)
- d. Duct Average temperature:
 - Temperature monitoring range +20 deg.+120 deg.F(-7 deg./+49 deg. C)
 - Output signal 4 – 20 mA DC
 - Accuracy at Calibration point +0.5 deg. F (+03 deg. C)
 - Sensor Probe Length 25 ft. L (7.3m)
- e. Outside air temperature:
 - Temperature monitoring range -58deg.+122deg.F(-50deg.Cto 50deg.C)
 - Output signal 4 – 20 mA DC
 - Accuracy at Calibration point +0.5 deg. F (+/-0.3 deg. C)
- 3. Liquid Differential Pressure Transmitter
 - Ranges 0-5/30 in. H2O
 - 0-25/150 in. H2O
 - 0-125/750 in. H2O
 - Output 4 – 20 mA DC
 - Calibration Adjustments Zero and span
 - Accuracy +/-0.2 percent of span
 - Linearity +/-0.1 percent of span
 - Hysteresis +/-0.05 percent of span
- 4. Differential pressure:
 - a. Unit for fluid flow proof shall be Penn P74.
 - Range 8 to 70 psi
 - Differential 3 psi
 - Maximum differential pressure 200 psi
 - Maximum pressure 325 psi
 - b. Unit for air flow settings.
 - c. Set point ranges: 0.5 in. WG to 1.0 in. WG (124.4 to 248.8 Pa)
1.0 in. WG to 12.0 in. WG (248.8 to 497.6 Pa)
- 5. Static pressure sensor:
 - Range 0 to .5 in.WG (0 to 124.4 Pa)
 - 0 to 1 in.WG (0 to 248.8 Pa)
 - 0 to 2 in. WG (0 to 497.7 Pa)
 - 0 to 5" in.WG (0 to 1.2 kPa)
 - 0 to 10" WG (0 to 2.5 kPa)
 - Output Signal 4 – 20 mA VDC
 - Combined static error 0.5 percent full range
 - Operating Temperature -40 deg. to 175 deg. F (-40 deg. C to 79.5 deg. C)

6. Air Pressure Sensor:
Range: 0 to 0.1 in. water (0 to 24.9 Pa)
0 to 0.25 in. water (0 to 63.2 Pa)
0 to 0.5 in. water (0 to 124.5 Pa)
0 to 1.0 in. water (0 to 249 Pa)
0 to 2.0 in water 90 to 498 Pa)
0 to 5.0 in. water (0 to 1.25 kPa)
0 to 10.0 in. water (0 to 2.49 kPa)
Output signal 4 to 20 mA
Accuracy +1.0 percent of full scale
7. Humidity Sensors: All room/zone humidity sensors shall be BACnet compatible network type.
Range 0 to 100 percent RH
Sensing Element Bulk Polymer
Output Signal 4 – 20 mA DC
Accuracy At 77 deg. F (25 deg. C) + 2 percent RH
Humidistat:
Range 0 to 100 percent RH
Sensing Element Bulk Polymer
Output Signal 4 – 20 mA DC
Accuracy At 77 deg. F(25 deg. C) + 2 percent RH
8. Insertion Flow Meters (Equal to-Onicon F-5300)
Sensing Method Impedance Sensing
Accuracy + 2 percent of Actual Reading
Maximum Operating Pressure 400 PSI
Output Signal 4 – 20 mA
Bi-directional where required.
9. Pressure to Current Transducer
Range 3 to 15 psig (21 to 103 kPa) or
3 to 30 psig (21 to 207 kPa)
Output signal 4 – 20 mA
Accuracy + 1 percent of full scale (+ 0.3 psig)
10. Carbon Dioxide Sensor : All room/zone CO₂ on duct mounted sensors shall be BACnet compatible network type and shall have a minimum 5 year calibration period.
Range 0 to 1500 ppm
Accuracy 20+ ppm
CO₂ sensors located in gymnasiums and locker rooms shall be provided with tamper proof guard.
11. Control Valves (all control valves modulating shall have electric actuators with spring return, fail open and position feedback to provide confirmation of valve position).
 - a. Electric Control

Rangeability	40:1
Flow Characteristics	Modified. Equal percentage
Control Action	Normal open for hot water with fail open spring return
Medium	Steam, water, glycol
Body Type	Screwed ends 2 in. and smaller, flanged Valves 2½ in. and larger
Body Material	Bronze
Body Trim	Bronze
Stem	Stainless Steel
Actuator	0-10 VDC, 4-20 MA 24 VAC/120VAC – Modulating for all hot water valves.

- b. All automatic temperature control valves in water lines shall be provided with Characterized throttling plugs and shall be sized for minimum 25 percent of the system pressure drop or five psi, whichever is less.
 - 1) Positive positioning relays shall be provided on pneumatic control when required to provide sufficient power for sequencing.
 - 2) Two position valves shall be line size.
- 12. Damper Actuators
 - a. Electric control shall be direct coupled actuators with position feedback to BMS.
 - b. Damper actuators shall be Brushless DC Motor Technology with stall protection, bi-directional, fail safe spring return, all metal housing, manual override, independently adjustable dual auxiliary switch.
 - 1) The actuator assembly shall include the necessary hardware and proper mounting and connection to a standard ½ in. diameter shaft or damper blade.
 - c. Actuators shall be designed for mounting directly to the damper shaft without the need for connecting linkages.
 - d. All actuators having more than 100 lb-in torque output shall have a self-centering damper shaft clamp that guarantees concentric alignment of the actuator's output coupling with the damper shaft. The self-centering clamp shall have a pair of opposed "v" shaped toothed cradles; each having two rows of teeth to maximize holding strength. A single clamping bolt shall simultaneously drive both cradles into contact with the damper shaft.
 - e. All actuators having more than a 100 lb-in torque output shall accept a 1 in. diameter shaft directly, without the need for auxiliary adapters.
 - f. All actuators shall be designed and manufactured by Belimo or approved equal using ISO900 registered procedures, and shall be Listed under Standards UL873 and CSA22.2 No. 24-93 I.
- T. Meters: Meters shall be provided to monitor and trend the energy consumed by the HVAC (heating, cooling, ventilation, fans) and Hot water (Heating and Domestic) serving the building. Provide the following meters (or connection to meters) and network these devices into the Building Management System.
 - 1. Provide hydronic BTU Energy Meters (Ultrasonic, strap on type flow meters and temperature sensors) for the following systems. Hydronic system energy data obtained from meters and sensors shall be input to the building automation system for calculating, trending and storing energy consumption information of the following systems:
 - a. Heating Hot Water
 - b. Chilled Water
 - c. Cold Water Make-Up (Building Water Use)
 - 2. Provide all necessary components and accessories required for connection to main electrical KYZ pulse consumption meters (kWh). Meters shall be provided by Division 260000. Refer to Electrical Drawings for meter location.
 - 3. The ATC Contractor shall provide and program a digital interactive kiosk which shall display building graphics, energy consumption meters, HVAC equipment, outdoor air temperature and humidity. Provide model podium HD manufactured by Industrial Computing Products from I&E or equal. Provide all necessary programming wiring and software from a complete and functional kiosk.
 - 4. Domestic hot water consumption shall be determined and calculated by the ATC contractor. Relays shall be installed on the domestic water heater burner to calculate usage. ATC Contractor shall provide relays and programming required to achieve consumption.
 - 5. Sensors to monitor building natural gas consumption. Gas meters shall be furnished and installed by the Plumbing contractor. The ATC contractor shall provide control wiring from the meter to the BMS.

6. Flow meters for building cold water consumption will be installed by the Plumbing Contractor and furnished and wired to the BMS by the ATC Contractor.

U. Miscellaneous Devices

1. Thermostats (Stand-alone electric type - only where specified or indicated on drawings)
 - a. Room thermostats shall be of the gradual acting type with adjustable sensitivity.
 - b. They shall have a bi-metal sensing element capable of responding to a temperature change of one-tenth of one degree. (Provide all thermostats with limit stops to limit adjustments as required.)
 - c. Thermostats shall be arranged for either horizontal or vertical mounting.
 - d. In the vertical position thermostat shall fit on a mullion of movable partitions without overlap.
 - e. Mount the thermostat covers with tamper-proof socket head screws.
2. Firestats:
 - a. Provide manual reset, fixed temperature line voltage type with a bi-metal actuated switch.
 - 1) Switch shall have adequate rating for required load.
3. Electronic Airflow Measurement Stations and Transmitters (Where indicated on Control Drawings).
 - a. Provide air flow moving stations as shown on drawings.
 - b. Stations – each insertion station shall contain an array of velocity sensing elements and straightening vanes. The velocity sensing elements shall be of the RTD or thermistor type. The sensing elements shall be distributed across the duct cross section in a quality to provide accurate readings. The resistance to airflow through the airflow measurement station shall not exceed 0.08 in. water gage at an airflow of 2,000 fpm. Station construction shall be suitable for operation at airflow of up to 5,000 fpm over a temperature range of 40 to 120 degrees F, and accuracy shall be plus or minus 3 percent over a range of 125 to 2,500 fpm scaled to air volume. Each transmitter shall produce a linear, temperature compensated 4 to 40 mA DC, output corresponding to the required velocity pressure measurement. Provide local readout on unit.
 - c. Fan inlet airflow sensing
 - 1) Where mounted into controllable pitch axial inlet bells, or inlet cones of centrifugal fans, the traverse probe assemblies shall be complete with all necessary end mounting plates and master takeoff fittings. All mounting bolts, lock washers and nuts; interconnecting tubing and compression fittings to be provided by the installing contractor.
 - 2) Primary flow elements shall not be used on fan inlet applications where the narrowest diameter of the inlet cone is under ten in. without prior approval. Fan inlet sensors shall not be used on fans having inlet guide vanes. The use of only one static element and one total pressure element on fan inlets is prohibited. Fan primary elements shall not exceed .562 in. in diameter on fans having inlet cone diameters less than 30 in..
 - 3) Fan inlet airflow sensing similar to Ebtron GTx116F or Paragon Controls model FE-1050.
 - d. Electronic Transducers
 - 1) Provide individual differential static pressure and airflow transducers, selected for the required range of each of the above primary elements, and in accordance with the following:
 - 2) The transducer(s) shall be solid-state electronic type, with infinite output resolution, capable of performing dedicated static pressure and air volume control functions. Microprocessor based transducers with time-

- sharing of multiple square root extractors and/or controllers are not acceptable.
- 3) Each transducer's output shall not be affected by direction of mounting (attitude) or external vibrations, and shall be furnished with a factory-calibrated range that matches the application.
 - 4) Airflow transducers shall be provided with an integral dual scale indicating meter operating independent of all other control devices. The top scale shall indicate the measured air volume in units of cubic ft. per minute (CFM), and the bottom scale shall indicate the air velocity in units of ft. per minute (FPM).
 - a) The meter shall be a differential pressure type that is diaphragm actuated, and is to be flush mounted on the enclosure door.
 - b) The meter shall be calibrated to an accuracy of +2 percent of span.
 - 5) Transducer performance shall be equal to or better than the following:
 - a) Accuracy: +/- 0.5 percent F.S. (Terminal Point) / +/- 0.35 percent F.S. (BFSL)
 - b) Temperature Effects: <0.03 percent F.S./deg F
 - c) Over-pressure: 5 PSIG Proof / 10 PSIG Burst
 - d) Response: <0.25 seconds for full scale input
 - e) Noise Filtration: Low Pass Filter, factory set @ 3.2Hz
 - 6) Each transducer shall be selected for its respective duty. Supply, Exhaust and/or Return Airflow Transducers shall provide analog output signal linear to air volume that are factory set for a full scale value equal to 110 percent of the maximum design capacity of the flow measuring element served for variable air volume applications, or 200 percent of the design operating value for constant volume applications.
 - 7) Airflow transducers for operating velocities below 1266 ft. per minute shall provide the following features:
 - a) Local electronic indication of the measure airflow rate.
 - b) The indicating meter shall be one-half in. high, three and one half digit light emitting diode (LED) type.
 - c) The LED shall indicate the measured air volume in engineering units of cubic ft. per minute (CFM).
 - d) Automatic zeroing circuit that shall maintain the transducer output to within 0.1 percent of value, and shall be field configurable for frequency of activation between one and seventy two hours.
 - e) The transducer output shall be locked and maintained at the last given output value during the automatic zeroing period so as not to interrupt the automatic control process.
 - f) The meter shall be auto calibrated to an accuracy of +/- 1 count.
 - g) Transducer accuracy shall be +/- 0.25 percent F.S. (Terminal Point) / +/- 0.15 percent F.S. (BFSL)
4. Current Sensing Relay:
- a. Provide solid-state, adjustable, current operated relay. Provide a relay which changes switch contact state in response to an adjustable set point value of current in the monitored A/C circuit.
 - b. Adjust the relay switch point so that the relay responds to motor operation under load as an "on" state and so that the relay responds to an unloaded running motor as an "off" state. A motor with a broken belt is considered an unloaded motor.

- c. Provide for status device for all fans and pumps.
- V. Manufacturer: Subject to compliance with requirements, provide an Automatic Temperature Control System as manufactured by:
- 1. Siemens
 - 2. Control Technologies
 - 3. Automated Logic
 - 4. Schneider Electric
 - 5. Johnson Controls
 - 6. Trane
 - 7. Or equal

PART 3 EXECUTION

3.1 CUTTING AND PATCHING:

- A. Penetrations through new and existing construction as required for the Work of this Section:
- 1. Coring: Perform all coring for required work.
 - 2. Notify Masonry Sub-Contractor of exact locations and sizes for openings required in masonry, to be executed under Section 042000 – Unit Masonry, utilizing lintels furnished per Section 055000 – Metal Fabrications.
 - 3. Cut openings in new and existing non-masonry construction where required for penetrations. All cutting shall conform to the requirements of Section 017329 – Cutting and Patching and Section 024119 – Demolition.
 - 4. Refer to Section 024119 – Demolition for restrictions on all alterations to structural elements.
- B. Patching around penetrations through construction as required for the Work of this Section:
- 1. Notify Masonry Sub-Contractor when work is complete at penetrations through masonry construction, and ready for patching under Section 042000 – UNIT MASONRY.
 - 2. Notify appropriate Sub-Contractors when work is complete at penetrations through non-masonry construction, and ready for patching under Sections in Division 09 - FINISHES.
 - 3. Patching of surfaces shall be performed by the trade responsible for the surface penetrated, associated costs for patching shall be borne by this HVAC sub contractor.

3.2 INSTALLATION OF VALVES

- A. Examine valve interior through the end ports, for cleanliness, freedom from foreign matter and corrosion. Remove special packing materials, such as blocks used which prevents disc movement during shipping and handling.
- B. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the position in which it was shipped.
- C. Examine threads on both the valve and the mating pipe for form (out-of-round or local indentation) and cleanliness.
- D. Examine mating flange faces for conditions which might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size and material, and for freedom from defects and damage.

- E. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.
- F. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select valves with the following ends or types of pipe/tube connections:
 - 1. Copper Tube 2 in. and smaller (Heating Hot Water): Solder ends.
 - 2. Steel Pipe Sizes 2 in. and smaller: Threaded or grooved-end.
 - 3. Steel Pipes Sizes 2-1/2 in. and larger: Grooved-end or welded.
- G. Valve Installation
 - 1. Locate valves for easy access and provide separate support where necessary.
 - 2. Install valves and unions for each fixture and item of equipment in a manner to allow equipment removal without system shut-down. Unions are not required on flanged devices.
 - 3. Install valves in horizontal piping with the stem at or above the center of the pipe.
 - 4. Install isolation valves at all branch supply and return piping lines which serve more than two pieces of terminal heating equipment.
 - 5. Installation of Check Valves: Install for proper direction of flow as follows:
 - a. Swing Check Valves: Install in horizontal position with hinge pin level.
 - b. Wafer Check Valves: Install between 2 flanges in horizontal or vertical position.
 - c. Lift Check Valves: Install in piping line with stem upright and plumb.
- H. Threaded Connections
 - 1. Note the internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
 - 2. Align threads at point of assembly.
 - 3. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).
 - 4. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.
- I. Flanged Connections
 - 1. Align flanges surfaces parallel.
 - 2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using a torque wrench.
- J. Grooved Connections
 - 1. Installation shall be in accordance with the latest published instructions from the manufacturer.
- K. Field Quality Control
 - 1. Testing: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks; replace valve if leak persists.
- L. Adjusting and Cleaning
 - 1. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare to receive painting or insulation.

3.3 INSTALLATION OF METERS AND GAGES

- A. Installation of Temperature Gages
 - 1. General: Install temperature gages in vertical upright position, and tilted so as to be easily read by observer standing on floor.
 - 2. Temperature Gage Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure Cap.
- B. Installation of Pressure Gages
 - 1. General: Install pressure gages in piping tee with pressure gage located on pipe at most readable position.
 - 2. Pressure Gage Cocks: Install in piping tee with snubber. Install siphon for steam pressure gages.
 - 3. Pressure Gage Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap.
- C. Installation of Flow Measuring Fittings
 - 1. General: Install flow measure fittings in piping systems located in accessible locations.
- D. Adjusting and Cleaning
 - 1. Adjusting: Adjust faces of meters and gages to proper angle for best visibility.
 - 2. Cleaning: Clean windows of meters and gages and factory-finished surfaces. Replace cracked or broken windows; repair any scratched or marred surfaces with manufacturer's touch-up paint.

3.4 INSTALLATION OF HANGERS & ATTACHMENTS

- A. Vibration Control and Seismic Restraint: Refer to Section 230548 and drawing VS.1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in Section 230548 and drawing VS.1.
- B. Examine areas and conditions under which supports and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.
- C. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors, and other building structural attachments.
- D. Prior to installation of hangers, supports, anchors, and associated work, Installer shall meet at project site with Contractor, installer of each component of associated work, inspection and testing agency representatives (if any), installers of other work requiring coordination with work of this section and Architect/Engineer for purposes of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified.

- E. Install building attachments at required locations within concrete or on structural steel for proper piping support. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert securely to forms. Where concrete with compressive strength less than 2500 psi is indicated, install reinforcing bars through the openings at the tops of inserts.
- F. Install hangers, supports, clamps, and attachments to support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Install supports with maximum spacing complying with MSS SP-69. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.
 - 1. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.
 - 2. Prevent electrolysis in support of copper tubing by the use of hangers and supports which are copper plated, or by other recognized industry methods.
 - 3. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
 - 4. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.
 - 5. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 Pressure Piping Codes are not exceeded.
 - 6. Insulated Piping: Comply with the following installation requirements:
 - a. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.
 - b. Shields: For pipe sizes up to and including 4 in. provide heavy gage shield at each hanger point.
 - c. Saddles: For all pipe sizes over 4 in. provide saddle at each hanger point. Completely fill void in saddle with loose insulation.
- G. Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31, and to prevent transfer for loading and stresses to connected equipment.
- H. Fabricate and install anchor by welding steel shapes, plates, and bars to piping and to structure. Comply with ANSI B31 and with AWS standards.
- I. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
- J. Anchor Spacing: Where not otherwise indicated, install anchors at ends of principal pipe-runs, at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping.

- K. Concrete housekeeping bases shall be provided by the General Contractor for all floor-mounted equipment. Size bases to extend minimum of 4 in. beyond equipment base in any direction; and 4 in. above finished floor elevation. Construct of reinforced concrete, roughen floor slab beneath base for bond, and provide steel rod anchors between floor and base. Locate anchor bolts using equipment manufacturer's templates. Chamfer top and edge corners.
- L. Provide structural steel stands to support equipment not floor mounted or hung from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks mounted on steel stands.
- M. Adjusting and Cleaning:
 - 1. Hanger Adjustment: Adjust hangers so as to distribute loads equally on attachments.
 - 2. Support Adjustment: Provide grout under supports so as to bring piping and equipment to proper level and elevations.
 - 3. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.5 INSTALLATION OF MECHANICAL IDENTIFICATION

- A. Coordination: Where identification is to be applied to surfaces which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces; install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.
- B. General: Install pipe markers of the following type on each system indicated to receive identification, and include arrows to show normal direction of flow:
 - 1. Plastic pipe markers, with application system as indicated. Install on pipe insulation segment where required for hot non-insulated pipes.
- C. Locate pipe markers and color bands as follows wherever piping is in or above occupied spaces or corridors, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
 - 1. Near each valve and control device.
 - 2. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
 - 3. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
 - 4. At access doors, manholes and similar access points which permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced intermediately at maximum spacing of 50 ft. along each piping run, except reduce spacing to 25 ft. in congested areas of piping and equipment.
 - 7. On piping above removable acoustical ceilings.
- D. Valve Identification:
 - 1. General: Provide valve tag on every valve, cock, and control device in each piping system; exclude check valves, valves within factory-fabricated equipment units, HVAC terminal devices and similar rough-in connections of end-use fixtures and units. List each tagged valve in valve schedule for each piping system.
 - 2. Mount valve schedule frames and schedules in machine rooms where indicated or, if not otherwise indicated, where directed by Architect/Engineer.

- E. Mechanical Equipment Identification:
 - 1. General: Install engraved plastic laminate sign or plastic equipment marker on or near each major item of mechanical equipment and each operational device, as specified herein if not otherwise specified for each item or device.
 - 2. Lettering Size: Minimum 1/4 in. high lettering for name of unit where viewing distance is less than 2 ft. – 0 in., 1/2 in. high for distances up to 6 ft. – 0 in. and proportionately larger lettering for greater distances. Provide secondary lettering of 2/3 to 3/4 of size of the principal lettering.
- F. Ductwork Identification:
 - 1. Install or apply labels per manufacturer's recommendations.
 - 2. Install in locations where it can be viewable by personnel.
- G. Adjusting and Cleaning:
 - 1. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.
 - 2. Cleaning: Clean face of identification devices, and glass frames of valve charts.

3.6 INSTALLATION OF MECHANICAL INSULATION

- A. Installation of Piping Insulation:
 - 1. Insulation
 - 2. Composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated. Do not cover calibrated balance valves until testing adjusting and balancing has been completed. Omit insulation on hot piping within radiation enclosures which serve the zone: hot water passing through the zone must be insulated or unit cabinets; on cold piping within unit cabinets provided piping is located over drain pan. (Couplings in mechanical grooved systems will be insulated.)
 - 3. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
 - 4. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance tests.
 - 5. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
 - 6. Clean and dry pipe surfaces prior to insulating. Butt installation joints firmly together to ensure a complete and tight fit over surfaces to be covered.
 - 7. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
 - 8. Cover valves, fittings and similar items in each piping system with equivalent thickness and c
 - 9. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.
 - 10. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3 in. wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3 in. wide vapor barrier tape or band.

- B. Installation of Ductwork Insulation:
1. General: Do not insulate ductwork until ductwork has been sealed successfully, pressure tested, and approved for application of insulation by engineer or commissioning agent. Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.
 2. Install insulation materials with smooth and even surfaces.
 3. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
 4. Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage.
 5. Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated.
 6. Lined Ductwork: Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.
- C. Installation of Equipment Insulation:
1. General: Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose.
 2. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.
 3. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.
 4. Do not apply insulation to equipment, breechings, or stacks while hot.
 5. Apply insulation using the staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.
 6. Coat insulated surfaces with layers of insulating cement, troweled in workmanlike manner, leaving a smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.
 7. Cover insulated surfaces with all-service jacketing neatly fitted and firmly secured. Lap seams at least 2 in. Apply over vapor barrier where applicable.
 8. Do not insulate boiler manholes, handholes, cleanouts, ASME stamp, and manufacturer's nameplate. Provide neatly beveled edge at interruption of insulation.
 9. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.
- D. Protection and Replacement:
1. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.
 2. Protection; Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

3.7 INSTALLATION OF GREASE DUCT INSULATION

A. EXAMINATION

1. Do not begin installation until substrates have been properly prepared.
2. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
3. Coordinate installation of the Thermal Ceramics FastDoor XL access door between sheet metal and insulation trades.

B. PREPARATION

1. Remove dirt and dust from surfaces of openings and items penetrating rated floors and rated walls.

C. INSTALLATION

1. Install FireMaster FastWrap XL or Pyroscat Duct Wrap XL in direct contact with the ductwork in accordance with manufacturer's instructions, applicable laboratory listings and building code reports, and referenced standards. For additional complex duct design installation recommendations, see the Thermal Ceramics' complete installation guide.
2. Install two layers of FireMaster FastWrap XL or Pyroscat Duct Wrap XL for zero clearance and a 1 and 2 hour commercial kitchen grease duct applications per ASTM E 2336.
 - a. General Installation Instructions for Double Layer Installations: The inside and outside layers of FireMaster or Pyroscat blankets are cut to a length that will fit around the duct and meet with a tight butt joint. Adjacent blankets on the inside and outside layers are tightly butted against each other. Joints between blankets on the outside layer shall be offset from joints on the inside layer by a minimum 6 in. (152 mm). Cut edges of the blanket shall be taped with aluminum foil tape. During installation the blankets are temporarily held in place with filament tape until the wrap is mechanically attached with steel bands or steel insulation pins.
3. Install 1 layer of FireMaster FastWrap XL or Pyroscat Duct Wrap XL for 1 and 2 hour air ventilation duct enclosures per ISO 6944-1985.
 - a. General Installation Instructions for Single Layer Installations: FireMaster or Pyroscat blankets are cut to a length that will fit around the duct and overlap itself no less than 3 in. (152 mm). Adjacent blankets overlap each other a minimum of 3 in. (152 mm), or they can be fitted together with a tight butt joint and covered with a 6 in. (305 mm) wide collar centered over the butt joint. Cut edges of the blanket are taped with aluminum foil tape. During installation the blankets are temporarily held in place with filament tape until the wrap is mechanically attached with steel bands or steel insulation pins.
4. Install one layer of Thermal Ceramics PlenumWrap+ on plastic pipe or plastic jacketed electrical cables per Intertek listing reports and testing to NFPA 262 and UL1887.
 - a. Cut plenum blanket to a length that will fit around the pipe or cable and overlap itself no less than 1 in. (25 mm). Adjacent blankets overlap each other a minimum of 1 in. (25 mm). Plenum blanket is secured using either 1/2 in. (12 mm) steel banding or 16 gauge carbon or stainless steel tie wire on maximum 11-1/2 in. (292 mm) spacing.

5. Mechanical Fastening of Enclosure Material to Ductwork:
 - a. Banding - Carbon steel or stainless steel banding is used to hold the outer layer of the blanket enclosure in place. Banding is minimum 1/2 in. (12.7 mm) wide, and is placed around the entire perimeter of the duct on maximum 10-1/2 in. (267 mm) centers and 1-1/2 in. (38 mm) from each blanket or collar edge.
 - b. Pinning - To prevent blanket sag on duct spans wider than 24 in. (610 mm), minimum 12-gauge steel insulation pins are welded to the duct along bottom horizontal and outside vertical runs in columns spaced 12 in. (305 mm) apart, 6 to 12 in. (152 to 305 mm) from each edge, and on 10-1/2 in. (267 mm) centers. Pins are locked in place with 1-1/2 in. (38 mm) diameter or 1-1/2 in. (38 mm) square galvanized steel speed clips or cup head pins. Pins are turned down or the excess cut off to eliminate sharp edges.
6. Grease Duct Access Door Installation:
 - a. Install Thermal Ceramics FastDoor XL per manufacturers' instructions, and applicable building code reports and laboratory design listings.
7. Through-Penetration Firestop System:
 - a. When the duct penetrates a concrete or dry wall fire rated floor, ceiling, or wall an approved firestop system shall be employed. FireMaster or Pyroscat insulation shall be installed directly to the duct through the penetration, or terminated on both sides of the penetration depending on the annular space allowance between the duct and the duct opening. When the FireMaster or Pyroscat enclosure system is terminated on both sides of the through penetration, the duct wrap material is mechanically attached to the duct at the termination points using either steel banding or steel pins.
 - b. To fire stop the through penetration void area, fill the annular space between the wrapped duct or bare duct and the periphery of the opening with scrap FireMaster or Pyroscat insulation firmly packed into the opening. Compress scrap blanket to percentage stated in the firestop listing for a minimum depth as specified in the firestop listing. Recess packing material below surface on both sides of walls or top side only for floors to the depth stated in the firestop listing. Seal over the packing material using an approved firestop sealant to a depth as stated in the firestop listing, flush with top side of a floor assembly and both sides of a wall assembly.

D. REPAIR PROCEDURES

1. Repair damaged FireMaster FastWrap XL or Pyroscat Duct Wrap XL in accordance with manufacturer's instructions.
2. Remove damaged section by cutting the bands and removing the anchor clips holding it in place. Apply a new section of the same dimension ensuring the same overlap and installation method that existed previously. Cut edges and tears in the foil must be taped with aluminum tape to prevent the insulation from wicking moisture or grease.

E. PROTECTION

1. Protect installed products until completion of project.
2. Touch-up, repair or replace damaged products before Substantial Completion.

3.8 INSTALLATION OF HYDRONIC PIPING AND ACCESSORIES

- A. Vibration Control and Seismic Restraint: Refer to Section 230548 and Drawing VS.1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in Section 230548 and Drawing VS.1.

- B. Piping Installations:
1. Locations and Arrangements: Drawings indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design consideration. So far as practical, install piping as indicated.
 2. Install piping at a uniform grade of 1 in. in 40 ft. upward in the direction of flow.
 3. Make reductions in pipe sizes using eccentric reducer fitting installed with the level side up.
 4. Install branch connections to mains using Tee fittings in main with take-off out the bottom, except for up-freed risers which shall have take-off out the top of the main line.
 5. Install unions in pipes 2 in. and smaller, adjacent to each valve, at final connections of each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.
 6. Install flanges on valves, apparatus, and equipment having 2-1/2 in. and larger connections.
 7. Install strainers on the supply side of each control valve, pressure reducing valve, pressure regulating valve, solenoid valve, inline pump, and elsewhere as indicated. Install nipple and ball valve in blow down connection of strainers 2 in. and larger.
 8. Anchor piping to ensure proper direction of expansion and contraction. Expansion loops and joints are indicated on the Drawings.
 9. Install pipe sleeves at all wall and floor penetrations.
 10. Install escutcheons at all exposed pipe wall penetrations.
 11. Provide Dielectric couplings at all dissimilar piping/valve connections.
- C. Pipe Applications:
1. Copper Tubing: Use Type L, drawn copper tubing with wrought copper fittings and solder joints for 2 in. and smaller, above ground, within building. Use Type K, annealed temper copper tubing for 2 in. and smaller without joints, below ground or within slabs. Mechanical fittings (crimp or flair) are not permitted.
 2. Steel Pipe: Use steel pipe with threaded joints and fittings for 2 in. and smaller, and with welded joints for 2-1/2 in. and larger.
 3. Steel Pipe: Use mechanical grooved end steel pipe and mechanical couplings and fittings.
- D. Grooved Ends:
1. Roll Groove pipe ends in accordance with the latest published instructions from manufacturer of grooved couplings.
- E. Valve Applications:
1. General Duty Valve Applications: The Drawings indicate valve types to be used. Where specific valve types are not indicated the following requirements apply:
 - a. Shut-Off Duty: Use gate, and ball, valves.
 - b. Throttling Duty: Use globe, ball, and plug valves.
 2. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.
 3. Install pump discharge valves with stem in upward position; allow clearance above stem for check mechanism removal.
 4. Install safety relief valve on hot water generators, and elsewhere as required by ASME Boiler and Pressure Vessel Code. Pipe discharge to floor without valves. Comply with ASME Boiler and Pressure Vessel Code Section VIII, Division 01 for installation requirements.
 5. Install pressure reducing valves on hot water generators, and elsewhere as required to regulate system pressure.

6. Install isolation valves in all branch supply take-offs from piping mains which serve more than two terminal heating or cooling units. Provide balancing valve with positive shut off in all return branch take-offs which serve more than two terminal heating or cooling units. Provide isolation valves in floor supply main piping lines and balancing valves with positive shut-off in all floor return main piping take-offs.
- F. Hydronic Specialties Installation:
1. Install automatic air vents at high points in the system, heat transfer coils, and elsewhere as required for system air venting. Install air vents with cocks such that vents can be removed without draining system.
 2. Install combination separator/strainer in pump suction lines. Run piping to compression tank with 1/4 in. per foot (two percent) upward slope towards tank. Install blowdown piping with gate valve; extend to nearest drain.
 3. Install pump suction diffusers on pump suction inlet, adjust foot support to carry weight of suction piping. Install nipple and ball valve in blowdown connection.
 4. Install shot-type chemical feeders in each hydronic system; in upright position with top of funnel not more than 48 in. above floor. Install feeder in bypass line, off main using globe valves on each side of feeder and in the main between bypass connections. Pipe drain, with ball valve, to nearest equipment drain.
 5. Install diaphragm-type compression tanks as indicated. Vent and purge air from hydronic system, charge tank with proper air charge to suit system design requirements.
 - a. In the absence of details provide support from the floor or structure above sufficient for the weight of water assuming a full tank of water. Do not overload building components and structural members.
- G. Field Quality Control:
1. Preparation for Testing: Prepare hydronic piping in accordance with ASME B 31.9 and as follows:
 - a. Leave joints including welds uninsulated and exposed for examination during the test.
 - b. Provide temporary restraints for expansion joints which cannot sustain the reactions due to test pressure. If temporary restraints are not practical, isolate expansion joints from testing.
 - c. Flush system with clean water. Clean strainers.
 - d. Isolate equipment that is not to be subjected to the test pressure from the piping. If a valve is used to isolate the equipment, its closure shall be capable of sealing against the test pressure without damage to the valve. Flanged joints at which blinds are inserted to isolate equipment need not be tested.
 - e. Install relief valve set at a pressure no more than 1/3 higher than the test pressure, to protect against damage by expansion of liquid or other source of overpressure during the test.
 2. Testing: Test hydronic piping as follows:
 - a. Use ambient temperature water as the testing medium, except where there is a risk of damage due to freezing. Another liquid may be used if it is safe for workmen and compatible with the piping system components.
 - b. Use vents installed at high points in the system to release trapped air while filling the system. Use drains installed at point for complete removal of the liquid.
 - c. Examine system to see that equipment and parts that cannot withstand test pressures are properly isolated. Examine test equipment to ensure that it is tight and that low pressure filling lines are disconnected.

- d. Subject piping system to a hydrostatic test pressure which at every point in the system is not less than 1.5 times the design pressure. The test pressure shall not exceed the maximum pressure for any vessel, pump, valve, or other component in the system under test. Make a check to verify that the stress due to pressure at the bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength, or 1.7 times the "SE" value in Appendix A of ASME B31.9, Code for Pressure Piping, Building Services Piping.
 - e. After the hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connection for leakage. Eliminate leaks by tightening, repairing, or replacing components as appropriate, and repeat hydrostatic test until there are no leaks.
- H. Adjusting and Cleaning:
- 1. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.
 - 2. Chemical Treatment: Provide a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.9 INSTALLATION OF REFRIGERANT PIPING AND ACCESSORIES

- A. Vibration Control and Seismic Restraint: Refer to Section 230548 and Drawing VS.1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in Section 230548 and Drawing VS.1.
- B. Piping Installations:
- 1. Locations and Arrangements: Drawings indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, and other design consideration. So far as practical, install piping as indicated.
 - 2. Install pipe sleeves at all wall and floor penetrations.
 - 3. Install escutcheons at all exposed pipe wall penetrations.

3.10 INSTALLATION OF CONDENSING BOILERS

- A. Vibration Control and Seismic Restraint: Refer to Section 230548 and Drawing VS.1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in Section 230548 and Drawing VS.1.
- B. General: Install boilers in accordance with manufacturer's installation instructions, in accordance with State and Local Code requirements. Install units plumb and level, to tolerance of 1/8 in. in 10 ft. – 0 in. in both directions. Maintain manufacturer's recommended clearances around and over boilers.
- C. Support: Install boilers on 4 in. thick concrete pad, 4 in. larger on each side than base of unit. Provide supplemental structural steel supports (minimum 8 in. high) to elevate boiler as required to allow proper condensate drainage.

- D. Electrical Work: Install electrical devices furnished by manufacturer but not specified to be factory mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical work installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until electrical work is acceptable to equipment Installer.
- E. Gas Piping: Connect gas piping to boiler, full size of boiler gas train inlet, provide union with sufficient clearance for burner removal and service.
- F. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
- G. Hot Water Piping: Connect supply and return boiler tapplings as indicated, with shutoff valve and union or flange at each connection.
- H. Regulator Vents: Provide $\frac{3}{4}$ in. vent from each main and pilot regulator. Each vent shall terminate outdoors per code requirements.
- I. Breeching: Connect breeching to boiler outlet, full size of outlet. Route as indicated. Coordinate breeching routing and sizing with Boiler Manufacturer and vent system manufacturer.
- J. Flush and clean boilers upon completion of installation, in accordance with manufacturer's start-up instructions.
- K. Hydrostatically test assembled boiler and piping in accordance with applicable sections of ASME Boiler and Pressure Vessel Code.
- L. Arrange with National Board of Boiler and Pressure Vessel Inspectors for inspection of boiler piping, observation of hydrostatic testing, and for certification of completed boiler units.
- M. FIELD QUALITY CONTROL
 - 1. Perform tests and inspections and prepare test reports.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative or technician to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 - 2. Tests and Inspections:
 - a. Perform installation and startup checks according to manufacturer's written instructions.
 - b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 - c. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
 - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 1) Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
 - 2) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
 - 3. Remove and replace malfunctioning units and retest as specified above.
- N. Owner's Instructions: Provide services of manufacturer's technical representative for 4-hour day to instruct Owner's personnel in operation and maintenance of boilers.
 - 1. Schedule training with Owner, provide at least 7-day notice to Contractor and Engineer of training date.

3.11 INSTALLATION OF HVAC PUMPS

- A. Vibration Control and Seismic Restraint: Refer to Section 230548 and Drawing VS.1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in Section 230548 and Drawing VS.1.
- B. General: Install HVAC pumps where indicated, in accordance with manufacturer's published installation instructions, complying with recognized practices to ensure that HVAC pumps comply with requirements and serve intended purposes.
- C. Access: Provide access space around HVAC pumps for service as indicated, but in no case less than that recommended by manufacturer.
- D. Support: Install pump assembly on unitstrut utilizing flex connectors to eliminate vibration. Fasten unistrut as required to floor and/or wall as needed.
- E. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- F. Adjusting and Cleaning
 - 1. Alignment: Check alignment, and where necessary, realign shafts of motors and pumps within recommended tolerances by manufacturer, and in presence of manufacturer's service representative.
 - 2. Start-Up: Lubricate pumps before start-up. Start-up in accordance with manufacturer's instructions.
 - 3. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.12 INSTALLATION OF AIR INTAKE AND EXHAUST BREECHING, CHIMNEYS AND STACKS

- A. VIBRATION CONTROL AND SEISMIC RESTRAINT: Refer to section 230548 and drawing VS101 for the appropriate support of each piece of equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS101.
- B. Install all gas vents/intakes in accordance with manufacturer's installation instructions and UL listing. Maintain minimum clearances from combustibles specified in UL listing.
- C. Seal joints between sections of positive pressure vents in accordance with manufacturer's installation instructions, and using only sealants recommended by manufacturer.
- D. Support vents at intervals recommended by the manufacturer to support the weight of the vent and all accessories, without exceeding loading of appliances.
- E. Install barometric and thermostatically operated dampers in accordance with manufacturer's instructions. Locate as close to draft hood collar as possible.
- F. Clean breechings internally during installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth.

- G. Temporary Closure: At ends of breechings and chimneys which are not completed or connected to equipment, provide temporary closure which will prevent entrance of dust and debris until installations are completed.

3.13 INSTALLATION OF CONDENSATE NEUTRALIZING TUBES

- A. Refer to the Manufacturer's recommendations for the installation of Condensate Neutralizing Tubes.

3.14 INSTALLATION OF HVAC ROOFTOP UNITS (RTU)

- A. Vibration Control and Seismic Restraint: Refer to Section 230548 and Drawing VS.1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in Section 230548 and Drawing VS.1.
- B. General: Install rooftop units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in location indicated, and maintain manufacturer's recommended clearances.
- C. Support: Contractor shall coordinate installation with the roofing contractor, and shall install and secure roof curb to roof structure, per details on the drawings and in accordance with National Roofing Contractor's Association (NRCA) installation recommendations and shop drawings. Install and secure rooftop units on curbs and coordinate roof penetrations and flashing.
- D. Access: Provide access space around air handling units for service as indicated, but in no case less than that recommended by manufacturer.
- E. Duct Connections: Provide ductwork, accessories, and flexible connections as indicated.
- F. Grounding: Provide positive equipment ground for air-handling unit components.
- G. Provide one spare set of belts for each belt-driven air handling unit, obtain receipt from Owner that belts have been received.
- H. Electrical Connections: Refer to electrical sections for final connections to equipment and installation of loose shipped electrical components.
- I. Start-Up Services:
 - 1. Provide the services of a factory-authorized service representative to start-up rooftop units, in accordance with manufacturer's written start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
- J. Operating and Maintenance Training:
 - 1. Provide services of manufacturer's service representative (minimum 8 hrs.) to instruct Owner's personnel in operation and maintenance of rooftop units. Training shall include start-up and shut-down, servicing and preventative maintenance schedule and procedures, and trouble-shooting procedures plus procedures for obtaining repair parts and technical assistance.
 - 2. Schedule training with Owner, provide at least 7-day prior notice to the Architect/Engineer.

- K. Provide four sets of spare filters for each rooftop unit, both final filters and pre-filters. Obtain receipt from Owner that stock of spare filters has been received. These four sets are additional to those provided for flush out requirements and indoor air quality requirements.

3.15 INSTALLATION OF AIR COOLED CHILLER

- A. VIBRATION CONTROL AND SEISMIC RESTRAINT: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.
- B. GENERAL:
 - 1. Verify all dimensions by field measurements. Verify structure, mounting supports, and membrane installations are completed to the proper point to allow installation of units. Examine rough-in for piping systems to verify actual locations of piping connections prior to installation. Do not proceed until unsatisfactory conditions have been corrected.
 - 2. Install chiller in accordance with manufacturers installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.
- C. FIELD QUALITY CONTROL:
 - 1. Provide the services, to include a written report, of a factory authorized service representative to examine the field assembly of the components, installation, and piping and electrical connections.
- D. DEMONSTRATION:
 - 1. Provide the services of a factory authorized service representative to provide start-up service and to demonstrate and train the Owner's maintenance personnel as specified below.
 - 2. Start-up service: Place units into operation and adjust controls and safeties. Replace damaged or malfunctioning components and controls.
- E. TRAINING:
 - 1. Train the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, and servicing and preventative maintenance schedules and procedures.
 - 2. Schedule training with Owner through the Architect/Engineer with at least 7 days prior notice.

3.16 INSTALLATION OF TERMINAL HEATING UNITS (HYDRONIC)

- A. Vibration Control and Seismic Restraint: Refer to Section 230548 and Drawing VS.1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in Section 230548 and Drawing VS.1.
- B. Installation of Horizontal Unit Heaters: (Hydronic)
 - 1. General: Install unit heaters as indicated, and in accordance with manufacturer's installation instructions.
 - 2. Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.
 - 3. Hang units from building substrate, not from piping. Mount as high as possible to maintain greatest headroom possible unless otherwise indicated.

4. Support units with rod-type hangers anchored to building substrate.
 5. Install piping as indicated.
 6. Protect units with protective covers during balance of construction.
- C. INSTALLATION OF UNIT VENTILATORS: (HYDRONIC)
1. General: Install unit ventilators as indicated, and in accordance with manufacturer's installation instructions.
 2. Install piping as indicated
 3. Protect units with protective covers during balance of construction.
 4. Install shelving and auxiliary radiation, provide wall trim pieces for continuous wall-to-wall installation.
 5. Provide for cooling coil, stainless steel drain pan under coil of sufficient height to allow installation of condensate trap to allow drainage of condensate from pan when installed on suction side of fan.
- D. Installation of Cabinet Unit Heaters: (Hydronic)
1. General: Install cabinet heaters as indicated, and in accordance with manufacturer's installation instructions.
 2. Coordinate with other trades to assure correct recess size for recessed units.
 3. Install piping as indicated.
 4. Protect units with protective covers during balance of construction.
- E. Installation of Radiant Panels & Radiation Wall Units:
1. Install components level and plumb. Maintain sufficient clearance for normal services, maintenance, or in accordance with construction drawings.
 2. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Verify that controls and control enclosure are accessible.
 - b. Verify that control connections are complete to control valves as needed.
 - c. Verify that any identification tags are visible.
 - d. Verify that controls respond to inputs as specified.
 3. Connections
 - a. Piping installation requirements are specified in other Division 23 Sections. Drawings indicated general arrangement of piping, fittings, and specialties.
 - b. Install piping adjacent to radiant panels to allow for service and maintenance.
 - c. In addition to Division 23 Section "Hydronic Piping", connect copper tubing to supply with shut-off valve, strainer, control valve, and union or flange, and return pipe with balancing valve and union or flange.
 4. Field Quality Control
 - a. Perform the following field tests and inspections and prepare test reports:
 - 1) Leak Test: After installation, fill water tubes and test for leaks. Repair leaks and retest until no leaks exist.
 - 2) Operational Test: After electrical circuitry has been energized, start units to conform to proper unit operation.
 - 3) Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - b. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field assembled components and equipment installation, including connections, and to assist in field testing. Report any findings in writing.
 - c. Remove and replace malfunctioning units and retest as specified above.
 5. Cleaning and Protection
 - a. Clean all visible surfaces of equipment; touch up as required.
 - b. Protect all units before, during and after installation. Damaged materials due to improper protection shall be cause for rejection.

6. Construction Phase Services
 - a. Manufacturer or factory-authorized representative shall visit the site regularly during the installation process to ensure proper means and methods are being employed. Bid shall include the cost of a minimum of two (2) such visits.
 - b. Manufacturer or factory-authorized representative shall provide start-up and training services to owners/staff to adjust, operate, and maintain radiant panels.

- F. Adjusting and Cleaning:
 1. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
 2. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
 3. Install new filter units for terminal units, provide four sets of spare filters.
 4. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - a. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

- G. Provide spare filters for each cabinet unit heater. Provide enough filters to do 4 complete filter change outs at each cabinet unit heater. Obtain receipt from Owner that stock of spare filters has been received.

- H. INSTALLATION OF COILS: (HYDRONIC)
 1. General: Install coils as indicated, and in accordance with manufacturer's installation instructions.
 2. Pitch coil casings for drainage, not less than 1/8" toward return connections, except where drainage feature is included in coil design.
 3. Provide for each bank of cooling coils, stainless steel drain pan under each coil supported off of floor of sufficient height to allow installation of condensate trap to allow drainage of condensate from pan when installed on suction side of fan. (AD2.01.176)

- 3.17 INSTALLATION OF TERMINAL HEATING UNITS (ELECTRIC)
 - A. Vibration Control and Seismic Restraint: Refer to Section 230548 and Drawing VS.1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in Section 230548 and Drawing VS.1.

 - B. Installation of Electric Heating Terminals:
 1. Install electric heating terminal units including components as indicated, in accordance with equipment manufacturer's written instructions, and with recognized industry practices; complying with applicable installation requirements of NEC and NECA's "Standard of Installation".
 2. Coordinate with other electrical work, including wiring/cabling, as necessary to properly interface installation of heating terminal units with other work.
 3. Clean dust and debris from each heating terminal as it is installed to ensure cleanliness.
 4. Comb out damaged fins where bent or crushed before covering elements with enclosures.
 5. Touch-up scratched or marred heating terminal enclosure surfaces to match original finishes.

6. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminal to comply with tightening torques specified in UL Std. 486A.
- C. Grounding:
1. Provide equipment grounding connections for electric heating terminals as indicated, Tighten connections to comply with tightening torque values specified in UL std. 486A to assure permanent and effective grounding.
- D. Electrical Wiring:
1. General: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electric Installer.
 - a. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
 - b. Upon completion of installation of electric heating terminals, and after building circuitry has been energized, test heating terminals to demonstrate capability and compliance with requirements. Where possible, field correct malfunctioning units, then retest to demonstrate compliance; otherwise, remove and replace with new units and proceed with retesting.
 - c. Replace electric heating terminals and accessories which are damaged and remove damaged items from construction site.
- E. Adjusting and Cleaning:
1. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
 2. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
 3. Install new filter units for terminals requiring same.

3.18 INSTALLATION OF POWER AND GRAVITY VENTILATORS

- A. Vibration Control and Seismic Restraint: Refer to Section 230548 and Drawing VS.1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in Section 230548 and Drawing VS.1.
- B. General: Except as otherwise indicated or specified, install ventilators in accordance with manufacturer's installation instructions and recognized industry practices to insure that products serve the intended function.
- C. Coordinate ventilator work with work of roofing, walls and ceilings, as necessary for proper interfacing.
- D. Ductwork: Connect ducts to ventilators in accordance with manufacturer's installation instruction, and details on drawings.
- E. Roof Curbs: Furnish roof curbs to roofing Installer for installation.

- F. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Verify proper rotation direction of fan wheels. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- G. Remove shipping bolts and temporary supports within ventilators. Adjust dampers for free operation.
- H. Testing: After installation of ventilators has been completed, test each ventilator to possible, field correct malfunctioning units, then retest to demonstrate compliance. Replace units which cannot be satisfactorily corrected.
- I. Cleaning: Clean factory-finished surface. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- J. General: Furnish to Owner, with receipt, four spare set of belts for each belt driven power ventilator.

3.19 INSTALLATION OF VEHICLE EXHAUST SYSTEM

- A. General:
 - 1. Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.
 - 2. Install winch, hoisting cables, and related field installed accessories per manufacturer's recommendations.
- B. Adjusting and Cleaning:
 - 1. Test and adjust systems in presence of manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning equipment.
 - 2. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- C. Closeout Procedures:
 - 1. Owner's Instructions: Provide services of manufacturer's technical representative for one 2-hour day to instruct Owner's personnel in operation and maintenance of systems.

3.20 INSTALLATION OF METAL DUCTWORK

- A. Installation of Metal Ductwork:
 - 1. General: Assemble and install ductwork in accordance with recognized industry practices which will achieve air-tight (five percent leakage for systems rated 3 in. and under; one percent for systems rated over 3 in.) and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum number of joints. Align ductwork accurately with internal surface smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling. Support vertical ducts at every floor.

2. Sealing: All ductwork joints and seams shall be sealed with flexible duct sealer to assure an airtight installation.
 3. Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gage as duct. Overlap opening on 4 sides by at least 1-1/2 in. Fasten to duct and substrate.
 - a. Where ducts pass through fire-rated floors, walls, or partitions, provide firestopping between duct and substrate.
 4. Coordination: Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.
 5. Installation: Install metal ductwork in accordance with "SMACNA HVAC Duct Construction Standards".
- B. Installation of Duct Liners:
1. General Install duct liners in accordance with SMACNA "HVAC Duct Construction Standards".
- C. Installation of Flexible Ducts:
1. Maximum Length: For any duct run using flexible ductwork, do not exceed 4 ft.-0 in. extended length.
 2. Installation: Install in accordance with Section II of SMACNA's, "HVAC Duct Construction Standards, Metal and Flexible".
- D. Field Quality Control:
1. Leakage Tests: After each duct system that is constructed test for duct leakage in accordance with SMACNA "HVAC Air Duct Leakage Test Manual". Repair leaks and repeat tests until SMACNA requirements are achieved.
- E. Equipment Connections:
1. General: Connect metal ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery.
- F. Adjusting and Cleaning:
1. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.
 2. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until final connections are to be completed.
 3. Balancing: Refer to Division 23 section "Testing, Adjusting, and Balancing" for air distribution balancing of metal ductwork. Seal any leaks in ductwork that become apparent in balancing process.
- G. Construction IAQ Management:
1. Follow the SMACNA guidelines for "Duct Cleanliness for New Construction Guidelines" according to advanced levels of cleanliness. Including but not limited to:
 - a. Specify that ductwork be sealed when transported to the construction site
 - b. Store ductwork in clean, dry conditions and keep sealed while it is stored.
 - c. Wipe down internal surfaces of ductwork immediately prior to installation to remove dust.
 - d. Seal open ends on completed ductwork and overnight work-in-progress.
 - e. During installation, protect ductwork waiting to be installed with surface wrapping.

- f. During construction, seal HVAC supply and return openings to protect them from dust infiltration.

3.21 INSTALLATION OF DUCTWORK ACCESSORIES

- A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA standards, and in accordance with recognized industry practices to ensure that products serve intended function.
- B. Install turning vanes in square or rectangular 90 degree elbows in supply, return, and exhaust air systems, and elsewhere as indicated.
- C. Install volume and/or splitter damper with adjusting rod in each supply branch. Install according to detail on drawings.
- D. Install access doors to open against system air pressure, with latches operable from either side, except outside only where duct is too small for person to enter.
- E. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.
- F. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.
- G. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- H. Furnish extra fusible links to owner, one link for every 10 installed of each temperature range; obtain receipt.

3.22 INSTALLATION OF ACOUSTIC DUCT LINING

- A. Installation: All portions of duct designed to receive duct liner shall be completely covered. The smooth, black coated surfaces shall face the airstream. All liners shall be cut to assure tight, overlapped corner joints. The top pieces shall be supported by the side pieces. The liner shall be adhered to the sheet metal with full coverage of an approved adhesive that conforms to ASTM C 916, and all exposed leading edges and transverse joints shall be coated with Permacote factory-applied or field-applied edge coating and shall be neatly butted without gaps. Shop or field cuts shall be liberally coated with "Schuller SuperSeal Edge Treatment" or approved adhesive. The liner shall be additionally secured with mechanical fasteners. The pin length should be such as to hold the material firmly in place with minimum compression of the material.

3.23 INSTALLATION OF SOUND ATTENUATORS

- A. Vibration Control and Seismic Restraint: Refer to Section 230548 and Drawing VS.1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in Section 230548 and drawing VS.1.

- B. General: Install sound attenuators as indicated, and in accordance with manufacturer's installation instructions.
- C. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.
- D. Upon completion of installation test and demonstrate that sound attenuators, and duct connections to sound attenuators, are leak tight.

3.24 INSTALLATION OF AIR OUTLETS AND INLETS

- A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended function. Provide all necessary brackets, hangers, plenums and flanges as required for a complete and operational system.
- B. Locate diffusers, registers, and grilles, as indicated on general construction "Reflected Ceiling Plans" or architectural elevation drawings. Unless otherwise indicated, locate ceiling units in center of acoustical ceiling module.

3.25 INSTALLATION OF DUCTLESS COOLING UNIT SYSTEMS

- A. Vibration Control And Seismic Restraint: Refer to Section 230548 and Drawing VS.1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in Section 230548 and Drawing VS.1.
- B. General:
 - 1. Verify all dimensions by field measurements. Verify roof structure, mounting supports, wall structure, and membrane installations are completed to the proper point to allow installation of wall mounted and roof mounted units. Examine rough-in for refrigerant piping systems to verify actual locations of piping connections prior to installation. Do not proceed until unsatisfactory conditions have been corrected.
 - 2. Install equipment in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.
 - 3. Provide four extra sets of outside air and return air filters, obtain receipt from owner that additional spare filters have been received.
- C. Field Quality Control:
 - 1. Provide the services, to include a written report, of a factory authorized service representative to examine the field assembly of the components, installation, and piping and electrical connections.
 - 2. Charge systems with refrigerant and oil, and test for leaks. Repair leaks and replace lost refrigerant and oil.
- D. Demonstration:
 - 1. Provide the services of a factory authorized service representative to provide start-up service and to demonstrate and train the Owner's maintenance personnel as specified below.
 - 2. Start-up service: Place units into operation and adjust controls and safeties. Replace damaged or malfunctioning components and controls.

- E. Training:
 - 1. Provide the services of manufacturer's service representative (two hours minimum) to instruct the Owner's maintenance personnel on start-up and shut-down procedures, troubleshooting procedures, controller features, and servicing and preventative maintenance schedules and procedures.
 - 2. Schedule training with Owner through the Architect/Engineer with at least seven days prior notice.

3.26 INSTALLATION OF CONDENSATE DISCHARGE PUMPS

- A. Examine areas and conditions under which pumps are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.
- B. Installation Of Equipment
 - 1. General: Install equipment in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in drain pans and locations indicated, and maintain manufacturer's recommended clearances.
 - 2. Accessories: Install equipment accessories not installed at factory.
 - 3. Connections: Connect discharge piping as indicated and terminate where indicated on the contract documents.
 - 4. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to electrical installer.
 - a. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- C. Field Quality Control
 - 1. General: Start-up equipment, in accordance with manufacturer's start-up instructions. Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
- D. Closeout Procedures
 - 1. Training: Instruct Owner's personnel in operation and maintenance of condensate discharge pumps.

3.27 INSTALLATION OF VARIABLE AIR VOLUME BOXES

- A. VIBRATION CONTROL AND SEISMIC RESTRAINT: Refer to section 230548 and drawing VS-1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS-1.
- B. General: Install variable air volume boxes as indicated, and in accordance with manufacturer's installation instructions.
- C. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.
- D. Install all transformers within junction boxes and maintain three foot clearance in front per the electrical code. This will allow the VAV control box to only utilize low voltage wiring and not be susceptible to the three foot clearance requirement by the electrical code.

3.28 INSTALLATION OF DUST COLLECTOR SYSTEM

- A. VIBRATION CONTROL AND SEISMIC RESTRAINT: Refer to section 230548 and drawing VS.1 for the appropriate support of each piece of HVAC equipment noted as requiring such. The vibration control and seismic restraint manufacturer shall recommend the correct connection and device as outlined in section 230548 and drawing VS.1.
- B. General: Install dust collection units where indicated, in accordance with equipment manufacturer's published installation instructions, and with recognized industry practices, to ensure that units comply with requirements and serve intended purposes. Unit shall be shipped in major components. Contractor shall erect unit, hopper, legs, fan, damper and silencer.
- C. Coordination: Coordinate with other work, including ductwork, piping, electrical, building structure etc. as necessary to interface installation of dust collection units with other work.
- D. Access: Provide access space around unit for service as indicated, but in no case less than that recommended by manufacturer.
- E. Support: Install unit with reinforced concrete pad, 4" larger on each side than unit base. Refer to structural details.
- F. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of the National Electrical Code. Do not proceed with equipment start-up until wiring installation is acceptable to equipment Installer.
 - 2. Provide electrical connection to control panel from main power supply as indicated on drawings.
- G. Duct Connections: Provide ductwork, accessories, etc. as indicated on drawings and as required by manufacturer's instructions.
- H. Grounding: Provide positive equipment ground for each unit component.
- I. Start-Up and Training: Factory test, check and start shall be provided by factory authorized technician along with training and maintenance instructions.
- J. Provide one complete extra set of filters for unit. Obtain receipt from Owner that new filters have been installed.

3.29 INSTALLATION OF FIRESTOP SYSTEMS

- A. General: Install firestop systems at all new and existing fire-rated construction where penetrated by the Work of this Section.
- B. Refer to Section 078400 - Firestopping, for all installation requirements for maintaining integrity of fire-rated construction at penetrations.

3.30 INSTALLATION OF WALL AND CEILING ACCESS DOORS

- A. General: Install access doors in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended function.
- B. All access doors shall be located in a workmanlike manner in closets, storage rooms, and/or other non-public areas, positioned so that the item or part can be easily reached, and the size shall be sufficient for this purpose (minimum size 12 in. X 16in.). Furnish access doors to permit thorough inspection. When access doors are required in corridors, lobbies, or other habitable areas, they shall be located as directed by the Architect.

3.31 AUTOMATIC TEMPERATURE CONTROLS (DDC)

- A. Installation Of Automatic Temperature Controls (DDC):
 - 1. Installation of Control Systems:
 - a. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.
 - b. Control Wiring: Install control wiring, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code.
 - 1) Install circuits over 25-volt with color-coded No. 12 wire in electric metallic tubing.
 - 2) Install circuits under 25-volt with color-code No. 18 wire with 0.031 in. high temperature 105 degrees F. (41 degrees C) plastic insulation on each conductor and plastic sheath over all.
 - 3) Install electronic circuits with color-coded No. 22 wire with 0.023 in. polyethylene insulation on each conductor with plastic-jacketed copper shield over all.
 - 4) Install low voltage circuits, located in concrete slabs, masonry walls, or in mechanical areas, in electrical conduit. Where exposed in occupied areas install all wiring in wiremold.
 - 5) Power sources from lighting circuits and wall outlets shall not be used to power DDC controllers.
 - c. Controllers and safety devices:
 - 1) All safety devices such as freezestats, duct mounted heat detectors, and smoke detectors shall be hard wired to shut down the fans independently. Provide audible alarm with silence switch as well as DDC indication.
 - 2) Humidifier controls shall be hard wired through fan proof flow differential switch and starter auxiliary contacts to disable humidifier system on fan shutdown. Provide DDC indication.
 - 3) All supply, return and exhaust fans shall be provided with pressure differential switches. Current sensing devices, starter auxiliary contacts, and relay contacts are unacceptable proof of fan operation.
 - 4) Primary and standby pumps shall be selectable through the DDC control system. Provide local pilot light to indicate selected pump as well as alarm and silence switch for failed pump. Provide differential pressure switch to prove flow.
 - 2. Adjusting and Cleaning:
 - a. Start-Up: Start-up, test, and adjust DDC control systems in presence of manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
 - b. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

- c. Final Adjustment: After completion of installation, adjust thermostats, control valves, motor and similar equipment provided as work of this section.
 - 1) Final adjustment shall be performed by specially trained personnel in direct employ of manufacturer of primary temperature control system.
- 3. Closeout Procedures:
 - a. Owner's Instructions: Provide services of manufacturer's technical representative for 40 hours of onsite instruction on running and basic troubleshooting of DDC control system.
 - b. Validation: The automatic temperature control sub-subcontractor shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequence of operation submitted.
 - 1) Witnessed validation demonstration shall consist of:
 - a) Execute digital and analog commands in English and graphic mode.
 - b) Demonstrate all specified diagnostics.
 - c) Demonstrate scan, update, and alarm responsiveness.
 - 2) Comply with Sections 019113 and 230800 requirements.
 - c. Training:
 - 1) All training shall be by the automatic temperature control sub-subcontractor and shall utilize specified manuals and as-built documentation.
 - 2) Operator training shall include:
 - a) Sequence of Operation review.
 - b) Sign on-Sign off.
 - c) Modifying warning limits, alarm limits and start-stop times.
 - d) System initialization.
 - e) Use of Portable Operators Terminal.
 - f) Troubleshooting of sensors (determining bad sensors).
 - g) Point disable/enable.
 - h) Software review of Sequence of Operation programs.
 - i) Modification of control programs.
 - j) Add/Delete/Modify data points.
 - k) Use of diagnostics.
 - l) Review of initialization.
 - 3) Training shall be for Owner-designated personnel at the subject site, and shall be scheduled by the Owner with two week notice.
 - 4) All training sessions shall be videotaped by professional videographer, refer to architectural specifications for further requirements.

- d. Seasonal Site Visits:
 - 1) In addition to the one year warranty period against component or workmanship defects, 40 hours of training and 40 hours of extra programming as it relates to the control system and as indicated in section 230000 paragraph 2.26 & 3.26, the ATC contractor shall provide a seasonal site visit to confirm, verify and modify as required the sequence and/or programming of each piece of equipment to ensure the system is functioning as required and per the sequence of operations. The ATC contractor shall provide 16 labor hours per season (four times within a year, total of 64 hours). During each visit they shall, for each piece of equipment confirm operation and functionality, modify and/or repair any control related issues and/or programming and provide training as requested by the owner. This requirement will ensure the equipment/building is operating properly and efficiently as it cycles through each season. These site visits shall begin the following season after substantial completion of the project is issued. Upon substantial completion the engineer of record shall issue four dates to the ATC contractor and owner. Signatures and time logs will be kept by both parties to ensure these visits occur.
- e. Perform Indoor Air Quality Management Building flush out procedures and adhere to IAQ Management Procedures referenced in Section 018119 – INDOOR AIR QUALITY REQUIREMENTS.

3.32 TESTING, ADJUSTING, AND BALANCING

A. REQUIREMENTS:

- 1. Requirements include verification of HVAC system operation, measurement of all system capacity, and establishment of the quantities of the mechanical systems as required to meet specifications, and recording and reporting the results.
- 2. The entire project is considered phased construction, and as such, as each phase of construction is completed the appropriate balancing for that phase of work shall be completed. At the completion of all phases of construction each previous phase of completed balancing must be re-checked and re-adjusted accordingly to match final design conditions. A preliminary report of each phase of construction will be submitted for approval during each phase of construction, and a final balancing report including all phases of construction will be submitted at the completion of the project.
- 3. Commission, test, adjust and balance the following mechanical systems:
 - a. Supply air systems.
 - b. Return air systems.
 - c. Exhaust air systems.
 - d. Outside air systems.
 - e. Hydronic heating systems.
 - f. Verify temperature control system operation.
- 4. Do not include:
 - a. Testing boilers and pressure vessels for compliance with safety code.
 - b. Installation of adjusting and balancing devices. If devices must be added to achieve proper adjusting and balancing. Contact Mechanical Subcontractor and the Engineer for direction.

5. Comply with Commissioning Test Requirements in Section 019113 and 230800.
 - 1) Each classroom has been inspected and observed to ensure that there are no health or safety concerns from any chemical, moisture and odor sources in or near the classrooms.
 - a) Conduct the flush-out for 24 hours a day of continuous ventilation for a total of days necessary for all supply fans at their maximum rate and position. Thermal comfort is maintained during occupied hours, per the criteria in the current ASHRAE Standard 55. Internal temperatures are maintained at the most energy efficient level above 60 deg. F; relative humidity is maintained no higher than 60 percent during non-occupancy hours. Under conditions where the heating can't be met (60 deg. F) at that fan speed, then adjust the fan to meet the 60 deg. F.
 - b) All air handling unit dampers are at their maximum outdoor air position during the 14 day flush-out
 - 2) Post-occupancy ventilation: When the contractor is required to perform touch-up (including furniture after occupancy) work involving products with chemical emissions, provide temporary construction ventilation during application and extend the building flush-out by a minimum of four days after touch-up application, with 100 percent tempered outside air for 24 hours each day.
 - b. All unit filters to be replaced upon completion of flush-out
- B. Report:
1. Format: Report forms shall be those standard forms prepared by the referenced standard for each respective item and system to be tested, adjusted, and balanced. Bind report forms complete with schematic systems diagrams and other data in reinforced, vinyl, three-ring binders. Provide binding edge labels with the project identification and a title descriptive of the contents. Divide the contents of the binder into the below listed divisions, separated by divider tabs:
 - a. General Information and Summary.
 - b. Air Systems.
 - c. Hydronic heating and cooling systems.
 - d. Temperature Control Systems.
 2. Contents: Provide the following minimum information, forms and data:
 - a. General Information and Summary: Inside cover sheet to identify testing, adjusting, and balancing agency, Contractor, Owner, Architect, Engineer, and Project. Include addresses, and contact names and telephone numbers. Also include a certification sheet containing the seal and name address, telephone number, and signature of the Certified Test and Balance Engineer. Include in this division a listing of the instrumentation used for the procedures along with the proof of calibration.
 - b. The remainder of the report shall contain the appropriate forms containing as a minimum, the information indicated on the standard report forms prepared by the AABC for each respective item and system.
 - c. Submit proof that all required instrumentation has been calibrated to tolerances specified in the referenced standards, within a period of six months prior to starting the project.

C. QUALITY ASSURANCE:

1. An independent testing, adjusting, and balancing agency certified by the AABC or NEBB as a Test and Balance Engineer in those testing and balancing disciplines required for this project.
2. Codes and Standards:
 - a. AABC: "National Standards For Total System Balance".
 - b. ASHRAE: ASHRAE Handbook, 1984 Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.
 - c. ANSI/ASHRAE 110: Method of Testing Performance of Laboratory Fume Hoods
3. Pre-Balancing Conference: Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a conference with the Architect/Engineer and Mechanical Subcontractor. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.
4. System Operation: Systems shall be fully operational prior to beginning procedures. All new automatic temperature controls shall be fully operational. Test, adjust and balance the air systems before refrigerant systems. Test, adjust and balance air conditioning systems during summer season, and heating systems during winter season, including at least a period of operation at outside conditions within 5E F. wet bulb temperature of maximum summer design condition, and within 10E F. dry bulb temperature of minimum winter design condition. Take final temperature reading during seasonal operation.
5. Test all fume hoods in accordance with ANSI/ASHRAE 110 Standards. Balancer shall record and report all data and adjust fan sheaves, dampers etc. as required to achieve desired velocities and air flows.

D. PRELIMINARY PROCEDURES:

1. Air Systems:
 - a. Obtain drawings and become thoroughly acquainted with the systems.
 - b. Compare drawings to installed equipment and field installations.
 - c. Walk the system from the system air handling equipment to terminal units to determine variations in installation.
 - d. Check filters for cleanliness.
 - e. Check all dampers (volume and fire) for correct and locked position, and temperature control for completeness of installation before starting fans.
 - f. Prepare report test sheets for both fans and outlets. Obtain manufacturer's outlet factors and recommended procedures for testing. Prepare a summation of required outlet volumes to permit a cross check with required fan volumes.
 - g. Determine best locations in main and branch ductwork for most accurate duct traverses. Traverses shall be performed in each supply and return duct main and sub-mains for each AHU and return air fan.
 - h. Place outlet dampers in the full open position.
 - i. Prepare schematic diagrams of system "as-built" ductwork and piping layouts to facilitate reporting.
 - j. Verify lubrication of all motors and bearings.
 - k. Check fan belt tension.
 - l. Check fan rotation.

2. Hydronic Systems:
 - a. Open valves to full open position. Close coil bypass valves.
 - b. Remove and clean all strainers.
 - c. Examine hydronic systems and determine if water has been treated and cleaned.
 - d. Check pump rotation.
 - e. Check expansion tanks to verify noted air pressure and that the system is completely full of water.
 - f. Check air vents at high points of system and determine if all are installed and operating freely.
 - g. Set temperature controls so all coils are calling for full flow.
 - h. Check operation of automatic bypass valves.
 - i. Check and set operating temperatures of chillers, boilers, and heat exchangers to design requirements.
 - j. Verify lubrication of all motors and bearings.
 3. Measurements:
 - a. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerance specified in the referenced standards. Instruments shall be properly maintained and protected against damage.
 - b. Provide instruments meeting the specifications of the referenced standards.
 - c. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.
 - d. Apply instrument as recommended by the manufacturer.
 - e. Use instruments with minimum scale and maximum subdivisions and with scaled ranges proper for the value being measured.
 - f. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5 percent. When measuring a single point, repeat readings until 2 consecutive identical values are obtained.
 - g. Take all reading with the eye at the level of the indicated value to prevent parallax.
 - h. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.
 - i. Take measurements in the system where best suited to the task.
- E. Performing Testing, Adjusting, and Balancing:
1. Test, adjust and balance all noted systems according to SMACNA standards and as follows:
 - a. Perform testing and balancing procedures on each system identified, in accordance with the detailed procedures outlined in the referenced standards.
 - b. Cut insulation and ductwork for installation of test probes to the minimum extent necessary to allow adequate performance of procedures.
 - c. Patch insulation, ductwork, and housings, using materials identical to those removed.
 - d. Seal ducts and test for and repair leaks.
 - e. Seal insulation to re-establish integrity of the vapor barrier.
 - f. Mark equipment settings, including damper control positions, valve indicators, fan speed control levers, and similar controls and devices, to show final settings. Mark with paint or other suitable, permanent identification materials.
 - g. Retest, adjust and balance system subsequent to significant system modifications, and resubmit test results.

2. System Deficiencies:
 - a. The Balancing Sub-subcontractor shall advise the Mechanical Subcontractor and the Engineer of all system deficiencies in writing. Report all motors not running, missing dampers, inoperative valves and controls, or lack of access.
 - b. Upon completion of system deficiencies, Balancing Contractor shall balance and record data again at no additional costs to the project/owner.
 - c. Any re-balancing required to meet the desired CFM or modified CFM due to system modifications or owner changes shall be provided at no additional costs to the project/owner.
 - d. The Balancing Sub-subcontractor shall provide the necessary sheave and belt changes to motors and fans as required to achieve the desired CFM at no additional costs to the project/owner.

END OF SECTION

SECTION 230548

VIBRATION CONTROL AND SEISMIC RESTRAINT

PART 1 - GENERAL..... 1

1.1 DESCRIPTION 1

1.2 SUBMITTAL DATA REQUIREMENTS 3

1.3 CODE AND STANDARDS REQUIREMENTS..... 3

1.4 MANUFACTURER'S RESPONSIBILITY 4

1.5 RELATED WORK..... 4

1.6 DESIGN REQUIREMENTS 4

1.7 QUALITY ASSURANCE 4

PART 2 - PRODUCTS..... 5

2.1 INTENT 5

2.2 PRODUCT DESCRIPTIONS 5

PART 3 - EXECUTION 12

3.1 GENERAL..... 12

3.2 VIBRATION ISOLATION AND SEISMIC RESTRAINT OF PIPING, DUCTWORK, AND
CONDUIT 14

3.3 SEISMIC RESTRAINT EXCLUSIONS 16

3.4 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT 16

END OF INDEX

SECTION 230548
VIBRATION CONTROL AND SEISMIC RESTRAINT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. General: The work noted within Section 230548 is referenced by Divisions 210000, 220000, 230000, and 260000. Provide all necessary labor & material in each division as required herein.
- B. Intent:
1. All mechanical, plumbing, fire protection & electrical equipment, piping, conduits and ductwork shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.
 2. All isolators and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.
 3. It is the intent of the seismic portion of this specification to keep all mechanical, plumbing, fire protection and electrical building system components in place during a seismic event.
 4. All such systems must be installed in strict accordance with seismic codes, component manufacturer's, and building construction standards. Whenever a conflict occurs between the manufacturer's or construction standards, the most stringent shall apply.
 5. This specification is considered to be minimum requirements for seismic consideration and is not intended as a substitute for legislated, more stringent, national, state or local construction requirements (i.e. California Title 24, California OSHPD, Canadian Building Codes, or other requirements).
 6. Any variance or non-compliance with these specification requirements shall be corrected by the contractor in an approved manner.
- C. The work in this section includes, but is not limited to the following:
1. Vibration isolation for piping, conduits, ductwork and equipment.
 2. Equipment isolation bases.
 3. Flexible piping connections.
 4. Seismic restraints for isolated equipment.
 5. Seismic restraints for non-isolated equipment.
 6. Certification of seismic restraint designs and installation supervision.
 7. Certification of seismic attachment of housekeeping pads.

8. All mechanical, plumbing, fire protection and electrical systems. Equipment buried underground is excluded but entry of services through the foundation wall is included. Equipment referred to below is typical. (Equipment not listed is still included in this specification).

AC Units	Generators
Air Cooled Condensing Units	Heat Exchangers
Air Handling Units	Light Fixtures
Air Separators	Motor Control Ctrs
Battery Racks	Piping
Boilers	Pumps (all types)
Bus Ducts	Rooftop Units
Cable Trays	Switching Gear
Chillers	Tanks (all types)
Comp. Room Units	Transformers
Conduit	Unit Heaters
Cooling Towers	Unit Substations
Ductwork	Var. Freq. Drives
Dust Collectors	VAV Boxes
Electrical Panels	Water Heaters
Fans (all types)	

D. Definitions:

1. Life Safety Systems
 - a. All systems involved with fire protection including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, fire dampers and smoke exhaust systems.
 - b. All systems involved with and/or connected to emergency power supply including all generators, transfer switches, transformers, and all flowpaths to fire protection and/or emergency lighting systems.
 - c. All medical and life support systems.
 - d. Fresh air & relief systems on emergency control sequence including air handlers, conduit, duct, dampers, etc.
2. Positive Attachment
 - a. A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, fire protection, electrical conduit, bus duct, or cable trays, etc. are not acceptable as seismic anchor points.
3. Transverse Bracing
 - a. Restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.
4. Longitudinal Bracing
 - a. Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.

1.2 SUBMITTAL DATA REQUIREMENTS

- A. In addition to requirements of Section 013300, the manufacturer of vibration isolation and seismic restraints shall provide submittals for products as follows:
1. Descriptive Data
 - a. Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the specification.
 - b. Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive drawings.
 2. Shop Drawings
 - a. Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.
 - b. Provide all details of suspension and support for ceiling hung equipment.
 - c. Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.
 - d. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.
 3. Seismic Certification and Analysis
 - a. Seismic restraint calculations must be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer with at least five years of seismic design experience, licensed in the state of the job location.
 - b. All restraining devices shall have a pre-approval number from California OSHPD or some other recognized government agency showing maximum restraint ratings. Calculations (including the combining of tensile and shear loadings) to support seismic restraint designs must be stamped by a registered professional engineer with at least five years of seismic design experience and licensed in the state of the job location. Testing and calculations must include both shear and tensile loads as well as one test or analysis at 450 to the weakest mode.
 - c. Analysis must indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the forces required acting through the equipment center of gravity. Overturning moments may exceed forces at ground level.

1.3 CODE AND STANDARDS REQUIREMENTS

- A. Typical Applicable Codes, Standards, and Categories:
1. International Building Code 2009 with an effective peak acceleration coefficient of 0.15.
 2. New Hampshire State Building Code.
 3. Seismic hazard exposure group of I, II, III and seismic performance category of C, D.

1.4 MANUFACTURER'S RESPONSIBILITY

- A. Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:
 - 1. Determine vibration isolation and seismic restraint sizes and locations.
 - 2. Provide vibration isolation and seismic restraints.
 - 3. Provide calculations and materials if required for restraint of unisolated equipment.
 - 4. Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.

1.5 RELATED WORK

- A. Housekeeping Pads:
 - 1. Housekeeping pads shall be coordinated with restraint vendor and sized to provide a minimum edge distance of ten (10) bolt diameters all around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embodiment.
- B. Supplementary Support Steel:
 - 1. Contractor shall supply supplementary support steel for all equipment, piping, ductwork, etc. including roof mounted equipment.
- C. Attachments:
 - 1. Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. in accordance with the requirements of the vibration vendor's calculations.

1.6 DESIGN REQUIREMENTS

- A. Design isolators for equipment installed outdoors to provide adequate restraint to withstand the force of a 100 mph wind applied to any exposed surface of the isolated equipment. Isolators for outdoor equipment shall have bolt holes for attachment to equipment and to supports. The vibration isolation Vendor shall submit verifying shear and over turning calculations, for their product and equipment installation arrangement, stamped by a licensed Professional Engineer. The design and supply of miscellaneous support steel above and below isolators will not be the responsibility of the vibration isolation manufacturer.

1.7 QUALITY ASSURANCE

- A. Coordinate the size, location, and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.
- B. Provide vibration isolators of the appropriate sizes, with the proper loading to meet the specified deflection requirements.
- C. Supply and install any incidental materials such as mounting brackets, attachments and other accessories as may be needed to meet the requirements stated herein, even if not expressly specified or shown on the drawings, without claim for additional payment.

- D. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.
- E. Should any rotating equipment cause excessive noise or vibration when properly installed on the specified isolators, the Contractor shall be responsible for rebalancing, realignment, or other remedial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

PART 2 - PRODUCTS

2.1 INTENT

- A. All vibration isolators and seismic restraints described in this section shall be the product of a single manufacturer. Mason Industry's products are the basis of these specifications; products of other manufacturers are acceptable provided their systems strictly comply with the specification.
- B. For the purposes of this project, failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8 inch and/or horizontal permanent deformation greater than 1/4 inch.

2.2 PRODUCT DESCRIPTIONS

- A. Vibration Isolators and Seismic Restraints.

GENERAL:

1. All metal parts installed out-of-doors shall be corrosion resistant after fabrication. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14.
2. Isolators installed out-of-doors shall have base plates with bolt holes for fastening the isolators to the support members.
3. Isolator types are scheduled to establish minimum standards. At the Contractor's option, labor-saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories and seismic restraint features must not degrade the isolation performance of the isolators.
4. Static deflection of isolators shall be as provided in the EXECUTION section and as shown on the drawings. All static deflections stated are the minimum acceptable deflection for the mounts under actual load. Isolators selected solely on the basis of rated deflections are not acceptable and will be disapproved.

SPECIFICATION:

1. Two layers of 3/4" thick neoprene pad consisting of 2" square waffle modules separated horizontally by a 16 gauge galvanized shim. Load distribution plates shall be used as required. Pads shall be Type Super "W" as manufactured by Mason Industries, Inc.

2. Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2" and all directional seismic capability. The mount shall consist of a ductile iron casting containing two separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing specifications. Mountings shall have an Anchorage Pre-approval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be Type BR as manufactured by Mason Industries, Inc.
3. Sheet metal panels shall be bolted to the walls or supporting structure by assemblies consisting of a neoprene bushing cushioned between 2 steel sleeves. The outer sleeve prevents the sheet metal from cutting into the neoprene. Enlarge panel holes as required. Neoprene elements pass over the bushing to cushion the back panel horizontally. A steel disc covers the inside neoprene element and the inner steel sleeve is elongated to act as a stop so tightening the anchor bolts does not interfere with panel isolation in 3 planes. Bushing assemblies can be applied to the ends of steel cross members where applicable. All neoprene shall be bridge bearing quality. Bushing assemblies shall be type PB as manufactured by Mason Industries, Inc.
4. A one (1) piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal to metal contact. Neoprene bushings shall be type HG as manufactured by Mason Industries, Inc.
5. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4" neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Mountings shall be Type SLF as manufactured by Mason Industries, Inc.
6. Restrained spring mountings shall have an SLF mounting as described in Specification 5, within a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of 1/2" shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Since housings will be bolted or welded in position there must be an internal isolation pad. Housing shall be designed to resist all seismic forces. Mountings shall have Anchorage Pre-approval "R" Number from OSHPD in the state of California certifying the maximum certified horizontal and vertical load ratings. Mountings shall be SLR as manufactured by Mason Industries, Inc.
7. Spring mountings as in specification 5 built into ductile iron or steel housing to provide all directional seismic snubbing. The snubber shall be adjustable vertically and allow a maximum of 1/4 inch travel in all directions before contacting the resilient snubbing collars. Mountings shall have an Anchorage Pre-approval "R" number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be SSLFH as manufactured by Mason Industries, Inc.

8. Air Springs shall be manufactured with upper and lower steel sections connected by a replaceable flexible nylon reinforced neoprene element. Air spring configuration shall be multiple bellows to achieve a maximum natural frequency of 3 Hz. Air Springs shall be designed for a burst pressure that is a minimum of three times the published maximum operating pressure. All air spring systems shall be connected to either the building control air or a supplementary air supply and equipped with three leveling valves to maintain leveling within plus or minus 1/8". Submittals shall include natural frequency, load and damping tests performed by an independent lab or acoustician. Air Springs shall be Type MT and leveling valves Type LV as manufactured by Mason Industries, Inc.
9. Restrained air spring mountings shall have an MT air spring as described in Specification 8, within a rigid housing that includes vertical limit stops to prevent air spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of 1/2" shall be maintained around restraining bolts and between the housing and the air spring so as not to interfere with the air spring action. Limit stops shall be out of contact during normal operation. Housing shall be designed to resist all seismic forces. Mountings shall be SLR-MT as manufactured by Mason Industries, Inc.
10. Hangers shall consist of rigid steel frames containing minimum 1 1/4" thick neoprene elements at the top and a steel spring with general characteristics as in specification 5 seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. To maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the rod bushing and short circuiting the spring. Submittals shall include a hanger drawing showing the 30° capability. Hangers shall be type 30° as manufactured by Mason Industries, Inc.
11. Hangers shall be as described in specifications 10, but they shall be pre-compressed and locked at the rated deflection by means of a resilient seismic upstop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc.
12. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges. Cable assemblies shall have an Anchorage Pre-approval "R" Number from OSHPD in the State of California verifying the maximum certified load ratings. Cable assemblies shall be Type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam all as manufactured by Mason Industries, Inc.
13. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and utilize two through bolts to provide proper attachment. Seismic solid brace assembly shall have anchorage pre-approval "R" number from OSHPD in the state of California verifying the maximum certified load ratings. Solid seismic brace assemblies shall be type SSB as manufactured by Mason Industries, Inc.

Note: Specifications 12 - 14 apply to trapeze as well as clevis hanger locations. At trapeze anchor locations piping must be shackled to the trapeze. Specifications apply to hanging equipment as well.

14. Steel angles, sized to prevent buckling, shall be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods is not acceptable. Rod clamp assemblies shall have an Anchorage Pre-approval "R" Number from OSHPD in the State of California. Rod clamp assemblies shall be Type SRC as manufactured by Mason Industries, Inc.
15. Pipe clevis cross bolt braces are required in all restraint locations. They shall be special purpose performed channels deep enough to be held in place by bolts passing over the cross bolt. Clevis cross braces shall have an Anchorage Pre-approval "R" Number from OSHPD in the State of California. Clevis cross brace shall be type CCB as manufactured by Mason Industries, Inc.
16. All-directional seismic snubbers shall consist of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene. Bushing shall be replaceable and a minimum of 1/4 inch thick. Rated loading shall not exceed 1,000 psi. A minimum air gap of 1/8 inch shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Neoprene bushings shall be rotated to insure no short circuits exist before systems are activated. Snubbers shall have an Anchorage Pre-approval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Snubber shall be Type Z-1 225 as manufactured by Mason Industries, Inc.
17. All directional seismic snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials compounded to bridge bearing specifications. Elastomeric materials shall be replaceable and a minimum of 3/4" thick. Rated loadings shall not exceed 1,000 psi. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8" nor more than 1/4". Snubbers shall be installed with factory set clearances. The capacity of the seismic snubber at 3/8" deflection shall be equal or greater than the load assigned to the mounting grouping controlled by the snubber multiplied by the applicable "G" force. Submittals shall include the load deflection curves up to 1/2" deflection in the x, y and z planes. Snubbers shall have an anchorage pre-approval "R" number from OSHPD in the state of California verifying the maximum certified horizontal and vertical load ratings. Snubbers shall be series Z-101 1 as manufactured by Mason Industries, Inc.
18. Stud wedge anchors shall be manufactured from full diameter wire, not from undersized wire that is "rolled up" to create the thread. The stud anchor shall also have a safety shoulder which fully supports the wedge ring under load. The stud anchors shall have an evaluation report number from the I.C.B.0 Evaluation Service, Inc. verifying its allowable loads. Drill-in stud wedge anchors shall be type SAS as manufactured by Mason Industries, Inc.
19. Female wedge anchors are preferred in floor locations so isolators or equipment can be slid into place after the anchors are installed. Anchors shall be manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female wedge anchors shall have an evaluation report number from the I.C.B.0 Evaluation Service, Inc. verifying to its allowable loads. Drill-in female wedge anchors shall be type SAB as manufactured by Mason Industries, Inc.

20. Vibration isolation manufacturer shall furnish integral structural steel bases. Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem. Pump bases for split case pump shall include supports for suction and discharge elbows. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14' provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 1 ". Bases shall be type WF as manufactured by Mason Industries, Inc.
21. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations. Bases for split case pumps shall be large enough to provide for suction and discharge elbows. Bases shall be a minimum of 1/1 2 of the longest dimension of the base but not less than 6". The base depth need not exceed 1 2" unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of 1/2" bars welded in place on 6" centers running both ways in a layer 1 1/2" above the bottom. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 1 " clearance below the base. Wooden formed bases leaving a concrete rather than a steel finish are not acceptable. Base shall be type BMK or K as manufactured by Mason Industries, Inc.
22. Roof Curb (by HVAC Contractor)
 - a. Curb mounted rooftop equipment shall be mounted on structural spring isolation curbs that bear directly on the roof support structure, and are flashed and waterproofed into the roof's membrane waterproofing system. All spring locations shall have removable waterproof covers to allow for spring adjustment and/or removal. Springs shall be Type A.
 - b. Unit shall be provided with wood nailer and flashing.
 - c. Curbs shall meet all NRCA Standards.
 - d. Curbs shall be similar to Novia Associates VibCurb III or equal having a minimum 3" rated static deflection and be 24" high.
 - e. Vibration control: The spring roof curb shall have the top isolated or floating rail attached in a manner to the fixed lower portion of the curb without short circuiting or bridging between the two. Restraining bolt(s) or threaded rod shall be of sufficient size to withstand the applied wind & or seismic forces at each spring pack location.
 - f. An alignment bolt shall be installed before connecting the floating to non-floating parts to guarantee perfect centering of the restraining bolts.
 - g. Weather proofing & air seal: The spring curb must keep the weather (air and water) out and any airflow from the RTU in. The weather seal must not have the ability to fail and allow water or air into the building.
 - h. The use of exposed exterior neoprene or some other elastomer material to seal the top floating rail from the base of the curb in not acceptable.
 - i. Vibration Mountings: Provide a rubber gasket covered by formed galvanized sheet metal top flashing that overhangs the top wood nailer and galvanized bottom flashing. The overlapping shall effectively cover the rubber gasket so it is protected from the elements.
 - j. The top flashing / support rail shall be 14 ga. G60-Zc steel formed with 90 bends that extend down to the wood nailer. Provide a counter flashing member with a sponge gasket attached that presses up against the horizontal bend. The seal shall be replaceable, protected from the elements and easy to install.
 - k. Curb side material: Provide 12 Ga. G60 galvanized steel for curb side construction. All side and end seam between sheets shall be continuously welded, corner joints to be caulked and bolted.

- I. Structural Capability:
- 1) Curbs shall be installed on metal decking/concrete slab. Air handling unit load shall be properly distributed. Coordinate curb construction with pitch of roof. Curbs shall be built to match the roof pitch in accordance with all requirements of this project. Positive attachment of the curb to the structure is imperative. Pitch correction shall be fabricated from 12 gauge galvanized material and be continuous on all sides and ends. Field fabricated and installed tube steel stub-ups are not acceptable. HVAC contractor shall provide detailed information to the curb manufacturer regarding pitch correction.
 - 2) Plenum Sections: The side material must be capable of handling the static pressure developed by the fans and not 'oil can'. Provide spanning bar joists as required to support plenum installation (even when the spring pockets are center span).
 - 3) Provide a continuous bottom tube steel member or side material of sufficient strength. Mechanical contractor shall coordinate and verify all dimensions, weights, roof penetrations, etc. with the Structural Engineer prior to installation.
 - 4) Curb Insulation: Provide spring curbs with a space between the floating and non-floating parts for the installation of insulation. Curb manufacturer shall provide factory installed insulation adhered to roof curb. Curbs shall be externally factory insulated with a 1.7" thick R-12 foam insulation, FM Class 1 and UL Class A Ratings, with bonded fiber reinforced facer.
- m. Protection: Curbs shall be completely shrink-wrapped during shipping.
- n. Mechanical contractor shall provide all necessary materials to completely weather proof and sound proof the curb installation.
- o. Additional features:
- 1) Sound barrier: Provide a sound barrier package, consisting of G60 galvanized back-to-back angles. Sound barrier package shall be capable of supporting two layers of 1/2" concrete board with a maximum deflection over the width of the curb of L/360. Cement board furnished and installed by the HVAC Contractor. Overlap all joints, caulk all seams and edges. Transmission Loss & STC shall be as shown as follows. Sound Transmission Loss at Frequency (Cycles per second) of (125)=20, (250)=27, (500)=30, (1000)=32, (2000)=30, (4000)=38, (STC)=31.
 - 2) Provide with framed Supply & Return air duct openings. Openings shall match duct sizes and have 1" galvanized steel flanges.
 - 3) Plenum sections: Where indicated on the drawings, provide in the interior of the curb, double wall acoustical floor, walls and plenum divider. All insulation shall be 2" thick fiber glass acoustical duct liner with reinforced coating system. Insulation acoustical performance shall be as follows. Liner shall not support microbial growth and shall be EPA registered and pass ASTM C 1071 & ASTM G21 bacterial tests conducted in accordance with ASTM G22. Floors up to 90" curb I.D. width shall be constructed of 22 Ga., 20 Ga. thereafter, solid G60 galvanized bottom panels and 22 Ga. galvanized perforated 22.7% open area top panel. Floor shall be attached to walls and plenum divider to provide an airtight plenum. Walls shall have 22 Ga. galvanized perforated 22.7% open area inside panels. Plenum divider shall be double wall 22 Ga. perforated galvanized 22.7% open area panel on the supply side with a 14 gauge solid panel opposite. Sound Absorption Coefficient at Frequency (Cycles per second) of (125)=.23, (250)=.64, (500)=.99, (1000)=1.05, (2000)=1.00, (4000)=.98, (NRC)=.90,

23. Flexible spherical expansion joints shall employ peroxide cured EPDM in the covers, liners and Dacron tire cord friction ring. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2" and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron or steel flanges with hooked or similar interlocks. Sizes 16' to 24" may be single sphere. Sizes 3/4" to 1 1/2" may have threaded bolted flange assemblies, one sphere and cable retention. 14" and smaller connectors shall be rated at 250 psi up to 190°F. with a uniform drop in allowable pressure to 190 psi at 250°F. 16" and larger connectors are rated 180 psi at 190°F. and 135 psi at 250°F. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5 minute factory test at twice the rated pressure. Concentric reducers to the above specifications may be substituted for equal ended expansion joints.

Expansion joints shall be installed in piping gaps equal to the length of the expansion joints under pressure. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have 1/2" thick Neoprene washer bushings large enough in area to take the thrust at 1000 psi maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves.

Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc.

24. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" and larger shall be flanged. Smaller sizes shall have male nipples. Minimum lengths shall be as tabulated:

<u>Flanged</u>		<u>Male Nipples</u>	
3 x 14	10 x 26	1/2 x 9	1-1/2 x 13
4 x 15	12 x 28	3/4 x 10	2 x 14
5 x 19	14 x 30	1 x 11	2-1/2 x 18
6 x 20	16 x 32	1-1/4 x 12	
8 x 22			

Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be type BSS as manufactured by Mason Industries, Inc.

25. All-directional acoustical pipe anchor, consisting of two sizes of steel tubing separated by a minimum 1/2" thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi and the design shall be balanced for equal resistance in any direction. All-directional anchors shall be type ADA as manufactured by Mason Industries, Inc.

26. Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" thickness of 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of + 1 5/8" motion, or to meet location requirements. Pipe guides shall be type VSG as manufactured by Mason Industries, Inc.
27. Split Wall Seals consist of two bolted pipe halves with minimum 3/4" thick neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of 1" past either face of the wall. Where temperatures exceed 240°F., 10# density fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.
28. The horizontal thrust restraint shall consist of a spring element in series with a neoprene molded cup as described in specification 5 with the same deflection as specified for the mountings or hangers. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4" movement at start and stop. The assembly shall be furnished with 1 rod and angle brackets for attachment to both the equipment and the duct work or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit. Horizontal thrust restraints shall be type WBI/WBD as manufactured by Mason Industries, Inc.

PART 3 - EXECUTION

3.1 GENERAL

- A. All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data. At the completion of all construction work the vibration and seismic device supplier shall inspect all installations and provided a written report of installation compliance to the engineer of record. A copy of this written certification shall also be provided in the operations manual provided to the owner.
- B. Installation of vibration isolators and seismic restraints must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.
- C. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.
- D. The contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.
- E. Coordinate work with other trades to avoid rigid contact with the building.
- F. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractors expense.

- G. Bring to the architects/engineers attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible contractors expense.
- H. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the contractors expense.
- I. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from:
 - 1. Flanges of structural beams.
 - 2. Upper truss cords in bar joist construction.
 - 3. Cast in place inserts or wedge type drill-in concrete anchors.
- J. Specification 12 cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment, piping or conduit.
- K. Specification 12 cable assemblies are installed taut on non-isolated systems. Specification 13 seismic solid braces may be used in place of cables on rigidly attached systems only.
- L. At locations where specification 12 or 13 restraints are located, the support rods must be braced when necessary to accept compressive loads with specification 14 braces.
- M. At all locations where specification 12 or 13 restraints are attached to pipe clevis's, the clevis cross bolt must be reinforced with specification type 15 braces.
- N. Drill-in concrete anchors for ceiling and wall installation shall be specification type 18, and specification type 19 female wedge type for floor mounted equipment.
- O. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted on this project.
- P. Hand built elastomeric expansion joints may be used when pipe sizes exceed 24" or specified movements exceed specification 23 capabilities.
- Q. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer shall provide specification 27 wall seals.
- R. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight. Horizontal thrust restraint shall be specification type 28.
- S. Locate isolation hangers as near to the overhead support structure as possible.

3.2 VIBRATION ISOLATION AND SEISMIC RESTRAINT OF PIPING, DUCTWORK, AND CONDUIT

A. Where piping connects to rotating or vibrating mechanical equipment install specification 23 expansion joints or specification 24 stainless hoses if 23 is not suitable for the service.

B. Seismic Restraint of Piping:

1. Seismically restrain all piping listed as a, b or c below. Use specification 12 cables.
 - a. Fuel oil piping, gas piping, medical gas piping, and compressed air piping.
 - b. Piping located in boiler rooms, mechanical equipment rooms, and refrigeration equipment rooms that is 1 1/4" I.D. and larger.
 - c. All other piping 2 1/2" diameter and larger.
2. Transverse piping restraints shall be at 40' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
3. Longitudinal restraints shall be at 80' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
4. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.
5. For fuel oil and all gas piping transverse restraints must be at 20' maximum and longitudinal restraints at 40' maximum spacing.
6. Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24" of the elbow or TEE or combined stresses are within allowable limits at longer distances.
7. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.
8. Branch lines may not be used to restrain main lines.

C. Pipe Isolation

1. All chilled water, condenser water, hot water, steam, refrigerant, drain and engine exhaust piping that is connected to vibration-isolated equipment shall be isolated from the building structure within the following limits:
Within mechanical rooms;

Within 50' total pipe length of connected vibration-isolated equipment (chillers, pumps, air handling units, pressure reducing stations, etc.);

At every support point for piping that is greater than 4 inches in diameter.
2. Piping shall be isolated from the building structure by means of vibration isolators, resilient lateral supports, and resilient penetration sleeve/seals.
3. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than 1/2", Type FSN or HSN isolators shall be used. When the required static deflection is less than or equal to 1/2", Type FN or HN isolators shall be used. All other pipe support isolators within the specified limits shall be either Type FN or HN achieving at least 1/4" static deflection.
4. Where lateral support of pipes is required within the specified limits, this shall be accomplished by use of resilient lateral supports.
5. Pipes within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
6. Provide flexible pipe connections as called for under Major Equipment above and wherever shown on the drawings.

D. Seismic restraint of ductwork:

1. Seismically restrain all duct work with specification 12 or 13 restraints as listed below:
 - a. Restrain rectangular ducts with cross sectional area of 6 sq. ft. or larger.
 - b. Restrain round ducts with diameters of 28" or larger.
 - c. Restrain flat oval ducts the same as rectangular ducts of the same nominal size.
 - 1) Transverse restraints shall occur at 30' intervals or at both ends of the duct run if less than the specified interval. Transverse restraints shall be installed at each duct turn and at each end of a duct run.
 - 2) Longitudinal restraints shall occur at 60' intervals with at least one restraint per duct run. Transverse restraints for one duct section may also act as a longitudinal restraint for a duct section connected perpendicular to it if the restraints are installed within 4' of the intersection of the ducts and if the restraints are sized for the larger duct. Duct joints shall conform to SMACNA duct construction standards.
 - 3) The ductwork must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.
 - 4) A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.
 - 5) Walls, including gypsum board non bearing partitions, which have ducts running through them may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

E. Duct Isolation:

1. All sheet metal ducts and air plenums that are within mechanical rooms or within a distance of 50' total duct length of connected vibration-isolated equipment (whichever is longer) shall be isolated from the building structure by Type FN, PCF or HN isolators. All isolators shall achieve 0.1" minimum static deflection.
2. Ducts within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
3. Flexible duct connections shall be provided as called for above under Major Equipment and wherever shown on the drawings.

F. Seismic Restraint of Electrical Services:

1. All electrical conduit 2-1/2" in diameter and larger shall be restrained with specification type 12 seismic cable restraints or specification type 13 for seismic solid brace restraints.
2. All electrical bus ducts, cable trays and ladder trays shall be restrained with specification type 12, seismic cable restraints or specification 13 seismic solid brace restraints.
3. Transverse restraints shall occur at 30' intervals or both ends if the electrical run is less than the specified interval. Transverse restraints shall be installed at each electrical services turn and at each end of the electric run.
4. Longitudinal restraints shall occur at 60' intervals with at least one restraint per electric run. Transverse restraints for one electric section may also act as a longitudinal restraint for a duct for an electric section connected perpendicular to it if the restraints are installed within 4' of the intersection of the electric run and if the restraints are sized for the larger electric run.

5. All rigid floor mounted equipment must have a resilient media between the equipment mounting hole and the anchor bolt. Neoprene bushings shall be specification type 4 and anchor bolts shall be specification type 18 or 19.
 6. Wall mounted panels shall be mounted with specification type 3 bushings. Floor mounted panels shall be mounted on specification type 4 bushings. Anchor bolts shall be specification type 18 or 19.
- G. All fire protection piping shall be braced in accordance with NFPA 13 and 14.
- H. All mechanical equipment shall be vibration isolated and seismically restrained.
1. All fire protection equipment is considered life safety equipment and shall be seismically restrained.

3.3 SEISMIC RESTRAINT EXCLUSIONS

- A. Piping:
1. All piping less than 2 1/2" except for gas and fire protection piping.
 2. All piping in boiler and mechanical equipment rooms less than 1 1/4" I.D.
 3. All clevis or trapeze supported piping suspended from hanger rods where the point of attachment is less than the 12" in length from the structure to the structural connection of the clevis or trapeze.
 - a. All PVC and fiberglass suspended waste or vent pipe 6" in diameter and smaller.
- B. Ductwork:
1. Rectangular, square or oval ducts less than 6 sq.ft. in cross sectional area.
 2. Round duct less than 28" in diameter.
 3. Duct supported by hanger rods where the point of attachment is less than 12" in length from the structure to the structural connection of the duct work.
- C. Electrical:
1. All conduit less than 2 1/2" diameter suspended by individual hanger rods.
 2. All clevis or trapeze supported conduits suspended by hanger rods where the point of attachment is less than 12" in length from the structure to the structural connection of the clevis or trapeze.

3.4 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT

- A. General
1. Locations of all vibration isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation.
 2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.

B. Isolators

1. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.
2. Isolators for equipment with bases shall be located on the sides of the bases which are parallel to the equipment shaft unless this is not possible because of physical constraints.
3. Locate isolators to provide stable support for equipment, without excess rocking.
4. Consideration shall be given to the location of the center of gravity of the system and the location and spacing of the isolators. If necessary, a base with suitable footprint shall be provided to maintain stability of supported equipment, whether or not such a base is specifically called for herein.
5. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.
6. Hanger rods for vibration-isolated support shall be connected to major structural
7. members, not the floor slab between major structural members. Provide suitable intermediate support members as necessary.
8. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360° about the rod axis without contacting any object.
9. Parallel running pipes may be hung together on a trapeze that is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze. Do not mix isolated and unisolated pipes on the same trapeze.
 - a. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.
 - b. Resiliently isolated pipes, ducts and equipment shall not come in rigid contact with the building construction or rigidly supported equipment.
 - c. The installed and operating heights of equipment supported by Type FSNTL isolators or with Type RC-2 isolation bases shall be identical. Limit stops shall be out of contact during normal operation. Adjust isolators to provide 1/4" clearance between the limit stop brackets and the isolator top plate, and between the travel limit nuts and travel limit brackets.
 - d. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

C. Bases

1. No equipment unit shall bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators and such direct support is approved by the equipment manufacturer. This provision shall apply whether or not a base frame is called for on the schedule. In the case that a base frame is required for the unit because of the equipment manufacturer's requirements and is not specifically called for on the equipment schedule, a base frame recommended by the equipment manufacturer shall be provided at no additional expense.
2. Unless otherwise indicated, there is to be a minimum operating clearance of 1" between steel rails, steel frame bases or inertia bases and the floor beneath the equipment. The isolator mounting brackets shall be positioned and the isolators adjusted so that the required clearance is maintained. The clearance space shall be checked by the Contractor to ensure that no construction debris has been left to short circuit or restrict the proper operation of the vibration isolation system.
3. Isolation bases shall be installed in strict accordance with the manufacturer's instructions.

- D. Flexible Duct Connections:
 - 1. Prior to installation of the flexible connection, sheet metal ducts and plenum openings shall be squarely aligned with the fan discharge, fan intake, or adjacent duct section, and the gap between connected parts shall be uniform. Flexible duct connections shall not be installed until this provision is met. There shall be no metal-to-metal contact between connected sections, and the fabric shall not be stretched taut.

- E. Flexible Pipe Connections:
 - 1. Install flexible pipe connections in strict accordance with the manufacturer's instructions.

- F. Thrust Restraints:
 - 1. Thrust restraints shall be attached on each side of the fan parallel to the thrust force. This may require custom brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Thrust restraints shall be adjusted to constrain equipment movement to the specified limit.

- G. Grommets:
 - 1. Where grommets are required at hold down bolts of isolators, bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers shall be galvanized.

- H. Resilient Penetration Sleeve/Seals:
 - 1. Maintain an airtight seal around the penetrating element and prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.

END OF SECTION

SECTION 23 08 00 - COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.
- B. The OPR and BOD documentation are included by reference for information only.

1.2 SUMMARY

- A. This section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
- C. Certificates of readiness
- D. Certificates of completion of installation, prestart, and startup activities.
- E. O&M manuals
- F. Test reports

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC&R system and controls system in Division 23, except for equipment specific to and used by TAB in their commissioning responsibilities.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems
- B. Red-lined Drawings: The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which

will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.

- C. Operation and Maintenance Data: Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.
- D. Demonstration and Training: Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior to the training session.

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning functional test procedures at the direction of the CxA. This includes but is not limited to the controls contractor verifying with the CxA that all sequences of operations are functioning properly.
- B. Attend construction phase controls coordination meetings.
- C. Attend testing, adjusting, and balancing review and coordination meetings.
- D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- E. Provide information requested by the CxA for final commissioning documentation. This may include but is not limited to pipe pressure tests, duct leakage tests and flushing / cleaning reports.
- F. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- G. Prepare preliminary schedule for Mechanical system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.
- H. Update schedule as required throughout the construction period.
- I. Assist the CxA in all verification and functional performance tests. While the CxA is onsite the contractor does not need to be with the CxA throughout the entire day but only needs to be available if assistance is needed (such as turning a piece of equipment on). The exception is that the controls contractor is expected to verify all sequences of operation with the CxA.
- J. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- K. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.
- L. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.

- M. Notify the CxA a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.
- N. Participate in, and schedule vendors and contractors to participate in the training sessions.
- O. Provide written notification to the CM/GC and CxA Authority that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
- P. The equipment supplier shall document the performance of his equipment.
- Q. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- R. Test, Adjust and Balance Contractor
 1. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.
 2. Submit the site specific testing and balancing plan to the CxA and AE for review and acceptance.
 3. Attend the testing and balancing review meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in testing, adjusting, and balancing the HVAC&R system.
 4. At the completion of the testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R contractor and the CM/GC.
 5. At the completion of testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R Contractor and the CM/GC.
 6. Participate in verification of the testing and balancing report, which will consist of repeating measurements contained in the testing and balancing reports. Assist in diagnostic purposes when directed.
- S. Equipment Suppliers
 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 2. Assist in equipment testing per agreements with contractors.
 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- T. Refer to Division 01 Section “General Commissioning Requirements” for additional contractor responsibilities.

3.3 CxA'S RESPONSIBILITIES

- A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

3.4 TESTING PREPARATION

- A. Certify in writing to the CxA that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

- C. Certify in writing that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.5 TESTING, ADJUSTING AND BALANCING VERIFICATION

- A. Prior to performance of Testing, Adjusting and Balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- B. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.
 - 1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
 - 2. The testing and balancing subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 - 3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
 - 4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.6 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA along with the HVAC&R contractor, testing and balancing Subcontractor, and HVAC&R Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.

- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.7 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 23 sections. Provide submittals, test data, inspector record, and certifications to the CxA.
- B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 23 Sections. Assist the CxA with preparation of testing plans.
- C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment: Test requirements are specified in Division 23 piping Sections. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
 - 1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 - 2. Description of equipment for flushing operations.
 - 3. Minimum flushing water velocity.
 - 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
- D. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- E. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.
- F. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

- G. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
1. HVAC Systems: Heating, ventilating and air conditioning systems, and all mechanical equipment forming a part of these systems including, but not limited to, all boilers, chillers, direct expansion refrigeration equipment, fuel storage and handling systems, pumps, piping, air handler systems, terminal equipment, fans, exhaust systems, ventilation systems, variable frequency drives, heat recovery systems, thermal solar systems, and automated temperature controls and energy management systems.
 2. Building Automation and Controls and all equipment forming a part of these systems including, but not limited to, the interface of these systems with HVAC systems, fire alarm and security systems.

3.8 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.9 APPROVAL

- A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.10 DEFERRED TESTING

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.11 OPERATION AND MAINTENANCE MANUALS

- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
- B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.12 TRAINING OF OWNER PERSONNEL

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

END OF SECTION 23 08 00

SECTION 231123

FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Gas Services: As shown on drawings and as required by Gas Utility Company.

1.2 QUALITY ASSURANCE

A. Applicable requirements of following standards and codes apply:

1. Building and Fire Codes.
2. National Electric Safety Code (NESC) and OSHA requirements.

B. City of Concord Construction Standards, latest edition.

1.3 JOB CONDITIONS

A. Inspection:

1. Examine areas for conditions under which work is to be performed. Report in writing to the Owner's Representative all conditions contrary to those shown on Drawings or specified herein and all other conditions that will affect satisfactory execution of work such as improper constructed substrates or adjoining work. Do not proceed with work until unsatisfactory conditions have been corrected.
2. Starting work constitutes acceptance of conditions under which work is to be performed. After such acceptance the Gas Utility Company shall at his expense, be responsible for correcting all unsatisfactory and defective work resulting from such unsatisfactory conditions.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Gas line: Material and size as specified by Gas Utility Company.

B. Fittings and Appurtenances: Material and size as specified by Gas Utility Company.

C. Gas Meter: As specified by Gas Utility Company.

PART 3 - EXECUTION

3.1 TRENCHING, BACKFILLING AND COMPACTION

- A. All trenching, backfilling and compacting to be conducted by Gas Utility Company: In accordance with most stringent requirements of Division 31 Section "Earth Moving" or with utility company requirements.

3.2 INSTALLATION

- A. Gas Utility Company shall install all gas piping and appurtenances in accordance with the Gas Utility Company's standard specifications.
- B. Minimum depth of cover on all gas piping will be 36", or as required by Gas Utility Company.
- C. Minimum vertical clearance will be 12" from other utilities.
- D. Concrete blocking will be provided at all bends in accordance with specifications of the Gas Utility Company.

3.3 TESTING AND INSPECTION

- A. Representatives of the Gas Utility Company providing service to site shall inspect applicable gas piping installation prior to backfilling.

3.4 CONSTRUCTION

- A. All gas piping and appurtenances will be installed as shown on Drawings and in accordance with the Gas Utility Company requirements.

END OF SECTION 231123

SECTION 260000

ELECTRICAL

PART 1 - GENERAL.....	1
1.1 GENERAL PROVISIONS.....	1
1.2 DESCRIPTION OF WORK.....	1
1.3 WORK TO BE PERFORMED.....	1
1.4 DEFINITIONS.....	3
1.5 ITEMS TO BE FURNISHED ONLY.....	3
1.6 ITEMS TO BE INSTALLED ONLY.....	3
1.7 RELATED WORK SPECIFIED ELSEWHERE.....	4
1.8 ENVIRONMENTAL REQUIREMENTS.....	4
1.9 CONTRACT COST BREAKDOWN.....	4
1.10 INSPECTION OF SITE.....	4
1.11 CONTRACTOR'S REPRESENTATIVE.....	5
1.12 COOPERATION.....	5
1.13 CODES, ORDINANCES, AND PERMITS.....	5
1.14 ELECTRICAL ROOMS OR SPACES.....	5
1.15 SUBMITTALS.....	6
1.16 GUARANTEE.....	6
1.17 ELECTRICAL CHARACTERISTICS.....	6
1.18 TEMPORARY LIGHT & POWER.....	6
1.19 TEMPORARY ELECTRICAL SUPPORT FACILITIES.....	6
1.20 INSPECTIONS AND TESTS.....	7
1.21 ENERGY REBATE PROGRAM.....	7
1.22 INFORMATION TECHNOLOGY SYSTEM (I.T.S.), and SECURITY SYSTEM PROVISIONS.....	7
1.23 RECORD DRAWINGS.....	7
1.24 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS.....	7
1.25 STAGING AND SCAFFOLDING.....	8
1.26 RETURN AIR PLENUM.....	8
1.27 TRADE RESPONSIBILITY FOR INTERCONNECTIONS MATRIX.....	9
PART 2 - PRODUCTS.....	10
2.1 GENERAL.....	10
2.2 RACEWAYS AND FITTINGS.....	10
2.3 CONDUCTORS.....	13
2.4 ACCESS PANELS.....	14
2.5 SLEEVES, INSERTS, AND OPENINGS.....	14
2.6 FLOOR OUTLETS (FLUSH TYPE).....	15
2.7 WIRING DEVICES.....	20
2.8 LIGHTING FIXTURES.....	22
2.9 ELECTRICAL POWER EQUIPMENT.....	26
2.10 ELECTRICAL SYSTEM CONTROLS AND INSTRUMENTS.....	28
2.11 GROUNDING SYSTEM.....	28
2.12 MAIN BUILDING SWITCHBOARD.....	29
2.13 PANELBOARDS.....	30
2.14 DRY-TYPE TRANSFORMERS.....	32
2.15 ELECTRIC SERVICE.....	33
2.16 FIRE ALARM AND DETECTION SYSTEM (Voice Evacuation Required).....	33
2.17 SURGE PROTECTION DEVICES.....	46
2.18 AUTOMATED LIGHTING CONTROL SYSTEM.....	51
2.19 LADDER TRAY/WIREWAYS.....	67
2.20 SEALS.....	68

2.21	UNDERGROUND DUCTBANKS.....	69
2.22	VARIABLE FREQUENCY DRIVES	70
2.23	STANDBY ELECTRICAL SYSTEM	74
2.24	UNINTERRUPTIBLE POWER SUPPLY, UPS.....	77
2.25	FIRESTOP SYSTEMS:	86
2.26	STAGE LIGHTING AND DIMMING SYSTEM.....	87
2.27	PUBLIC SAFETY RADIO DISTRIBUTED ANTENNAE SYSTEM (DAS)	90
2.28	MANUAL PMH PAD-MOUNTED GEAR	100
2.29	MEDIUM VOLTAGE CABLE	103
PART 3 - EXECUTION.....		105
3.1	INSPECTION AND ACCEPTANCE	105
3.2	WORK COORDINATION AND JOB OPERATIONS	105
3.3	PLANS AND SPECIFICATIONS	105
3.4	IDENTIFICATION	106
3.5	PROTECTION AND CLEANUP	106
3.6	PORTABLE OR DETACHABLE PARTS.....	107
3.7	MOUNTING HEIGHTS	107
3.8	WORKMANSHIP AND INSTALLATION METHODS.....	107
3.9	FEEDER CIRCUITS	112
3.10	BRANCH CIRCUITS	112
3.11	FIRESTOP SYSTEMS:	112
3.12	WATERPROOFING	112
3.13	CUTTING AND PATCHING	113
3.14	ELEVATOR COORDINATION	113
3.15	MECHANICAL SYSTEM COORDINATION	113
3.16	DISTRIBUTION EQUIPMENT TESTING.....	114
3.17	ARC FLASH HAZARD ANALYSIS / SHORT CIRCUIT COORDINATION STUDY	117
3.18	STORAGE AND INSTALLATION OF EQUIPMENT	122
3.19	WASTE MANAGEMENT	123
3.20	TRAINING.....	123

END OF INDEX

SECTION 260000

ELECTRICAL

PART 1- GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 DESCRIPTION OF WORK

- A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:
 - 1. All Work of Section 260000 ELECTRICAL
 - 2. All Work of Section 260800 – COMMISSIONING OF ELECTRICAL SYSTEMS
 - 3. All Work of Section 230548 – VIBRATION CONTROL & SEISMIC RESTRAINT
 - 4. All Work of Section 270000 - TECHNOLOGY
 - 5. All Work of Section 280000 – INTEGRATED ELECTRONIC SECURITY SYSTEM
 - 6. All Work of Section 274116 – INTEGRATED AUDIOVISUAL SYSTEMS AND EQUIPMENT
- B. Reference Drawings: The Work of this Sub-contractor is shown on the following Contract Drawings: E0.1, E0.2, E0.3, E0.4, E0.5, E0.6, E1.0A, E1.0B, E1.0C, E1.0G, E1.1A, E1.1B, E1.1C, E1.1D, E1.1E, E1.1F, E1.2A, E1.2B, E1.2C, E1.2D, E1.2E, E1.2F, E2.0A, E2.0B, E2.0C, E2.0F, E2.1A, E2.1B, E2.1C, E2.1D, E2.1E, E2.1F, E2.2A, E2.2B, E2.2C, E2.2D, E2.2E, E2.2F, E2.3, E2.4, E3.0, E3.1, E3.2, E3.3, E3.4, E3.5, E3.6, E3.7, E3.8, E3.9, E3.10, E3.11, E3.12, E3.13, E4.0, E4.0A, E4.0B, E4.0C, E4.0F, E4.1A, E4.1B, E4.1C, E4.1D, E4.1E, E4.1F, E4.2A, E4.2B, E4.2C, E4.2D, E4.2E, E4.2F, E5.0, E5.0A, E5.0B, E5.0C, E5.0F, E5.1A, E5.1B, E5.1C, E5.1D, E5.1E, E5.1F, E5.2A, E5.2B, E5.2C, E5.2D, E5.2E, E5.2F, T0.1, T1.0A, T1.0B, T1.0C, T1.0F, T1.1A, T1.1B, T1.1C, T1.1D, T1.1E, T1.1F, T1.2A, T1.2B, T1.2C, T1.2D, T1.2E, T1.2F, T2.0, T3.0, T3.1, T4.0, and T4.1.

1.3 WORK TO BE PERFORMED

- A. Work described herein shall be interpreted as work to be done by the Electrical Subcontractor. Work to be performed by other trades will be referenced to a particular contractor or subcontractor.

- B. Provide all labor, materials, tools, and equipment, including scaffolding, to complete the installation of the electrical system. Install, equip, adjust, and put into operation the respective portions of the installation specified, and so interconnect various items or sections of work in order to form a complete and operating whole. Systems may reference in singular or plural terms, also refer to drawings confirm quantities. The work shall consist of, but shall not necessarily be limited to, the following:
1. Primary, secondary and low tension ductbanks, manholes, and handholes.
 2. Primary, secondary distribution equipment, including secondary switchboard and metering, motor controls, Variable Frequency Drives, dry-type transformers, distribution panels, and panelboards, including feeders and subfeeders.
 3. Fire alarm system.
 4. Emergency power system, including natural gas fueled emergency generator, emergency lighting and exit signs.
 5. Lighting systems exterior and interior, including lamps, fixtures, and controls.
 6. All raceway systems, including boxes, couplings, and fittings.
 7. All branch circuit wiring systems, including wiring devices, and plates.
 8. Excavation and backfill within building foundation walls for any underground raceways.
 9. Connections for all building equipment, including mechanical, plumbing, fire protection, elevators, and the like.
 10. All testing of equipment installed.
 11. Any other item of work hereinafter specified or indicated on electrical drawings.
 12. Drilling, coring, and cutting of holes (where the largest dimension thereof does not exceed 12 in.) for electrical conduit, systems, and equipment. Cutting through non-masonry construction in accordance with section 017329 – Cutting and Patching.
 13. Systems Identification.
 14. Scaffolding, Rigging, and Staging required for all Electrical Work. Temporary facilities, including but not limited to stairs and ladders, staging, scaffolding, chutes, and hoisting in accordance with SECTION 015000 – TEMPORARY FACILITIES AND CONTROLS.
 15. Provide Seismic Restraints for all Electrical Systems conforming to the requirements of Section 230548 which Section is herein incorporated by reference.
 16. Coordination Drawings, refer to Section 013100.
 17. Communications cable tray, outlet boxes and raceway system provisions including voice, data, cable TV, paging, intercom, and clock. as indicated on drawings and specified in Section 270000.
 18. Temporary Power and Lighting, refer to Section 015000.
 19. Alternates affecting this section, refer to Section 012300.
 20. Raceways system provisions for Integrated Electronic Security System including outlet boxes, raceway system, 120 volt sources as indicated on drawings. Raceways system provisions for Integrated Electronic Security System including outlet boxes, raceway system, 120 volt sources as indicated on drawings and specified in Section 280000.
 21. Firestop systems in accordance with section 078400 – Firestopping.
 22. Furnish access doors and frames in accordance with SECTION 083100 – ACCESS DOORS AND FRAMES.
 23. Commissioning: Section 019113 – COMMISSIONING REQUIREMENTS and Section 260800 – COMMISSIONING OF ELECTRICAL SYSTEMS.

24. Install Stage Dimming and lighting system, furnished by Stage Lighting/Rigging Contractor under Sections 110610 and 110640. Provide all conduit, both low and high voltage, high voltage wire and terminations. Refer to equipment shown on TL Series.
 - a. Provide all conduit, both control and high voltage, high voltage wire and controls for motorized batten hoists over the audience seating area. Batten hoists furnished and installed by Section 110610 contractor. Refer to equipment shown on TR Series.
 - b. Provide all conduit, both control and high voltage, high voltage wire and terminations for motorized batten hoists over the stage area. Batten hoists furnished and installed by Section 110610 contractor. Refer to equipment shown on TR Series.
 - c. The matrix of responsibilities indicated in Paragraph 2.27 is intended as a guide for delineating the work between the Electrical Contractor and the Stage Lighting/Rigging Contractor, Section 110610.
 - d. Receive and store dimming system equipment supplied by the Section 110610 Contractor.

1.4 DEFINITIONS

- A. Most terms used within the documents are industry standard. Certain words or phrases shall be understood to have specific meanings as follows:
 1. Provide: Furnish and install completely connected up and in operable condition.
 2. Furnish: Purchase and deliver to a specific location within the building or site.
 3. Install: With respect to equipment furnished by others, install means to receive, unpack, move into position, mount and connect, including removal of packaging materials.
 4. Conduit: Raceways of the metallic type which are not flexible. Specific types as specified.
 5. Connect: To wire up, including all branch circuitry, control and disconnection devices so item is complete and ready for operation.
 6. Subject to Mechanical Damage: Equipment and raceways installed exposed and less than eight feet above finished floor in mechanical rooms or other areas where heavy equipment may be in use or moved.
 7. General Contractor and CM are one in the same.

1.5 ITEMS TO BE FURNISHED ONLY

1. Furnish the following items for installation under designated sections.
 - a. Duct smoke detectors with sampling tube – Section 230000 – HVAC.

1.6 ITEMS TO BE INSTALLED ONLY

1. Install the following items furnished under designated sections.
 - a. Specialty backboxes – Section 270000.
 - b. Power operated window shades – Section 122400.
 - c. Athletic Equipment Section 116620.
 - d. Projection Screens Section 111320.
 - e. Motorized Window Shades Section 122400.

1.7 RELATED WORK SPECIFIED ELSEWHERE

- A. The following related work is to be performed under designated sections.
1. Temp. Controls: SECTION 015000 – TEMPORARY FACILITIES AND CONTROLS.
 2. Excavation and Backfill (except within building foundation): SECTION 310000 - EARTHWORK.
 3. Concrete Pole Bases, Pads and Duct Envelopes: SECTION 033000 – CAST-IN-PLACE CONCRETE.
 4. Insulation: SECTION 072100 – THERMAL INSULATION.
 5. Finish Painting: SECTION 099000 – PAINTING AND COATING.
 6. Payment for energy for temporary light and power shall be made by General Contractor.
 7. Cutting beyond Section 017329, Paragraph 1.3-C above, and patching of all openings regardless of size shall be by trade responsible for Section on which penetration occurs.
 8. Automatic Temperature Control: SECTION 230000 - HEATING, VENTILATING, AND AIR CONDITIONING.
 9. Hardware: SECTION 087100 – DOOR HARDWARE.
 10. Technology Wiring and Equipment: SECTION 270000 – TECHNOLOGY.
 11. Integrated Electronic Security System Wiring and Equipment: Under separate State Contract. Integrated Electrical Security System Wiring and Equipment: Section 280000 - Integrated Electronic Security System.
 12. Power Operated Shades – SECTION 122400 – WINDOW SHADES
 13. Commissioning: Section 019100 – GENERAL COMMISSIONING REQUIREMENTS and Section 260800 – COMMISSIONING OF ELECTRICAL SYSTEMS.
 14. Temporary Power and Lighting: Section 015000 – TEMPORARY FACILITIES AND CONTROLS.
 15. Audio Visual Systems – SECTION 274116
 16. Theatrical Lighting Control and Fixtures- SECTION 110640.
- B. The following work is included in other sections. Coordinate the Work of this Section as required:
1. Cutting and patching in masonry construction, and associated lintels.
 2. Patching of non-masonry construction.

1.8 ENVIRONMENTAL REQUIREMENTS

- A. The work of this section shall comply with requirements of the following:
1. SECTION 013100 – PROJECT MANAGEMENT AND COORDINATION
 2. SECTION 018119 – INDOOR AIR QUALITY REQUIREMENTS

1.9 CONTRACT COST BREAKDOWN

- A. Submit a breakdown of contract price to aid Architect in determining value of work installed as job progresses.

1.10 INSPECTION OF SITE

- A. Electrical bidders will be permitted to inspect site. Failure to inspect existing conditions or to fully understand work which is required shall not excuse

- B. Electrical Subcontractor from his obligations to supply and install work in accordance with specifications and the drawings and under all site conditions as they exist.

1.11 CONTRACTOR'S REPRESENTATIVE

- A. Retain a competent representative on the project.

1.12 COOPERATION

- A. Work shall be carried on under usual construction conditions, in conjunction with other contractors work. Cooperate with other contractors, coordinate work and proceed in a manner as not to delay progress.
- B. Before proceeding, examine all construction drawings and consult other contractors to coordinate installation and avoid interference.
- C. In case of dispute, the Architect will render a decision in accordance with General and Supplementary General Conditions.

1.13 CODES, ORDINANCES, AND PERMITS

- A. Codes and Ordinances:
 - 1. All material and work provided shall be in accordance with the following codes and standards as most recently amended.
 - International Building Code 2009
 - National Electric Code, 2014 Edition
 - State Department of Public Safety
 - NFPA 101 "Life Safety Code"
 - NFPA Standards
 - Standards of the Underwriters Laboratories (UL)
 - Occupational Safety and Health Act (OSHA)
 - Americans with Disabilities Act (ADA)
 - Energy Conservation Code 2012
 - City of Dover
 - State of New Hampshire Fire Code
 - 2. Where contract documents indicate more stringent requirements than codes, the contract documents shall take precedence.
- B. Permits: Be responsible for filing documents, and securing of inspection and approvals. Pay all local connection & permit fees. Utility Company backcharges related to permanent service will be paid directly by the City. Costs related to temporary service, refer to Section 015000. Refer to AIA 201 General Conditions.

1.14 ELECTRICAL ROOMS OR SPACES

- A. Be responsible for ensuring that the dedicated space and clearances required in the NEC, Sections 110-16 and 110-26 are maintained for all electrical equipment.
- B. Call other contractors' attention to the requirements contained in the above mentioned code sections, prior to the installation of equipment by other contractors, in order to ensure no violations.

1.15 SUBMITTALS

- A. Refer to Section 013300 – SUBMITTAL PROCEDURES, for requirements.

1.16 GUARANTEE

- A. All parts of the work shall be guaranteed for a period of one year from the date of acceptance of the job by Owner. If during that period of general guaranty, any part of the work fails, becomes unsatisfactory, or does not function properly due to any fault in material or workmanship whether or not manufactured or job built, the Owner shall upon notice from owner promptly proceed to repair or replace such faulty material or workmanship without expense to owner, including cutting, patching, and painting, or other work involved, and including repair or restoration of any damaged sections of the premises resulting from such faults.
- B. In the event that a repetition of any one defect occurs indicating the probability of further failure and which can be traced to faulty design, material, or workmanship, then repair or replacement shall not continue to be made but the fault shall be remedied by a complete replacement of the entire defective unit.
- C. In addition to the general guaranty, obtain and transmit to owner any guaranties or warranties from manufacturers of specialties, but only as supplementary to the general guaranty which will not be invalidated by same.

1.17 ELECTRICAL CHARACTERISTICS

- A. In general, and unless specifically indicated otherwise, all building service, heating, ventilating, air conditioning, and plumbing equipment shall be of the following characteristics:
- B. Power Factor: All equipment provided rated greater than 1,000 watts and lighting equipment greater than 15 watts with an inductive reactance load component shall have a power factor of not less than 90 percent under rated load conditions.
 - 1. Motors up to and including 1/3 HP shall be suitable for 120 volts, single phase operation.
 - 2. Motors larger than 1/3 HP shall be suitable for 480 volts, three phase operation.
 - 3. Electric heating equipment 4 KW and less shall be suitable for 277 volt single phase operation. Over 4 KW shall be 480 volt three phase.

1.18 TEMPORARY LIGHT & POWER

- A. Refer to Section 015000 - TEMPORARY FACILITIES AND CONTROLS.

1.19 TEMPORARY ELECTRICAL SUPPORT FACILITIES

- A. Refer to Section 015000 – TEMPORARY FACILITIES AND CONTROLS.
- B. Provide own field office and/or storage facilities which shall be located as directed or permitted by General Contractor and in accordance with local regulations. Provide all tools, equipment, ladders, and temporary construction required for execution of the work.

- C. All scaffolding, ladders, and other temporary construction shall be rigidly built in accordance with all local and state requirements, and shall be removed upon completion.

1.20 INSPECTIONS AND TESTS

- A. Inspection: If inspection of materials installed shows defects, such defective work, materials, and/or equipment shall be replaced and inspection and tests repeated.
- B. Tests: Make reasonable tests and prove integrity of work and leave electrical installation in correct adjustment and ready to operate. All panels and switchboards shall have phases balanced as near as practical. A consistent phase orientation shall be adhered to at all terminations.

1.21 ENERGY REBATE PROGRAM

- A. This project has been designed to incorporate equipment approved for energy rebate such as fixtures, ballasts and lamps, dimming controls, and VFDs. Meet with Utility Company prior to lighting shop drawing submittal to ascertain that submittal meets program guidelines. All lighting shall be DLC listed.

1.22 INFORMATION TECHNOLOGY SYSTEM (I.T.S.), and SECURITY SYSTEM PROVISIONS

- A. Electrical Contractor shall work closely with the I.T.S. Contractor, and Security System Contractor to assure a first class installation. Coordinate all back boxes and conduits required prior to installations. In general, the electrical contractor shall provide conduits from systems outlets to accessible ceiling space.
- B. The Electrical Contractor shall be responsible for providing all related building preparation including, but not limited to: power, cable trays, conduits with bushings, conduit stubs with bushings, sleeves with bushings (all conduit, stubs, and sleeves, shall be brought to an accessible ceiling of the same floor), backboxes, pull strings, bonding, grounding, for a completely operational system, as specified and shown on Drawings.

1.23 RECORD DRAWINGS

- A. Refer to Section 017839 – PROJECT RECORD DRAWINGS, for requirements.

1.24 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. Refer to Section 017700 – CLOSEOUT PROCEDURES, for OPERATION AND MAINTENANCE DATA requirements.
- B. Contractor shall provide a computerized maintenance management system in format compatible with School Dude (excel or other similar program) for Electrical equipment. The preventative maintenance program includes the following fields:
 1. Step 1: PM Schedule Name
 2. Step 2: Classification
 3. Step 3: Type
 4. Step 5: Location
 5. Step 6: Building

6. Step 9: Job Startup
7. Step 10: Safety Points
8. Step 11:
 - a. Task 1
 - b. Task 2
 - c. Task 3
 - d. Task 4
 - e. Task 5
 - f. Task 6
 - g. Task 7
 - h. Task 8
 - i. Task 9
 - j. Task 10
9. Step 12: Tools
10. Step 14: Journal Notes
11. Step 15:
 - a. Assigned To
 - b. Hours
 - c. Craft
 - d. Budget
 - e. Project
 - f. Custom
 - g. Category
12. Step 16: PM Frequency

1.25 STAGING AND SCAFFOLDING

- A. Unless otherwise specified, each sub-contractor shall provide all lifts and man-lifts, and furnish, erect and maintain in safe condition, all staging and scaffolding as specified under Section 015000 Temporary Facilities and Controls, as needed for proper execution of the work of this Section. Staging and scaffolding shall be of adequate design, erected and removed by experienced stage builders having all accident prevention devices required by Federal, state and local laws.

1.26 RETURN AIR PLENUM

- A. All wiring systems in areas above hung ceiling shall either be run in conduit or shall be "UL listed" plenum cable

1.27 TRADE RESPONSIBILITY FOR INTERCONNECTIONS MATRIX

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Smoke Detectors (Area type)	26 00 00	26 00 00	26 00 00	230000 (ATC)	26 00 00	
Smoke Detectors (Duct mounted)	26 00 00	23 00 00	26 00 00	230000 (ATC)	26 00 00	
Smoke & Fire/Smoke Dampers	23 00 00	23 00 00	N/A	N/A	N/A	
Smoke & Fire/Smoke Damper Actuators	23 00 00	23 00 00	26 00 00 & 230000 (ATC)	230000 (ATC)	26 00 00	2
Fire Dampers	23 00 00	23 00 00	N/A	N/A	N/A	
VAV Boxes	23 00 00	23 00 00	26 00 00	230000 (ATC)	N/A	2
VAV Box Damper Actuator	230000 (ATC)	Box Mfr	230000 (ATC)	230000 (ATC)	N/A	2
VAV Box DDC Controller	230000 (ATC)	Box Mfr	230000 (ATC)	230000 (ATC)	N/A	2
Hydronic Control Valves	230000 (ATC)	23 00 00	N/A	230000 (ATC)	N/A	1
Hydronic Control Valve Actuator	230000 (ATC)	23 09 23	230000 (ATC)	230000 (ATC)	N/A	1
Sheet Metal Damper	23 00 00	23 00 00	N/A	N/A	N/A	1
Sheet Metal Damper Actuators	230000 (ATC)	23 09 23	230000 (ATC)	230000 (ATC)	N/A	1
Natural Gas Energy Meters	22 00 00	22 00 00	26 00 00 & 230000 (ATC)	230000 (ATC)	N/A	3
Electrical Energy Meters	26 00 00	26 00 00	26 00 00 & 230000 (ATC)	230000 (ATC)	N/A	3
Domestic Water Meters	22 00 00	22 00 00	26 00 00 & 230000 (ATC)	230000 (ATC)	N/A	3
HVAC Hydronic Energy Meters	23 00 00	230000 (ATC)	26 00 00 & 230000 (ATC)	230000 (ATC)	N/A	3
Airflow Measuring Stations	230000 (ATC)	230000 (ATC)	N/A	230000 (ATC)	N/A	
DDC Panels	230000 (ATC)	230000 (ATC)	26 00 00 & 230000 (ATC)	230000 (ATC)	N/A	4
VFDs at AHU, EFs	230000 (ATC)	230000 (ATC)	26 00 00	230000 (ATC)	N/A	
Elevator Hoistway Vent Damper	23 00 00	23 00 00	N/A	N/A	N/A	
Elevator Hoistway Vent Damper Actuator	230000 (ATC)	230000 (ATC)	230000 (ATC)	230000 (ATC)	26 00 00	
Boiler/DHW/Generator Breeching	22 00 00	22 00 00	N/A	N/A	N/A	

Device	Furnished By	Installed By	Power Wiring	Control Wiring	Fire Alarm Wiring	Notes
Kitchen Emergency Gas Valve	22 00 00	22 00 00	26 00 00	26 00 00	26 00 00	

Notes:

1. Division 23 00 00 and Division 230000 (ATC) Contractors shall fully coordinate all airflow damper and hydronic valves sizes and quantities.
2. Smoke Damper and VAV Box power wiring shall be provided by Division 26 00 00 to junction box locations shown on electrical drawings; Division 230000 (ATC) Contractor shall provide final power wiring from junction box to end device location.
3. Division 26 00 00 Contractor shall provide all line-voltage power wiring required for meters; Division 23 09 23 Contractor shall provide all low-voltage power wiring required for meters.
4. Division 26 00 00 shall provide power at main DDC Panel. Division 230000 (ATC) shall provide power to all other DDC Panels.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Product specifications are written in such a manner so as to specify what materials may be used in a particular location or application and therefore do not indicate what is not acceptable or suitable for a particular location or application. As an example: non-metallic sheathed cable is not specified; therefore, it is not acceptable.
- B. For purpose of establishing a standard of quality and not for purpose of limiting competition, the basis of this Specification is upon specified models and types of equipment and materials, as manufactured by specified manufacturers.
- C. In all cases, standard cataloged materials and systems have been selected. Materials such as lighting fixtures specially manufactured for this particular project and not part of a manufacturers' standard product line will not be acceptable. In the case of systems, the system components shall be from a single source regularly engaged in supplying such systems. A proposed system made up of a collection of various manufacturers' products will be unacceptable.
- D. Where Specifications list manufacturers' names and/or "Or Equal", other manufacturers' equipment will be considered if equipment meets Specification requirements and has all features of the specified items as are considered essential by Architect.
- E. All material shall be new and shall be UL listed.

2.2 RACEWAYS AND FITTINGS

- A. Raceways - General:
 1. No raceway shall be used smaller than ¾ in. diameter and shall have no more than four 90o bends in any one run, and where necessary, pull boxes shall be provided. Only rigid metal conduit or intermediate metal conduit is allowed for slab work. Cable systems, if allowed to be used by other sections of this specification, shall not be used exposed or in slabs, whether listed by "UL" for such use or not.

2. Rigid metal conduit conforming to, and installed in accordance with, Article 344 shall be heavy wall zinc coated steel conforming to American Standard Specification C80-1 and may be used for service work, exterior work, slab work, and below grade level slab, wet locations, and in mechanical rooms for drops down to equipment from elevations below eight feet and also where raceway may be subject to mechanical damage.
3. Intermediate metal conduit conforming to, and installed in accordance with, Article 342, may be used for all applications where rigid metal conduit is allowed by these specifications.
4. Electrical Metallic Tubing (EMT), conforming to, and installed in accordance with, Article 358 shall be zinc coated steel, conforming to industry standards, may be used in masonry block walls, stud partitions, above furred ceilings, where exposed but not subject to mechanical damage, and may be used for fire alarm work.
5. Surface metal raceways conforming to, and installed in accordance with, Article 386 may be used only where raceways cannot be run concealed, and then, if only specifically approved.
6. Flexible metal conduit shall be used for final connections to recessed lighting fixtures from above ceiling junction boxes and for final flexible connections to motors and other rotating or vibrating equipment. Liquid tight flexible metal conduit shall be used for the above connections which are located in moist locations. All flexible connections shall include an insulated grounding conductor.
7. Rigid non-metallic conduit may be used for underground electric and telephone services outside the foundation wall and also below slab and shall be polyvinyl chloride (PVC) schedule 40, 90 deg. C. Rigid metal conduits shall be used thru-foundation walls and thru-slab. Below slab conduits do not require concrete encasement.
8. PVC Schedule 40 may be used for below slab circuits within building confines. Below slab rigid non-metallic conduits do not require concrete encasement. Rigid non-metallic conduits may be used for below slab feeders and branch circuits, but shall not be used in slabs, nor for elbows which penetrate slabs. Raceways and fittings shall be produced by same manufacturer.
9. PVC schedule 40 may also be used for underground branch circuits outside the foundation wall.
10. Acceptable manufacturers:
 - a. Pittsburgh Standard Conduit Company
 - b. Republic Steel and Tube
 - c. Youngstown Sheet and Tube Company
 - d. Carlon
 - e. Or equal
11. Fittings:
 - a. Provide insulated bushings on all raceways 1 inch diameter or larger.
 - b. Manufacturer's standard fittings shall be used for raceway supports.
 - c. Expansion Fittings: Expansion fittings shall be used where structural and concrete expansion joints occur and shall include a ground strap. Bond separate buildings in accordance with code.
 - d. Couplings for rigid metal and intermediate metal conduit shall be threaded type.
 - e. Threadless fittings for EMT shall be watertight compression type or set-screw type (dry-locations). All fittings shall be concrete tight. No diecast fittings allowed except for raceways larger than 1 inch diameter.
 - f. Cable supports in vertical raceways shall be of the split wedge type. Armored cable supports for vertical runs to be of wire mesh basket design.
 - g. Wall entrance seals shall be equal to O.Z. Gedney type "WSK".
 - h. Couplings, elbows and other fittings used with rigid nonmetallic conduit shall be of the solvent cemented type to secure a waterproof installation.

- 1) Acceptable manufacturers:
 - a) O.Z.
 - b) Crouse Hinds
 - c) Appleton
 - d) EFCOR
 - e) Steel City
 - f) Or equal
- B. Outlets, Pull and Junction Boxes:
1. Outlets:
 - a. Each outlet in wiring or raceway systems shall be provided with an outlet box to suit conditions encountered. Boxes installed in normally wet locations or surface mounted shall be of the cast-metal type having hubs. Concealed boxes shall be cadmium plated or zinc coated sheet metal type. Old work boxes with Madison clamps not allowed in new construction. Thru the wall boxes are not permitted.
 - b. Each box shall have sufficient volume to accommodate number of conductors in accordance with requirements of Code. Boxes shall not be less than 1-1/2 in. deep unless shallower boxes are required by structural conditions and are specifically approved by Architect. Ceiling and bracket outlet boxes shall not be less than 4 in. octagonal except that smaller boxes may be used where required by particular fixture to be installed. Flush or recessed fixtures shall be provided with separate junction boxes when required by fixture terminal temperature requirements. Switch and receptacle boxes shall be 4 in. square or of comparable volume.
 - c. Far side box supports shall be Caddy J-1A.
 - d. Acceptable manufacturers:
 - 1) Appleton
 - 2) Crouse Hinds
 - 3) Steel City
 - 4) RACO
 - 5) Or equal
 2. Pull and Junction Boxes: Where indicated on plans, and where necessary to terminate, tap off, or redirect multiple raceway runs or to facilitate conductor installation, furnish, and install appropriately designed boxes. Boxes shall be fabricated from code gauge steel assembled with corrosion resistant machine screws. Box size shall be sized per Code.

Boxes in moist or wet areas shall be galvanized type. Boxes larger than 4-11/16 inches square shall have hinged covers. Boxes larger than 12 inches in one dimension will be allowed to have screw fastened covers, if a hinged cover would not be capable of being opened a full 90 degrees due to installation location.

- a. Acceptable Manufacturers:
 - 1) Brasch
 - 2) Hoffman
 - 3) Keystone
 - 4) Lee Products Co.
 - 5) McKinstry Inc.
 - 6) Eldon Inc.
 - 7) Or equal

2.3 CONDUCTORS

- A. All conductors shall be a minimum size of #12 AWG except for control wiring and fire alarm wiring where #14 AWG may be used. For all exit sign circuits, normal/emergency and/or emergency only circuits, exterior lighting circuits, and also where distance from panelboard to first outlet exceeds 80 ft. at 120 volts and 150 ft. at 277 volts, #10 AWG shall be minimum size wire allowed. All feeder and branch circuit conductor shall be color coded as follows:
- | | | | |
|----|--------------------|---------|-------------------------|
| 1. | 208Y/120V | Phase A | Black |
| 2. | 208Y/120V | Phase B | Red |
| 3. | 208Y/120V | Phase C | Blue |
| 4. | 480Y/277V | Phase A | Brown |
| 5. | 480Y/277V | Phase B | Orange |
| 6. | 480Y/277V | Phase C | Yellow |
| 7. | Grounded Conductor | | |
| | | 120/208 | White |
| | | 277/480 | Grey |
| 8. | Equipment Ground | | |
| | | 120/208 | Green |
| | | 277/480 | Green with Yellow Trace |
| 9. | Isolated Ground | 120/208 | Green with Orange Trace |
- B. All conductors not installed in accordance with color scheme shall be replaced. All conductors larger than #6 AWG must be identified with colored tape.
- C. Connections throughout the entire job shall be made with solderless type devices.
1. For #10 AWG and smaller: spring type.
 2. For #8 AWG and larger: circumferential compression type.
 3. Acceptable manufacturers:
 4. 3M "Scotchlock"
 - a. IDEAL "Wingnut"
 - b. BURNDY
 - c. MAC
 - d. Or equal
 5. Any splices made up in ground mounted pull boxes shall be resin cast waterproof type or waterproof pressure type, as manufactured by King Technology, St. Louis, MO.
- D. Conductors shall be copper, soft drawn, and annealed of 98 percent conductivity. Conductors larger than #10 AWG shall be stranded; #10 AWG and smaller shall be solid. Conductors shall be insulated for 600 volts and be of following types:
1. All conductors shall have heat/moisture resistant thermoplastic insulation type THHN/THWN (75 degrees C) except as follows:
 - a. In sizes #1 AWG and larger: Crosslinked polyethylene insulation type XHHW (75 degrees C – 90 degrees C) may be used.
 - b. Fire alarm system conductors shall be #14 AWG, type THHN, solid. Color coding of fire alarm conductors shall be in accordance with fire codes.
 - c. Fixture whips #16AWG type "SF".
- E. Stranded conductors for all wiring systems except fire alarm will be allowed if installed and terminated as specified under Execution Section.

- F. Mineral-Insulated Metal-Sheathed Fire-Resistive Cables (Type MI) - Cables shall consist of a factory assembly of one or more solid copper conductors insulated with highly-compressed magnesium oxide and enclosed in a seamless, liquid-and-gas-tight continuous copper sheath. Cables shall be rated for 600 volts and less. Cables shall comply with Article 332 of the National Electrical Code. Cables shall be classified by Underwriters Laboratories, Inc. as having a 2-hour fire resistive rating. Cable terminations shall be made with UL listed mineral-insulated cable fittings. Approved Manufacturer - Pyrotenax USA, Inc., Pentair, Raychem, or approved equal.
- G. Type MC Cable may be used for concealed branch circuits in hollow spaces where allowed by code if installed and terminated as specified under Execution Section. Armor shall be galvanized steel and shall be UL listed for 2 hour fire wall penetration. Aluminum armor is not acceptable.
- H. Type MC Cable may also be used for fire alarm where concealed and allowed by Code. Armor shall be red.
- I. Acceptable manufacturers:
 - 1. AFC Cable Systems
 - 2. American Wire & Cable
 - 3. Cerro
 - 4. Cornish
 - 5. Crescent
 - 6. General Cable
 - 7. Okonite
 - 8. Or equal

2.4 ACCESS PANELS

- A. Refer to section 083100 – ACCESS DOORS AND FRAMES for requirements.
- B. Provide access panels for access to concealed junction boxes and to other concealed parts of system that require accessibility for operation and maintenance. In general, electrical work shall be laid out so access panels are not required.

2.5 SLEEVES, INSERTS, AND OPENINGS

- A. Sleeves: Provide sleeves of proper sizes for all openings required in concrete floors and walls. Sleeves passing through floors shall be set with top of sleeve 1 in. above finished floor. Core drilling will also be acceptable if in accordance with any structural standards. Any unsleeved openings shall be waterproofed.
- B. Inserts: Provide inserts or other anchoring devices in concrete and masonry construction to support raceways and equipment.
- C. Openings: Where an opening is required in concrete slabs to allow passage of a multitude of raceways, give adequate notice to General Contractor so he may box out opening in form work.

- D. Acceptable Manufacturers:
1. Specified Technologies Inc.
 2. Thomas & Betts
 3. International Protective Coatings Corp.
 4. 3M Fire Protection Products
 5. Dow Corning
 6. Or equal

2.6 FLOOR OUTLETS (FLUSH TYPE)

- A. Section includes flush floor boxes equal to Wiremold RFB Series. Provide appropriate floor box model that meets the intent of what is shown on the drawings.
- B. Quality Assurance
1. Electrical Raceways and Components: Comply with requirements of applicable local codes, NEC, UL, and NEMA Standards pertaining to raceways and components. Listed and labeled in accordance with NFPA 70, Article 100.
- C. Floor Boxes
1. RFB4 and RFB4-4DB Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 12-3/4" L x 10" W x 3-7/16" H [324mm x 254mm x 87mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles, communication and/or audio/video services. The RFB4 Series Box shall permit tunneling from end power compartment to end power compartment. The RFB4-4DB Series Box shall permit tunneling from adjacent or opposite compartments. Two (2) of the four (4) compartments shall have a minimum wiring capacity of 16.4 cu in [269cu cm], one (1) compartment shall have a minimum capacity of 32.3 cu in [529cu cm], and one (1) compartment shall have a minimum capacity of 50 cu in [820cu cm]. Four (4) compartments shall have a minimum of two (2) inches of space behind the device plates. The box shall include the following number of conduit knockouts: one (1) 1/2-inch [12.7mm], three (3) 1-inch [25mm], six (6) 3/4-inch [19.1mm], and six (6) 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-7/8-inch [47.7mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics® workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
 2. RFB4-CI-1 and RFB4-CI-NA Series Floor Boxes: Manufactured from cast-iron and approved for use on grade and above grade floors. The box shall be 14-1/2" L x 11-7/8" W x 3-7/16" H [368mm x 302mm x 87mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles and/or communication services. The box shall permit tunneling from adjacent or opposite compartments. Two (2) of the four (4) compartments shall have a minimum wiring capacity of 27 cu in [443cu cm], and two (2) compartments shall have a minimum wiring capacity of 36 cu in [590cu cm]. Four (4) compartments shall have a minimum of two (2) inches of space behind the device plates. The box shall include the following number of conduit hubs: four (4) 1-inch [25mm] and four (4) 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-7/8-inch [48mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics® workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

3. RFB4-SS Series Floor Boxes: Manufactured from stamped-steel and approved for use on above grade floors. The box shall be 13-5/8" L x 10" W x 2-7/16" H [346mm x 254mm x 62mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two (2) of the four (4) compartments shall have a minimum wiring capacity of 15.7 cu in [257cu cm] and two (2) compartments shall have a minimum wiring capacity of 31.2 cu in [511cu cm]. Four (4) compartments shall have a minimum of two (2) inches of space behind the device plates. The box shall contain the following number of conduit knockouts: two (2) 1/2-inch [12.7mm], six (6) 3/4-inch [19.1mm], and eight (8) 1-inch [25mm]. The box shall be fully adjustable, providing a maximum of 1-7/8-inch [48mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics® workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
4. RFB4E Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 13-1/8" L x 13-1/8" W x 4-1/16" H [333mm x 333mm x 103mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles, communication and/or audio/video services. The box shall permit feed through removable barriers from adjacent compartments. Four (4) compartments shall have a minimum wiring capacity of 75 cu in [1230cu cm]. Four (4) compartments shall have a minimum of 3-1/2 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: six 3/4-inch [19.1mm], ten (10) 1-inch [25mm], and eight (8) 1-1/4-inch [32mm]. The box shall have two removable knockout plates that can be replaced with a 2-inch trade size conduit hub (2HUB). The box shall be fully adjustable, providing a maximum of 2-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
5. RFB4E-OG Series Floor Boxes: Manufactured from stamped steel and painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and approved for use on grade and above grade floors. The box shall be 13-1/8" L x 13-1/8" W x 4-1/16" H [333mm x 333mm x 103mm]. Provide the box with four (4) independent wiring compartments that allow capacity for up to four (4) duplex receptacles, communication and/or audio/video services. The box shall permit feed through removable barriers from adjacent compartments. Four (4) compartments shall have a minimum wiring capacity of 75 cu in [1230cu cm]. Four (4) compartments shall have a minimum of 3-1/2 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: six 3/4-inch [19.1mm], ten (10) 1-inch [25mm], and eight (8) 1-1/4-inch [32mm]. The box shall have two removable knockout plates that can be replaced with a 2-inch trade size conduit hub (2HUB). The box shall be fully adjustable, providing a maximum of 2-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

6. RFB6 Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 13-1/8" L x 12-1/2" W x 3-1/4" H [333mm x 317mm x 83mm]. Provide the box with six (6) independent wiring compartments that allow capacity for up to six (6) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two (2) of the six (6) compartments shall have a minimum wiring capacity of 23 cu in [376cu cm] and four (4) compartments shall have a minimum wiring capacity of 52cu in [850cu cm]. Four (4) of the six (6) compartments shall have a minimum of 3-1/4 inches of space behind the device plates and two (2) of the six (6) compartments shall have a minimum of 2-3/8 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four (4) 1-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
7. RFB6-OG Series Floor Boxes: Manufactured from stamped steel and painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and approved for use on grade and above grade floors. The box shall be 13-1/8" L x 12-1/2" W x 3-1/4" H [333mm x 317mm x 83mm]. Provide the box with six (6) independent wiring compartments that allow capacity for up to six (6) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two (2) of the six (6) compartments shall have a minimum wiring capacity of 23 cu in [376cu cm] and four (4) compartments shall have a minimum wiring capacity of 52cu in [850cu cm]. Four (4) of the six (6) compartments shall have a minimum of 3-1/4 inches of space behind the device plates and two (2) of the six (6) compartments shall have a minimum of 2-3/8 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four (4) 1-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
8. RFB6E Series Floor Boxes: Manufactured from stamped steel and approved for use on above grade floors. The box shall be 13-1/8" L x 12-1/2" W x 4" H [333mm x 317mm x 102mm]. Provide the box with six (6) independent wiring compartments that allow capacity for up to six (6) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments through 1-1/4-inch grommet openings. Two (2) of the six (6) compartments shall have a minimum wiring capacity of 23 cu in [376cu cm] and four (4) compartments shall have a minimum wiring capacity of 52cu in [850cu cm]. Four (4) of the six (6) compartments shall have a minimum of 3-1/4 inches of space behind the device plates and two (2) of the six (6) compartments shall have a minimum of 2-3/8 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four (4) 1-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.

9. RFB6E-OG Series Floor Boxes: Manufactured from stamped steel and painted with a fusion-bonded epoxy designed for use on metal reinforcement bar and related accessories before encapsulation in concrete, and approved for use on grade and above grade floors. The box shall be 13-1/8" L x 12-1/2" W x 4" H [333mm x 317mm x 102mm]. Provide the box with six (6) independent wiring compartments that allow capacity for up to six (6) duplex receptacles, communication and/or audio/video services. The box shall permit feed through tunneling from adjacent compartments. Two (2) of the six (6) compartments shall have a minimum wiring capacity of 23 cu in [376cu cm] and four (4) compartments shall have a minimum wiring capacity of 52cu in [850cu cm]. Four (4) of the six (6) compartments shall have a minimum of 3-1/4 inches of space behind the device plates, and two (2) of the six (6) compartments shall have a minimum of 2-3/8 inches of space behind the device plates. The box shall contain the following number of conduit knockouts: twelve 3/4-inch [19.1mm], four (4) 1-inch [25mm], and twelve 1-1/4-inch [32mm]. The box shall be fully adjustable, providing a maximum of 1-3/8-inch [35mm] pre-pour adjustment, and a maximum of 3/4-inch [19.1mm] after-pour adjustment. The box shall include a series of device mounting plates that will accept both duplex power devices as well as plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, Legrand AVIP audio/video device plates, and other open system devices.
- D. Activation Covers
1. FloorPort FPCT, FPBT, and FPFPT Series Covers: Manufactured of die-cast aluminum or die-cast zinc, and available in brushed aluminum finish and powder-coated paint finishes (black, gray, bronze, nickel and brass). Activation covers shall be available in flanged and flangeless versions. Covers shall be available with options for tile or carpet inserts, or flush covers. The cover's hinge shall allow for the cover to open 180 degrees. The furniture feed covers shall come equipped with one (1) 1-inch trade size screw plug opening and one (1) combination 1-1/4-inch and 2-inch trade size screw plug.
 - a. Flanged covers shall be 7-3/4" L x 6-9/16" W [197mm x 167mm].
 - b. Flangeless covers shall be 6-3/4" L x 5-9/16" W [171mm x 142mm].
 2. 6CT, 6CTC, 6CFFTC, 8CTC, and 8CT Series Covers: Manufactured of die-cast aluminum alloy and available in powder-coated gray, black, brass, nickel or bronze finish. The covers shall be available in carpet and tile versions. Provide covers with two (2) gaskets (one (1) for carpet and one (1) for tile) to go under the trim flange to maintain scrub water tightness. The activation cover for the 8CTC and 8CT series shall be 9-1/4-inch [235mm] in diameter. The activation cover for the 6CT and 6CTC series shall be 7-1/4-inch [184mm] in diameter and the activation cover for the 6CFFTC series shall be 7-3/4-inch [197mm] in diameter. The carpet covers shall be surface mounted and the tile covers shall be flush with the finished floor covering. The covers shall have spring loaded slides to allow cables to egress out of the unit and maintain as small an egress opening as possible.
 3. The covers shall have been evaluated by UL to meet the applicable U.S. and Canadian safety standards for scrub water exclusion when used on tile, terrazzo, wood, and carpet covered floors.
- E. Communication Modules Mounting Accessories
1. The floor box manufacturer shall provide a complete line of faceplates and bezels to facilitate mounting of UTP, STP (150 ohm), fiber optic, coaxial, and communication devices. The box shall provide a series of device mounting plates that will accommodate Ortronics workstation connectivity outlets and modular adapters, and other open system devices.

- F. Installation
1. Strictly comply with manufacturer's installation instructions and recommendations and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.
 2. Mechanical Security: Raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer's installation sheets.
 3. Accessories: Provide accessories as required for a complete installation, including insulated bushings and inserts where required by manufacturer.
 4. Unused Openings: Close unused box openings using manufacturer's recommended accessories.
 5. Provide a minimum concrete pour depth of 3-7/16-inch [87mm] plus 1/16-inch [1.6mm] above the top of the box for the RFB4, RFB4-4DB, RFB2, and the RFB2-OG Series Boxes; 2-7/16-inch [62mm] plus 1/16-inch [1.6mm] for the RFB4-SS and RFB2-SS Series Boxes; and 3-7/16-inch [87mm] plus 13/16-inch [21mm] above the top of the box for the RFB4-CI-1, RFB6, and RFB6-OG Series Boxes; and 4-1/16-inch [103mm] above the top of the RFB4E and RFB4E-OG Series Boxes; and 4-inch [102mm] above the top of the RFB6E and RFB6E-OG Series Boxes. Provide the box with four (4) locations to accommodate leveling for pre-concrete pour adjustment and include four (4) leveling screws for the pre-pour adjustment.
- G. Poke-Through Assemblies:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell.
 - b. Pass & Seymour.
 - c. Thomas & Betts Corporation.
 - d. Wiremold
 2. Poke-Thru Assembly
 - a. Floor Fitting
 - 1) The floor fitting shall consist of an insert and an activation cover. Floor fitting shall accommodate power and communications services in a single unit. Floor fitting shall have one ¾" trade size channel for power and one 2" trade size channel for communication cabling. Floor fitting shall consist of intumescent fire stop material to maintain the fire rating of the floor slab and UL Listed with a fire rating of 1, 1½, & 2 hours in an unprotected reinforced concrete floor or a 1 or 2 hour rating in floors employing steel floor units and concrete topping. The floor fitting shall be suitable in concrete floor thicknesses of 2.5" or greater. The insert shall have 12 installation barbs that will hold the poke-thru device in the floor slab without additional fasteners.
 - b. Insert Body
 - 1) The insert body shall allow the devices to be recessed 3.5-inches, or 2.25-inches with the use of 1 ¼" supplied stand-offs. There shall be complete separation of channels allowing for individual separation of power and communications services. There shall be one channel arranged such that communication cables can be conduit protected and connected with a 2-inch trade size openings to accept both rigid and flexible conduit connectors. The inserts shall consist of multiple compartments that allow for up to 2 duplex receptacles that can be wired in configurations including standard receptacles, isolated ground or up to 12 communication ports.

- c. Activation Cover/ Flange Assembly
 - 1) Activation covers and Flange shall be manufactured of die-cast aluminum alloy and be capable of being plated in brushed brass, satin nickel, and bronze finish, lacquer coated brushed aluminum or powder-coated in , black, finishes. Flange shall be suitable for either carpet, tile, terrazzo and wood covered floors. Flange shall include a gasket adhered to the top inside surface to maintain scrub water tightness with sub plates. Flange shall include a gasket for assembly against the floor to maintain scrub water tightness. Cover assembly shall provide a single hinged access doors that rotate 180 degrees flush with flange and incorporate foam gaskets to maintain scrub water tightness by preventing water, dirt, and debris from entering the power and communication compartment. Cover assembly shall feature cable access doors which secure to the underside of the closed cover that allow each cable access door to be opened and closed independently
- d. Communication Modules Mounting Accessories
 - 1) The poke-through manufacture shall have available modular inserts to facilitate mounting UTP (including Category 5, 5e, 6, 6a), STP, fiber optic, coaxial, and data/communications devices. The S1R6 series shall accommodate Extron MAAP or Extron AAP adapter plates. Where indicated provide connectivity outlets and modular inserts by Hubbell or approved equal.

H. Cleaning and Protection

- 1. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer.
- 2. Protect boxes and fittings until acceptance.

2.7 WIRING DEVICES

A. Receptacles: Receptacles shall be flush mounted. All standard 20 ampere devices to be of same manufacturer.

- 1. Acceptable Manufacturers:
 - a. 20 ampere duplex grounding type NEMA 5-20R,
 - 1) Cooper 5362-V,
 - 2) Hubbell 5362I,
 - 3) Pass and Seymour 53621,
 - 4) Leviton 5362-I
 - 5) Or equal
 - b. 30 ampere, 250 volt NEMA 14-30R complete with plate,
 - 1) Cooper 1257,
 - 2) Hubbell 9350,
 - 3) Pass and Seymour 3853
 - 4) GE 1439-3
 - 5) Or equal

B. Switches: 20 ampere,

- 1. Cooper CWD 2221,
- 2. Hubbell 1221,
- 3. Pass and Seymour 20AC-2,
- 4. Leviton 1221.
- 5. GE 5951,
- 6. Or equal
- 7. Prewired devices with pigtails acceptable

- C. Composition material of wiring devices to be nylon with ivory finish. Outlets intended for computer use shall be grey finish.
- D. Coverplates: Painted steel with ivory finish.
 - 1. Provide gaskets on all wiring device plates where devices are on walls separating conditioned and non-conditioned spaces and exterior walls.
- E. Exterior Outlets with Lockable Covers:
 - 1. Provide exterior outlets with lockable covers at all exterior outlet locations. Provide GFCI Circuit Breakers on all branch circuits. Provide in-use weatherproof locking covers.
- F. Cord Reels:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell.
 - b. KH Industries.
 - 2. Industrial grade retractable power cord reel with the following features:
 - a. All steel construction, including mounting base
 - b. 12 position adjustable guide arm
 - c. Adjustable ratchet can be engaged (positive lock) or disengaged (constant tension) as needed
 - d. Adjustable ball stop
 - e. 6' Feeder Cord included
 - f. White powder-coat finish
 - g. Universal mounting overhead, wall or detached from bracket completely.
 - h. Adjustable cable stop.
 - i. Voltage 125 VAC
 - j. Slip Ring Rating 600V/30A
 - k. Payout End Blk Duplex/Duplex Outlet Box
 - l. Feeder End 5-20P
 - m. Max. Amperage 20 Amps
 - n. Gauge/Conductor 12/3
 - o. Cord Length 25 Feet
 - p. Cord Reel Series RTB NEMA 2
 - q. Cord Type/Color SEOW/White Cord Reel
 - r. Color White
 - s. KH industries Model#RTBB3LW-1DD520-H12F or equal.
 - 3. Cord Reels in CTC/double height spaces and labeled with "HD".
 - a. Reel manufacturer/catalog # Hubbell HBL45123C20
 - b. Industrial reel type with HBL 5369C Straight Blade Connector
 - c. 45 foot cable length
 - d. 125V AC
 - e. 20 Ampere
 - f. UL 355/CSA C22.2 No. 21
 - g. Commercial/Industrial Classification
 - h. All steel construction, 300 Volt rating with SJ cord and can be ceiling or bench mount
 - i. Supplied with 5 ft. power supply cord with ItBL 5366 C, 20A straight blade plug
 - j. Weight 28.3 lbs.

2.8 LIGHTING FIXTURES

A. General

1. Submit the following in accordance with project submittal procedures:
 - a. Catalog Data: Submit catalog data describing luminaires, lamps, and ballasts. Include data substantiating that materials comply with specified requirements. Arrange data for luminaires in the order of fixture designation.
 - b. Performance Curves/Data:
 - 1) Submit certified photometric data for each type of luminaire.
 - 2) Submit supply-air, return-air, heat-removal, and sound performance data for air handling luminaires.
 - c. Drawings: Submit shop drawings for non-standard luminaires.
 - d. Calculations: Submit as requested to support equal product proposals.
 - e. Warranty: Submit warranties for luminaires and for electronic ballasts.
2. All lamps, ballasts, led sources, drivers, and controls shall meet the latest utility company incentive requirements. Refer to the latest program requirements documentation and coordinate with the utility company to ensure compliance.

B. Quality Assurance

1. Comply with the National Electrical Code (NEC) and the Massachusetts Building Code (MBC) for components and installation.
2. Provide luminaires listed and labeled by a nationally recognized testing laboratory (NRTL) for the application, installation condition, and the environments in which installed.
3. Use manufacturers that are experienced in manufacturing luminaires, lamps and ballasts similar to those indicated for this Project and have a record of successful in-service performance.
4. Coordinate luminaires, mounting hardware and trim with the ceiling system.

C. Lamps

1. Furnish lamps that comply with requirements specified below and the luminaire schedule on the Drawings.

D. LED Assemblies

1. LED luminaires shall conform to UL 1598 and to UL 8250 – Safety Standard for Light-Emitting Diode (LED) Light Sources for Use in Lighting Products.
2. Products shall be lead and mercury free.
3. Photometric characteristics shall be established using IESNA LM-79-08, IESNA Approved Method for the Electrical and Photometric Measurement of Solid-State Lighting Products.
4. Color characteristics of LED luminaires shall be as follows in accordance with ANSI C78.377 – Specifications for the Chromaticity of Solid State Lighting Products.
5. LED and driver cooling system shall be passive and shall resist the buildup of debris.
6. LED luminaire output after 50,000 hours of operation shall be not less than 70 percent of the initial lumen output when determined in accordance with IESNA LM-80-08 – IESNA approved Method for Measuring Lumen Maintenance of LED Lighting Sources.
7. LED source package electrical characteristics:
 - a. Supply voltage: 120 V, 208 V, 240 V, 277 V, or 480 V as indicated on the Drawings. Provide step-down transformers if required to match driver input voltage rating.
 - b. Total harmonic distortion (current): Not more than 10 percent
 - c. Power factor: Not less than 90 percent
 - d. RF interference: Meet FCC 47 CFR Part 15/18
 - e. Transient protection: IEEE C62.41 Class A.

8. All LED Assemblies shall be provided by Osram, Phillips, GE, or equal.
- E. Extra Materials
1. Furnish the following extra materials matching products installed. Package with protective covering for storage and identify with labels describing contents.
 - a. Five percent of quantity of LED source packages of each type, but no fewer than two of each type.
 - b. One percent of quantity of louvers and lenses of each type, but not less than two of each type.
 - c. Five percent of quantity of LED drivers of each type, but not less than two of each type.
 - d. Ten percent of single faced exit signs, but no fewer than ten. Include 100' of type MC cable branch circuiting and installation labor.
 - e. Ten percent of double faced exit signs, but no fewer than five. Include 100' of type MC cable branch circuiting and installation labor.
- F. Interior General:
1. Furnish interior luminaries that comply with requirements specified below, indicated on the Drawings to meet conditions of installation.
 2. Metal parts shall be free from burrs and sharp corners and edges.
 3. Metal components shall be formed and supported to prevent sagging and warping.
 4. Steel parts shall be finished with manufacturer's standard finish applied over a corrosion-resistant primer. Finish shall be free from runs, streaks, stains, holidays or defects.
 5. Doors and frames shall be smooth operating and free from light leakage under operating conditions. Relamping shall be possible without the use of tools. Doors, frames, lenses and diffusers shall be designed to prevent accidental falling during relamping and when secured in the operating position.
 6. Luminaires shall have minimum reflecting surface reflectance as follows unless specified otherwise on the Drawings:
 - a. White Surfaces: 85 percent
 - b. Specular Surfaces: 83 percent
 - c. Diffusing Specular Surfaces: 75 percent
 7. Lenses, diffusers, covers and globes shall be 100 percent virgin acrylic unless specified otherwise on the Drawings. Lenses shall have 0.125 inch minimum thickness. Lenses for troffers shall be injection molded.
 8. Luminaires shall conform to UL 1598 - *Luminaires*. Provide product with damp location listing or wet location listing by installation location.
- G. Interior Accessories
1. Provide stud supports, mounting brackets, frames, plaster rings and other accessories required for luminaire installation.
 2. Furnish hangers as specified below by conditions of installation:
 - a. Stem hangers shall be made of 1/2-inch steel tubing with 45 degrees swivel ball hanger fitting and ceiling canopy. Finish the same as the luminaire.
 - b. Rod hangers shall be made of 1/4 inch threaded zinc-plated steel rod.
 3. Use NRTL-listed T-bar safety clips for lay-in luminaires.
- H. Interior Installation
1. Install interior lighting system in accordance with the NEC, manufacturer's installation instructions, approved shop drawings, and NECA National Electrical Installation Standards.
 2. Have the manufacturer's installation instructions available at the Project site.
 3. Mounting heights specified or indicated on the Drawings are to the bottom of the luminaire for ceiling-mounted fixtures and to the center of the luminaire for wall-mounted fixtures.

4. Where the ceiling forms the protective membrane of a fire resistive assembly, install protective coverings over luminaires in accordance with NRTL requirements.
 5. Install slack safety wires as described below for luminaires in or on suspended ceilings.
 - a. Wire shall be minimum 12 gage galvanized soft annealed steel wire conforming to ASTM A641.
 - b. Attach wire to the building structure directly above the attachment point on the box or luminaire; make trapezes of framing channel material to span obstacles
 - c. Secure wire(s) at each end with not less than three tight turns in 1-1/2 inch.
 6. Support pendant-mounted or cable-supported luminaires directly from the structure above using a 9 gage wire or an approved alternate support without using the ceiling suspension system for direct support.
 - a. Install seismic restraints for pendant-mounted and cable-supported luminaires.
 - b. Pendants, rods, cables, or chains 4 ft or longer shall be braced to prevent swaying using three cables at 120 degrees separation.
 7. Connect luminaires in suspended ceilings using 6 ft. lengths of flexible wiring method arranged accommodate not less than 4 inch of differential seismic movement in any direction.
- I. Interior Quality Control
1. Make electrical connections, clean interiors and exteriors of luminaires, install lamps, energize and test luminaires, inspect interior lighting system, and deliver spare parts in accordance with manufacturer's instructions and NECA National Electrical Installation Standards:
 2. Test electronic dimming ballasts for full range dimming capability.
 - a. Check for visually detectable flicker over the full dimming range.
 3. Prior to turnover to Owner, replace lamps that were installed and used during construction if more than 15 percent of their rated lamp life has been used.
- J. Exterior - General
1. Furnish exterior luminaires that comply with requirements specified in this Section and in the luminaire schedule on the Drawings.
 2. Luminaire photometric characteristics shall be based on IESNA approved methods for photometric measurements performed by a recognized photometric laboratory.
 3. Luminaire housing shall be primarily metal.
 - a. Metal parts shall be free from burrs and sharp corners and edges.
 - b. Sheet metal components shall be fabricated from corrosion-resistant aluminum, formed and supported to prevent sagging and warping.
 - c. Exposed fasteners shall be stainless steel.
 4. Doors and frames shall be smooth operating and free from light leakage under operating conditions.
 - a. Relamping shall be possible without the use of special tools.
 - b. Doors, frames, lenses and diffusers shall be designed to prevent accidental falling during relamping and when secured in the operating position.
 - c. Door shall be removable for cleaning or replacing lens.
 5. Luminaires shall have minimum reflecting surface reflectance as follows unless scheduled otherwise:
 - a. White surfaces: 85 percent
 - b. Specular surfaces: 83 percent
 - c. Diffusing specular surfaces: 75 percent
 6. Provide lenses, diffusers, covers and globes as scheduled on the Drawings fabricated from materials that are UV stabilized to be resistant to yellowing and other changes due to aging or exposure to heat and ultraviolet radiation.
 7. Doors shall have resilient gaskets that are heat-resistant and aging-resistant to seal and cushion lens and refractor.

- K. Exterior Poles and Accessories
1. Furnish poles and accessories that comply with requirements specified in this Section and the luminaire schedule on the Drawings.
 2. Pole, base, and anchorage shall carry the luminaires, supports, and appurtenances at the indicated height above grade without deflection or whipping.
 3. Mountings, fastenings and other appurtenances shall be fabricated from corrosion-resistant materials that are compatible with poles and luminaires and will not cause galvanic action at contact points. Mountings shall correctly position luminaires to provide scheduled light distribution.
 4. A reinforced access handhole shall be located in the wall of each metal pole.
 5. A welded 1/2 inch grounding lug shall be accessible through the handhole of each metal pole. Grounding connection shall be designed to prevent electrolysis when used with copper ground wire.
 6. Metal poles shall have anchor type bases and galvanized steel anchor bolts and leveling nuts.
 7. Metal poles shall have a metal base cover that covers the entire base plate and anchorage.
 8. Protect painted, anodized, or brushed pole finishes during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape, and shipping small parts in boxes.
 9. Aluminum poles shall be fabricated from corrosion resistant aluminum Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys or Alloy 356-T4 for cast alloys.
 - a. Poles shall be square or round, tapered or straight as indicated on the Drawings.
 - b. Aluminum poles over 30 feet tall shall include factory-installed vibration dampers.
 - c. Poles shall be seamless extruded or spun seamless type with minimum 0.188 inch wall thickness.
 - d. Tops of shafts shall be fitted with a round or tapered cover.
 - e. Base shall be anchor bolt mounted, made of cast 356-T6 aluminum alloy in accordance with ASTM B 108/B 108M, Standard Specification for Aluminum-Alloy Permanent Mold Castings and shall be machined to receive the lower end of shaft. Joint between shaft and base shall be welded.
 - f. Hardware, except anchor bolts, shall be either 2024-T4 anodized aluminum alloy or stainless steel.
 10. Anchor bolts shall be steel rod having minimum yield strength of 50,000 psi. The top 12 inch of the anchor bolt shall be galvanized in accordance with ASTM A153/A153M.
 11. Manufacturers: Subject to compliance with requirements, provide products as scheduled or specified on the Drawings.
 12. Fuses and Fuse holders
 - a. Furnish fuse overcurrent protection for each pole-mounted luminaire to isolate faulted ballasts from the lighting circuit.
 - b. Use 600 volt, Class CC, time-delay, current-limiting fuses.
 - c. Select fuses rated between 200 percent and 300 percent of the luminaire ballast or driver maximum current.
 - d. Manufacturer: Bussman, Cooper, Littlefuse, or equal.
- L. Exterior Installation
1. Install products in accordance with manufacturer's instructions, NECA/IESNA 501, and approved shop drawings.
 2. Locations of luminaires and poles shown on the Drawings are diagrammatic. Coordinate luminaire locations with building finishes, building structure, paving and striping, utility piping, security fences, and existing trees. Obtain approval for location changes through LANL Subcontract Technical Representative (STR).
 3. Set poles and luminaires plumb, square, level and secure.

4. Install surface mounted luminaires directly to an outlet box which is supported from structure.
5. Install in-grade luminaires flush with surrounding surface. Coordinate pitch or grading of surface with General Contractor to allow drainage away from fixture.
6. Install lamps in luminaires in accordance with manufacturer's instructions.
7. Concrete Foundations:
 - a. Construct concrete foundations with exterior 4000 psi concrete and reinforcing conforming to Section 033000 – CAST-IN-PLACE CONCRETE – SITE WORK.
 - b. Comply with details on the Drawings and manufacturer's recommendations for foundation dimensions, reinforcing, anchor bolts, nuts and washers.
 - c. Position power conduits and ground rod to terminate within the pole shaft area and 1 inch above the top of the foundation.
 - d. Cure concrete foundations for 7 full curing days before erecting poles.
8. Pole Erection
 - a. Do not install poles without luminaires.
 - b. Use fabric web slings to raise and set poles.
 - c. Use leveling nuts or shims to make poles plumb. When leveling nuts are used, set the lower nuts not more than 1 inch from the concrete foundation.
 - d. Tighten anchor bolt nuts and other pole hardware to torque recommended by manufacturer.
 - e. After pole is leveled, pack non-shrink grout between anchor base and concrete foundation to provide a full bearing surface. Use a short piece of 1/2-inch diameter pipe to make a drain hole through grout; arrange to drain condensation from interior of pole.
 - f. Set embedded poles to depth indicated on the Drawings, but not less than 1/6 of pole length below finish grade.
 - g. Auger holes large enough to permit the use of tampers the full depth of the hole.
 - h. Backfill in 6 inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of the undisturbed earth.

2.9 ELECTRICAL POWER EQUIPMENT

- A. Motor Controls - Manual and Solid State:
1. Individually mounted starters shall be NEMA rated solid state type with thermal overload on each reduced voltage start.
 2. Motor Starters shall be furnished by Electrical Sub-Contractor unless part of package mechanical equipment such as rooftop units. Refer to equipment schedules on Electrical Plans and provide accordingly.
 3. The solid state motor controller shall use silicon controlled rectifiers (SCR's) to control the voltage to the motor windings. Two SCR's shall be used in a back-to-back arrangement in each phase to allow alternating current to pass to the motor. When SCR triggering is delayed, the voltage to the load shall be reduced. This phase-controlled operation provides soft starting with stepless acceleration. Once the motor is running, voltage reduction can improve the motor's operating point at partial load, saving energy and lowering the reactive current. If one or more shorted SCRs are detected, the starter shall not energize. A fault LED will light and if provided with a shunt trip, the main circuit breaker will trip. Provide pump stop option to eliminate water hammer in pumping systems, by giving a controlled decel to the motor voltage. This process shall allow for smooth pressure reduction and quiet check valve operation. The controller shall trip off the line if one or more phases is lost.

4. Starters shall be of size and type required for particular motor horsepower and voltage. Minimum size starter to be size 1 FVNR, unless noted otherwise.
 - a. Starters shall have OL reset button, green push-to-test type pilot light to indicate "ON", and "HAND-OFF-AUTO" switch in cover.
 - b. Starters to have 120 volt control transformers with fused output being provided for those units operating on 277/480 volt system.
 - c. Provide Class 20 fixed heater overloads with auto/manual reset.
 - d. Provide four sets of auxiliary contacts of convertible type N.O. to N.C. for each starter.
 - e. Motor starters shall have NEMA I enclosures. Those in wet locations shall be NEMA 3R.
 - f. Acceptable Manufacturers:
 - 1) Westinghouse/Culter-Hammer
 - 2) Square D/Groupe Schneider
 - 3) Siemens
 - 4) Allen Bradley
 - 5) General Electric
 - 6) Or equal
 5. Manual motor starters shall have pilot lights and shall be furnished with thermal overloads on each phase.
- B. Motors: Each motor shall have disconnect switch and starter provided under this section.
1. Provide motor terminal boxes for each motor not furnished with same.
- C. Disconnect Switches:
1. Disconnect (safety) switches shall conform to industrial standards of NEMA, be UL listed and shall be heavy duty type, quick-make, quick-break type with interlocking cover mechanism and provisions for padlocking switch handle in "OFF" position. Three pole toggle switches are not acceptable as substitute for disconnect switches.
 2. Disconnect switches shall be of fused or unfused type as indicated with number of disconnecting poles indicated. The grounded conductor shall not be switched. Switches for use with current limiting fuses shall be rejection type and those used in conjunction with motors shall be horsepower rated. Provide oversize termination lugs if required by conductor size.
 3. Enclosures shall be of proper NEMA type for intended location and shall be phosphate coated or equivalent code gauge galvanized sheet steel with ANSI #24 dark gray baked enamel finish.
 4. Acceptable Manufacturers:
 - a. Culter-Hammer/Westinghouse
 - b. Square D/Groupe Schneider
 - c. Siemens
 - d. Allen Bradley
 - e. General Electric
 - f. Or equal
- D. Fuses:
1. Provide a complete set of fuses for each item of fusible type equipment.
 2. Turn over to authorized representative of Owner upon completion a spare set of fuses of each different type and ampere rating installed. These spares shall be bound with twine and tagged.
 3. Secondary system fuses, rated at 600 volts or less, shall be UL listed and constructed in conformance with the applicable standards set forth by NEMA and ANSI. All fuses of a particular class shall be of same manufacturer.
 4. All fuses in distribution panelboards and switchboards shall be class "L" above 600 amperes and class "RK1" for 600 amperes and below.

5. Main, Feeder, and Branch Circuits:
 - a. Circuits 601 amperes and above shall be protected by (Bussmann type KRP-C LOW-PEAK) current limiting time delay fuses.
 - b. Circuits 0-600 amperes shall be protected by (Bussmann "LOW-PEAK" dual element), time delay current limiting fuses, LPN-RK (250 volts), LPS-RK (600 volts), UL class RK-1.
6. Acceptable Manufacturers:
 - a. Bussmann, Division of McGraw
 - b. Gould/Shawmut
 - c. GEC-ALSTHOM
 - d. Or equal

2.10 ELECTRICAL SYSTEM CONTROLS AND INSTRUMENTS

- A. Provide a complete power system consisting of branch circuits, motor disconnect switches, pushbutton stations, motor starters, and other devices to connect up and leave in operating condition each piece of electrically operated equipment provided either under this section or other Divisions.
- B. All control wiring, not indicated in the electrical specifications or not shown on electrical drawings, will be provided by Temperature Control Subcontractor.

2.11 GROUNDING SYSTEM

- A. All equipment and systems shall be grounded. Refer especially to NEC Section 250 Requiring Connections to Building Steel, Foundation, Water Service, and Interior Piping. Provide transformer pad grounding in accordance with utility company standards.
- B. The grounded conductor shall be supplemented by an equipment grounding system.
- C. The equipment grounding system shall be installed so all conductive items in close proximity to electrical circuits operate continuously at ground potential and provide a low impedance path for ground fault currents.
- D. Grounding conductors shall be so installed as to permit shortest and most direct path to ground.
- E. Maximum measured resistance to ground of 5.0 ohms shall not be exceeded. Ground separately derived systems (dry type transformers) in accordance with Article 250-30 by grounding neutral to transformer ground lug and providing insulated grounding electrode conductor to nearest effectively grounded building steel or, if unavailable, to nearest available effectively grounded metal water pipe.
- F. Equipment grounding conductors and straps shall be sized in compliance with Code Table 250-122.
- G. Grounding conductors shall be insulated with green color. Grounding conductors for use on isolated ground receptacles shall be green with trace color to differentiate between normal ground conductors.

- H. Branch circuits shall consist of phase and grounded conductor installed in common metallic raceway. All receptacle circuits shall have dedicated neutrals. All circuits shall have a separate insulated grounding conductor installed. Any flexible cable system or non-metallic raceway system shall have an insulated grounding conductor. Any cable system for use on isolated ground circuits shall have both an isolated ground conductor as well as an equipment ground conductor, both of which shall be insulated.
- I. Each electrical expansion fitting shall be furnished with a bonding jumper. Provide grounding bushings and ground connections for all raceways terminating below equipment where there is no metal-to-metal continuity.
- J. Continuity between all metallic and nonmetallic raceway systems and equipment shall be maintained.
- K. Outdoor lighting fixtures shall be grounded and bonded in common with building system via a separate grounding conductor.
- L. Refer to Technology Specifications for additional grounding requirements.

2.12 MAIN BUILDING SWITCHBOARD

- A. Main building switchboard shall be constructed in accordance with UL 891 and ANSI standards and of the required number of vertical sections bolted together to form one metal enclosed rigid structure. The sides, top, and rear shall be covered with removable plates. Switchboard shall include all protective services and equipment as listed on drawings with necessary interconnections, instrumentation, and control wiring. Buses shall be copper. Provide oversize termination lugs for any terminations requiring same due to conductor sizing.
- B. Record drawings shall be furnished with the following: Complete rating, short-circuit withstandability of bus and of lowest rated device, overall outline dimensions, including space available for raceways, circuit schedule showing circuit number, device description, device fuse clip ampere rating, conductor ratings and one-line diagram with each circuit device numbered.
- C. Each section shall be 90 in. high, self-supported, and same depth as incoming line section, approximately 30 in. deep. Main protective device shall be individually mounted with front coverplate and bus connection straps. Where called for on schedule, "space" shall mean to include necessary bus, supports, and connections, leaving out only the breaker itself. Bus structure shall be arranged to permit future additions.
- D. Switchboard shall be arranged for operation as follows:
 - 1. Voltage - 480Y/277 volts
 - 2. Frequency - 60 cycles
 - 3. Service - 3 phase, 4 wire, ampere capacity as indicated on drawings.
 - 4. Neutral - full capacity
 - 5. Available short circuit current at line terminals - 65,000 RMS amperes symmetrical.
 - 6. Integrated equipment rating - 65,000 AIC
 - 7. Copper ground bus, full length
 - 8. UL service entrance label

- E. The main shall have solid-state trip device (100 percent rated) with the following features:
 - 1. Adjustable ampere setting between 50-100 percent rating
 - 2. Adjustable long time delay
 - 3. Adjustable short time pickup
 - 4. Adjustable short time delay
 - 5. Fixed instantaneous at 15 times rating
 - 6. Adjustable ground fault pickup
 - 7. Adjustable ground fault delay
- F. Provide electrical metering and voltage protection system equal to Square D Power Logic, Westinghouse IQ Data Plus or Siemens 4700 Series at main breaker.
- G. Branch Devices shall be standard molded case circuit breakers, current limiting circuit breakers, or other devices as scheduled. Branch devices shall be mounted in panelboard type construction.
- H. Include space and provisions for metering. Refer to electric service section of this Division.
- I. Acceptable Manufacturers:
 - 1. Cutler-Hammer/Westinghouse
 - 2. Square D/Groupe Schneider
 - 3. Siemens
 - 4. General Electric
 - 5. Or equal

2.13 PANELBOARDS

- A. Panelboards shall be dead-front, door in door safety type equipped with single or multi-pole circuit breakers suitable for 120/208 volt or 277/480 volt, 3 phase, 4 wire operation.
- B. Buses shall be copper. Panelboards shall have a circuit directory card mounted in a frame with plastic cover on inside of door. Panelboards to have a copper ground bus with terminals for each circuit. Panelboards serving isolated ground receptacles shall have a separate ground bus for terminations of the isolated grounds. The isolated ground bus shall be mounted to the panel tub via non-conducting means with a separate grounding conductor run to the normal panel ground bus. Provide oversize lugs for any termination requiring same due to oversize conductors. Provide 200 to neutral buses on all 120/208 volt panelboards.
- C. Cabinets shall be minimum of 20 inch wide and be made of code gauge steel. Surface type shall be ordered without knockouts.
- D. Trims shall be made of code gauge steel, surface or flush as indicated. Panelboards shall be keyed alike. Trims shall be provided with full length piano hinge on one side, and secured to tub with sufficient quantity of latches opposite the hinge side to allow trim to fit flush with tub and when released, allow full access to wiring gutters. Inner door shall allow access to circuit breakers only.

- E. Panelboards shall be of the following types with minimum circuit breaker frame sizes listed below. Refer to schedules for larger circuit breaker frame sizes due to fault current availability.
1. 120/208 volt, three phase, four wire. Symmetrical interrupting capacity 10,000 AIC.
Style

Westinghouse type PRL-1	BAB Breakers (bolt-on)
Square D type NQOD	QOB Breakers (bolt-on)
Siemens type CDP-7	BQ Breakers (bolt-on)
General Electric Type AQ	HHQB Breakers (bolt-on)
Or Equal	
 2. 277/480 volt, three phase, four wire. Symmetrical interrupting capacity 65,000 AIC.
Style

Westinghouse type PRL-2	GHB Breakers (bolt-on)
Square D type NEHB	EHB Breakers (bolt-on)
Siemens type CDP-7	BQCH Breakers (bolt-on)
General Electric Type AE	TEY Breakers
Or Equal	
 3. Distribution Panels:
 - a. Where scheduled as circuit breaker type, symmetrical interrupting capacity 65,000 AIC.

Westinghouse type PRL-3	FD Breakers
Square D I-Line type	FA Breakers
Siemens SPP	FXD6 Breakers
General Electrical Spectra	THED Breakers
Or equal	
- F. Panelboards and distribution panels shall be of same manufacturer as switchboard. Refer to drawings where higher interrupting are required.
- G. All power panels fed from K-13 transformers shall have surge protection. Coordination and Arc flash study shall be submitted with shop drawing submittal. All circuit breaker selection shall meet study recommendations and shall be provided as recommended by study.

2.14 DRY-TYPE TRANSFORMERS

A. Transformer Specification:

1. Compatibility: This product must facilitate the ability of the electrical system to supply a sinusoidal voltage in order to improve the long-term compatibility of the electrical system with all types of linear and nonlinear connected loads today and in the future. All national and international standards on harmonics and power quality set limits on levels of voltage distortion to maintain compatibility.
2. Copper-wound, 3-phase, common core, ventilated, dry-type, isolation transformer built to NEMA ST20 and relevant NEMA, UL and IEEE standards; 200 percent rated neutral; 60Hz rated; Transformers 750 kVA and less, 600 volt primary and less, shall be U.L. and CSA Listed and bear the label. All terminals, including those for changing taps, must be readily accessible by removing a front cover plate. Windings shall be continuous with terminations brazed or welded. 10kV BIL.
3. Insulation System:
 - a. Shall be NOMEX-based with an Epoxy Co-polymer impregnant for lowest environmental impact, long term reliability and long life expectancy
 - b. Class: 220 degrees C
 - c. Impregnant Properties for low emissions during manufacturing, highest reliability and life expectancy
 - d. Epoxy co-polymer
 - e. VOC: less than 1.65 lbs/gal (low emissions during manufacturing)
 - f. Water absorption (24hrs @25C): less than 0.05 percent (superior insulation, longer life)
 - g. Chemical Resistance: Must have documented excellent performance rating by supplier
 - h. Dielectric Strength: minimum of 3200 volts/mil dry (for superior stress, overvoltage tolerance)
 - i. Dissipation Factor: max. 0.02 @25C to reduce aging of insulation, extending useful life
4. Operating Temperature Rise: 130 degree C in a 40 degree C maximum ambient
5. Noise levels:
 - a. Per NEMA ST-20
 - b. Production Test every unit. Data to be available upon request.
6. UL Listed and Labeled K-Rating: K-7 or higher
7. Maximum No Load Losses
 - a. Transformers are energized 24 hours a day for their entire life, potentially 40 years or more. These losses are incurred whether the transformer is loaded or not, and cost the user many times the purchase price of the transformer even at current energy rates.
 - b. No load losses shall not exceed: 15kVA: 60W, 30kVA: 99W, 45kVA: 130W, 75kVA: 180W, 112.5kVA: 260W, 150kVA: 330W, 225kVA: 450W, 300kVA: 560W, 500kVA: 850W
8. Efficiency at 35 percent loading
 - a. Data shows that transformers are typically very lightly loaded for extended periods of time, therefore to minimize operating cost under real world loading conditions, efficiency at 1/6 loading shall be maximized.
 - b. Efficiency at 35% load shall meet or exceed: 15kVA: 89 percent, 30kVA: 98.23 percent, 45kVA: 98.40 percent, 75kVA: 98.6 percent, 112.5kVA: 98.74 percent, 150kVA: 98.83 percent, 225kVA: 98.94 percent, 300kVA: 99.02 percent, 500kVA: 99.14 percent, 750kVA: 99.23 percent
9. Voltage Taps: For transformers 30kVA-300kVA, provide two 2-1/2 percent full capacity taps above and below nominal primary voltage. For transformers 15kVA and smaller as well as 500kVA and larger provide one 5 percent full capacity tap above and below nominal primary voltage.
10. Impedance: Between 3.5 percent and 5.8 percent unless otherwise noted.
11. Enclosure type: Ventilated NEMA 2, drip-proof

12. Maximum Footprint for 130 degree C rise model in a NEMA 1 enclosure:
 - a. 17 in. Wide x 17 in. Deep x 27 in. High for 15kVA.
 - b. 26 in. Wide x 18 in. Deep x 30 in. High for 30kVA, 45kVA
 - c. 33 in. Wide x 22 in. Deep x 40 in. High for 75kVA, 112.5kVA
 - d. 38 in. Wide x 28 in. Deep x 52 in. High for 150kVA
 - e. 38 in. Wide x 32 in. Deep x 52 in. High for 225kVA, 300kVA
 - f. 52 in. Wide x 38 in. Deep x 61 in. High for 500kVA
 - g. 63 in. Wide x 46 in. Deep x 67 in. High for 750kVA
 - B. Transformer Features:
 1. Electrostatic Shield for K Rated Transformers: Each winding shall be independently single shielded with a full-width copper electrostatic shield.
 2. All transformers shall meet Department of Energy 2016 efficiency standards.
 - C. Acceptable Manufacturers: Powersmiths International Corp. General Electric, Eaton, Square D, ACME, Jefferson Electric, or equal.
- 2.15 ELECTRIC SERVICE
- A. Coordinate and cooperate with NGRID, hereinafter called utility company, with respect to providing service and metering.
 - B. Provide all primary manholes, primary conductors, primary switch, system raceways, elbows, pull wires, precast foundation pads and all pad grounding. Utility company will provide pad mounted transformers.
 - C. Provide secondary service complete including all conductors, raceways, and connectors at transformer. Provide oversize lugs if required due to conductor sizing. Attachment of secondary conductors to the transformer terminals will be done by utility company.
 - D. General Contractor shall do all excavation and back filling in accordance with utility company standards.
 - E. All work to be done in accordance with utility company standards.
 - F. Metering: All usage will be on one primary meter. Utility Company will furnish current transformers and potential transformers. Meter will be by Utility Company.
- 2.16 FIRE ALARM AND DETECTION SYSTEM (Voice Evacuation Required)
- A. Description:
 1. This section of the specification includes the furnishing, installation, connection and testing of the microprocessor controlled, intelligent reporting fire alarm equipment required to form a complete, operative, coordinated system. It shall include, but not be limited to, alarm initiating devices, alarm notification appliances, Fire Alarm Control Panel (FACP), auxiliary control devices, annunciators, and wiring as shown on the drawings and specified herein.
 2. The fire alarm system shall comply with requirements of latest NFPA Standard 72 for Protected Premises Signaling Systems except as modified and supplemented by this specification. The system shall be electrically supervised and monitor the integrity of all conductors.

3. The fire alarm manufacturer shall be of the highest caliber and insist on the highest quality. The system shall be manufactured by an ISO 9001 certified company and meet the requirements of BS EN9001: ANSI/ASQC Q9001-1994.
 4. The FACP and peripheral devices shall be manufactured 100 percent by a single U.S. manufacturer (or division thereof).
 5. The system and its components shall be Underwriters Laboratories, Inc. listed under the appropriate UL testing standard as listed herein for fire alarm applications and shall be in compliance with the UL listing.
 6. Each designated zone shall transmit separate and different alarm, supervisory and trouble signals to the Fire Command Center (FCC) and designated personnel in other buildings at the site via a multiplex communication
 7. The installing company shall employ NICET (minimum Level II Fire Alarm Technology) technicians on site to guide the final check-out and to ensure the systems integrity.
- B. Scope:
1. An intelligent reporting, microprocessor controlled fire detection and system shall be installed in accordance with the specifications and drawings.
 2. Basic Performance:
 - a. Alarm, trouble and supervisory signals from all intelligent reporting devices shall be encoded onto NFPA Style 7 (Class A) Signaling Line Circuits (SLC).
 - b. Initiation Device Circuits (IDC) shall be wired Class A (NFPA Style D).
 - c. Notification Appliance Circuits (NAC) shall be wired Class A (NFPA Style Z).
 - d. Digitized electronic signals shall employ check digits or multiple polling.
 - e. Power for initiating devices and notification appliances must be from the main fire alarm control panel, the transponder to which they are connected or to a Field Charging Power Supply (FCPS).
 - f. A single ground or open on any system signaling line circuit, initiating device circuit, or notification appliance circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.
 - g. Alarm signals arriving at the main FACP shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
 3. Basic System Functional Operation: When a fire alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:
 - a. The FACP alarm LED on the FACP shall flash.
 - b. A local piezo-electric signal in the FACP control panel shall sound.
 - c. The 80-character LCD display on the local FACP node and on the intelligent network display shall indicate all information associated with the fire alarm condition, including the type of alarm point, and its location within the protected premises. This information shall also be displayed on the network reporting terminal.
 - d. Printing and history storage equipment shall log the information associated with the fire alarm control panel condition, along with the time and date of occurrence.
 - e. All system output programs assigned via control-by-event interlock programming to be activated by the particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated on either local outputs or points located on other network nodes.

4. Software Modifications:
 - a. Provide the services of a factory trained and authorized technician to perform all system software modifications, upgrades or changes. Response time of the technician to the site shall not exceed 4 hours.
 - b. Provide all hardware, software, programming tools and documentation necessary to modify the fire alarm network on site. Modification includes addition and deletion of devices, circuits, zones and changes to system operation and custom label changes for devices or zones. The system structure and software shall place no limit on the type or extent of software modifications on-site. Modification of software shall not require power-down of the system or loss of system fire protection while modifications are being made.
5. Certifications:
 - a. Together with the shop drawing submittal, submit a certification from the major equipment manufacturer indicating that the proposed supervisor of installation and the proposed performer of contract maintenance is an authorized representative of the major equipment manufacturer and trained on network applications. Include names and addresses in the certification.
6. Any system that is proprietary and does not allow multiple fire alarm service vendors to work on/service the system will be prohibited on this project.

C. Applicable Publications:

The publications listed below form a part of this specification. The publications are referenced in text by the basic designation only.

1. National Fire Protection Association (NFPA) - USA:
 - a. No. 72 National Fire Alarm Code
 - b. No. 70 National Electric Code
 - c. No. 101 Life Safety Code
2. Underwriters Laboratories Inc. (UL) - USA:
 - a. No. 50 Cabinets and Boxes
 - b. No. 268 Smoke Detectors for Fire Protective Signaling System
 - c. No. 864 Control Units for Fire Protective Signaling Systems
 - d. No. 268A Smoke Detectors for Duct Applications
 - e. No. 521 Heat Detectors for Fire Protective Signaling Systems
 - f. No. 228 Door Closers-Holders for Fire Protective Signaling Systems
 - g. No. 464 Audible Signaling Appliances
 - h. No. 38 Manually Actuated Signaling Boxes
 - i. No. 346 Waterflow Indicators for Fire Protective Signaling Systems
 - j. No. 1481 Power supplies for Fire Protective Signaling Systems
 - k. No. 1076 Control Units for Burglar Alarm Proprietary Protective Signaling Systems
 - l. No. 1971 Visual Notification Appliances
3. Local and State Building Codes.
4. All requirements of the Authority Having Jurisdiction (AHJ).
5. State of New Hampshire Fire Code.

- D. Approvals:
1. The system must have proper listing and/or approval from the following nationally recognized agencies:
 - a. UL Underwriters Laboratories Inc.
 - b. FM Factory Mutual
 - c. MEA Material Equipment Acceptance (NYC)
 - d. CSFM California State Fire Marshal
 2. The fire alarm control panel, shall meet the modular labeling requirements of Underwriters Laboratories, Inc. Each subassembly, including all printed circuits, shall include the appropriate UL modular label. Systems which do not include modular labels which may require return to the manufacturer for system upgrades, and are not acceptable.
- E. Equipment and Material - General:
1. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a protected premises protective signaling (fire alarm) system. The authorized representative of the manufacturer of the major equipment, such as control panels, shall be responsible for the satisfactory installation of the complete system.
 2. All equipment and components shall be installed in strict compliance with each manufacturer's recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes. before beginning system installation. Refer to the riser/connection diagram for all specific system installation/termination/wiring data.
 3. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place. (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.
 4. All fire alarm equipment that requires kegs shall be keyed alike.
- F. Conduit and Wire:
1. Conduit:
 - a. Conduit shall be in accordance with the National Electrical Code (NEC), local and state requirements.
 - b. All wiring shall be installed in conduit or raceway. Conduit fill shall not exceed 40 percent of interior cross sectional area where three or more cables are contained within a single conduit.
 - c. Cable must be separated from any open conductors of power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, per NEC Article 760-29.
 - d. Wiring for 24 volt control, alarm notification, emergency communication and similar power-limited auxiliary functions may be run in the same conduit as initiating and signaling line circuits. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.
 - e. Conduit shall not enter any FACP, or any other remotely mounted control panel equipment or backboxes, except where conduit entry is specified by the FACP manufacturer.
 - f. Conduit shall be 3/4 inch (19.1 mm) minimum.

2. Wire:
 - a. All fire alarm system wiring must be new, unless specified herein.
 - b. Wiring shall be in accordance with local, state and national codes (e.g., NEC Article 760) and as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 16 AWG (1.02 mm) for initiating device circuits and signaling line circuits, and 14 AWG (1.32 mm) for notification appliance circuits.
 - c. All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.
 - d. Wiring used for the SLC multiplex communication loop shall be twisted and shielded unless specifically excepted by the fire alarm equipment manufacturer.
 - e. All field wiring shall be completely supervised.
 3. Terminal Boxes, Junction Boxes and Cabinets: All boxes and cabinets shall be UL listed for the intended purpose.
 4. Initiating circuits shall be arranged to serve like categories (manual, smoke, waterflow). Mixed category circuitry shall not be permitted except on signaling line circuits connected to intelligent reporting devices.
 5. The FACP shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the main power distribution Panel as FIRE ALARM. Fire alarm control panel primary power wiring shall be 12 AWG. The FACP cabinet shall be grounded securely to either a cold water pipe or grounding rod.
- G. Fire Alarm Control Panel and Fire Command Center:
1. Fire alarm control panel shall be Honeywell, EST3, Notifier, or equal. Panel shall contain a microprocessor based central processing unit (CPU). The FACP shall communicate with and control the following types of equipment used to make up the system: intelligent detectors, addressable modules, transponders, local and remote operator terminals, printers, annunciators, and other system controlled devices.
 2. Node Capacity and General Operation:
 - a. Each node shall provide, or be capable of, expansion to 198 intelligent addressable devices per loop plus 2048 annunciation points per system. FACP shall support a minimum of 10 intelligent loops.
 - b. Each FACP node shall include a full featured operator interface control and annunciation panel which shall include a backlit Liquid Crystal Display (LCD), individual, color coded system status LEDs, and an alpha-numeric keypad for field programming and control of the node.
 - c. All programming or editing of the existing programming the system shall be achieved without special equipment or interrupting the alarm monitoring functions of the fire alarm control panel.
 - d. The system shall include emergency voice communications utilizing distributed amplification and intelligence such that loss of operation by the main FACP will not result in the loss of evacuation signal throughout the balance of the building.
 - e. Each FACP node shall provide the following features:

1) Block Acknowledge	Printer Interface
2) Charger rate Control	CRT Display Interface
3) Control-by-Time	Non-Alarm Module Reporting
4) Day/Night Sensitivity	Periodic Detector Test
5) Device Blink Control	Remote Page
6) Drift Compensation	Trouble Reminder
7) NFPA 72, Sensitivity Test	Upload/Download to PC computer
8) System Status Reports	Verification Counters
9) Security Monitor Points	Walk Test
10) Alarm Verification	Maintenance Alert

3. Loop Interface Board (LIB):
 - a. Loop interface boards shall be provided to monitor and control each of the Signaling Line Circuit (SLC) loops in the network node. The loop interface board shall contain its own microprocessor and shall be capable of operating in local mode in the case of a failure in the main CPU of the control panel. In local mode, the loop interface board shall detect alarms and activate output devices on its own SLC loop.
 - b. The LIB shall not require any jumper cuts or address switch settings to initialize SLC Loop operations.
 - c. The loop interface board shall provide power to, and communicate with, all of the intelligent detectors and addressable modules connected to its SLC Loop over a single pair of wires. This SLC Loop shall be capable of operation as NFPA Style 4, Style 6, or Style 7.
 - d. The LIB shall be able to drive two Style 4 SLC loops, each up to 10,000 feet in length, for an effective loop span of 20,000 feet.
 - e. The loop interface board shall receive analog information from all intelligent detectors and shall process this information to determine whether normal, alarm, or trouble conditions exist for that particular detector. The loop interface board software shall include software to automatically adjust and compensate for dust accumulation to maintain detector performance as it is affected by environmental factors. The analog information may also be used for automatic detector testing and for the automatic determination of detector maintenance requirements.
 - f. The LIB shall communicate with each intelligent addressable detector and addressable module on its SLC loop and verify proper device function and status. Communication with up to 198 intelligent devices shall be performed every 6 seconds or less.
4. Enclosures:
 - a. Control panels shall be housed in UL listed cabinets suitable for semi-flush mounting. Cabinets shall be corrosion protected, given a rust-resistant prime coat, and the manufacturer's standard finish.
 - b. The back box and door shall be constructed of .060 steel with provisions for electrical conduit connections into the sides and top.
 - c. The door shall provide a key lock and include a transparent opening for viewing all indicators. For convenience, the door shall have the ability to be hinged on either the right or left-hand side.
 - d. The control unit shall be modular in structure for ease of installation, maintenance, and future expansion.
5. FACP nodes shall be designed so that it permits continued local operation of remote transponders under both normal and abnormal network communication loop conditions. This shall be obtained by having transponders operate as local control panels upon loss of network communication.
6. FACP nodes shall be modular in construction to allow ease of servicing. Each CPU and transponder shall be capable of being programmed on site without requiring the use of any external programming equipment. Systems, which require use of external programmers or change of EPROMs are not acceptable.
7. The CPU and associated equipment are to be protected so that they will not be affected by voltage surges or line transients including RFI and EMI.

8. FACP Power Supplies:
 - a. Main power supplies shall operate on 120 VAC, 60Hz, and shall provide all necessary power for the FACP.
 - b. Each main supply shall provide 3.0 amps of usable notification appliance power, using a switching 24 VDC regulator.
 - c. The main power supply shall be expandable for additional notification appliance power in 3.0 ampere steps.
 - d. Each main power supply shall provide a battery charger for 60 hours of standby using dual-rate charging techniques for fast battery recharge. It shall charge 55 Amp hour batteries with-in a 48 hour period.
 - e. The supply shall provide a very low frequency sweep earth detect circuit, capable of detecting earth faults on sensitive addressable modules.
 - f. It shall provide meters to indicate battery voltage and charging current.
 - g. The main power supply shall be power-limited per 1995 UL864 requirements.
9. System Circuit Supervision:
 - a. Each FACP node shall supervise all circuits to intelligent devices, transponders, annunciators and peripheral equipment and annunciate loss of communications with these devices. The FACP CPU shall continuously scan the above devices for proper system operation and upon loss of response from a device shall sound an audible trouble, indicate which device or devices are not responding and print the information on the printer.
 - b. Sprinkler system valves, standpipe control valves, PIV, and main gate valves shall be supervised for off-normal position.
10. Field Wiring Terminal Blocks: For ease of service, all wiring terminal blocks shall be the plug-in type and have sufficient capacity for 18 to 12 AWG wire. Fixed terminal blocks are not acceptable.
11. Operators Terminal: Provide the following functions in addition to any other functions required for the system.
 - a. Acknowledge (ACK/STEP) Switch:
 - 1) Activation of the control panel Acknowledge switch in response to a single new Alarm and/or trouble condition shall silence the local panel piezo electric signal and change the system alarm or trouble LED from flashing mode to steady-ON mode. If additional new alarm or trouble conditions exist or are detected and reported in the system, depression of this switch shall advance the 80-character LCD display to the next alarm or trouble condition.
 - 2) Depressing the acknowledge switch shall also silence all remote annunciator piezo sounders.
 - b. Signal Silence Switch: Activation of the signal silence switch shall cause all programmed alarm notification appliances and relays to return to the normal condition after an alarm activation. The selection of notification circuits and relays which are silence able by this switch shall be fully field programmable within the confines of all applicable standards.
 - c. System Reset Switch: Activation of the system reset switch shall cause all local electronically-latched initiating devices, software zones, output devices and circuits, to return to their normal condition.
 - d. If an alarm condition(s) still exists, or if they reoccur in the system after system reset switch activation, the system shall then resound the alarm conditions.

- e. System Test Switch: Activation of the system test switch shall initiate an automatic test of all intelligent/addressable detectors in the local system. The system test shall activate the electronics in each intelligent sensor, simulating an alarm condition and causing the transmission of the alarm condition from that sensor to the fire alarm control panel. The fire alarm control panel shall interpret the data from each sensor installed in the system. A report summarizing the results of this test shall be displayed automatically on the system LCD and on any CRTs or printers in the system.
 - f. Lamp Test Switch: Activation of the lamp test switch shall sequentially turn on all LED indicators, system liquid crystal display and local piezo signal, and then automatically return the fire alarm control panel to the previous condition.
12. Field Programming:
- a. The system shall be programmable, configurable and expandable in the field without the need for special tools or electronic equipment and shall not require field replacement of electronic integrated circuits.
 - b. All local FACP node programming shall be accomplished through the FACP keyboard or through the video display terminal.
 - c. All field defined programs shall be stored in non-volatile memory.
 - d. The programming function shall be enabled with a password that may be defined specifically for the system when it is installed. Two levels of password protection shall be provided in addition to a key-lock cabinet. One level is used for status level changes such as zone disable or manual on/off commands. A second (higher-level) is used for actual change of program information.
13. Specific System Operations:
- a. Smoke Detector Sensitivity Adjust: Means shall be provided for adjusting the sensitivity of any or all analog intelligent detectors in the FACP node from each system keypad or from the keyboard of the video terminal. Sensitivity range shall be within allowed UL limits.
 - b. Alarm Verification: Each of the intelligent addressable detectors in the system may be independently selected and enabled for alarm verification. Each FACP shall keep a count of the number of times each detector has entered the verification cycle. These counters may be displayed and reset by the proper operator commands.
 - c. System Point Operations:
 - 1) All devices in the FACP node may be enabled or disabled through the local keypad or video terminal.
 - 2) Any FACP node output point may be turned on or off from the local system keypad or the video terminal.
 - d. Point Read: The FACP node shall be able to display the following point status diagnostic functions without the need for peripheral equipment. Each point will be annunciated for the parameters listed:
 - 1) Device Status
 - 2) Device Type
 - 3) Custom Device Label
 - 4) Software Zone Label
 - 5) Device Zone Assignments
 - 6) Detector Analog Value
 - 7) All Program Parameters
 - e. System Status Reports: Upon command from a password-authorized operator of the system, a status report will be generated, and printed, listing all local FACP system status.

- f. System History Recording and Reporting: Each FACP node shall contain a history buffer that shall be capable of storing a minimum of 400 system events. Each local activation will be stored and time and date stamped with the actual time of the activation, until an operator requests that the contents be either displayed or printed. The contents of the history buffer may be manually reviewed, one event at a time, and the actual number of activations may also be displayed and or printed.
 - 1) The history buffer shall use non-volatile memory. Systems which use volatile memory for history storage are not acceptable.
 - g. Automatic Detector Maintenance Alert: Each FACP node shall automatically interrogate each intelligent system detector and shall analyze the detector responses over a period of time.
 - 1) If any intelligent detector in the system responds with a reading that is below or above normal limits, then the system will enter the trouble mode, and the particular intelligent detector will be annunciated on the system display, network display and printed on the optional system printer. This feature shall in no way inhibit the receipt of alarm conditions in the system, nor shall it require any special hardware, special tools or computer expertise to perform.
- H. Addressable Devices – General:
- 1. Addressable devices shall use simple to install and maintain decade (numbered 1 to 10) type address switches.
 - 2. Addressable devices which use a binary address setting method, such as a Dip switch, are difficult to install and subject to installation error. This type of device is not an allowable substitute.
 - 3. Detectors shall be intelligent (analog) and addressable, and shall connect with two wires to the FACP signaling line circuit.
 - 4. Addressable smoke and thermal detectors shall provide dual alarm and power/polling LEDs. Both LEDs shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel, and both LEDs shall be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. If required, the LED flash shall have the ability to be removed from the system program. An output connection shall also be provided in the base to connect an external remote alarm LED.
 - 5. Smoke detector sensitivity shall be set in the fire alarm control panel and shall be adjustable in the field through the field programming of the system. Sensitivity may be automatically adjusted by the panel on a time-of-day basis.
 - 6. Using software in the FACP, detectors shall automatically compensate for dust accumulation and other slow environmental changes that may affect their performance. The detectors shall be listed by UL as meeting the calibrated sensitivity test requirements of NFPA Standard 72, Chapter 7.
 - 7. The detectors shall be ceiling-mount and shall include a separate twist-lock base with tamper proof feature. Base shall include a sounder base with a built-in (local) sounder rated at 85 DBA minimum, a relay base and an isolator base designed for Class A applications.
 - 8. The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel.
 - 9. Detectors shall also store an internal identifying type code that the control panel shall use to identify the type of device (ION, PHOTO, THERMAL).

10. Detectors will operate in an analog fashion, where the detector simply measures its designed environment variable and transmits an analog value to the FACP based on real-time measured values. The FACP software, not the detector, shall make the alarm/normal decision, thereby allowing the sensitivity of each detector to be set in the FACP program and allowing the system operator to view the current analog value of each detector.
 11. A magnetic test switch shall be provided to test each detector for 100 percent obscuration, reported to the FACP.
 12. Addressable devices shall provide address-setting means using decimal switches and shall also store an internal identifying code that the control panel shall use to identify the type of device. LED(s) shall be provided that shall flash under normal conditions, indicating that the device is operational and is in regular communication with the control panel.
 13. A magnetic test switch shall be provided to test detectors and modules. Detectors shall report an indication of an analog value reaching 100 percent of the alarm threshold.
- I. Addressable Pull Box (Manual Station):
1. Addressable pull boxes shall, on command from the control panel, send data to the panel representing the state of the manual switch and the addressable communication module status. They shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, they cannot be restored to normal use except by the use of a key. Manual pull stations shall be of the double action type.
 2. All operated stations shall have a positive, visual indication of operation and utilize a key type reset.
 3. Manual stations shall be constructed of Lexan with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in raised letters, 1.75 inches or larger.
 4. Stations shall be suitable for surface mounting or semiflush mounting as shown on the plans, and shall be installed not less than 42 inches, nor more than 48 inches above the finished floor.
- J. Intelligent Photoelectric Smoke Detector:
1. The detectors shall use the photoelectric (light-scattering) principal to measure smoke density and shall, on command from the control panel, send data to the panel representing the analog level of smoke density.
- K. Intelligent Thermal Detectors:
1. Thermal detectors shall be intelligent addressable devices rated at 135 degrees Fahrenheit (58 degrees C) and have a rate-of-rise element rated at 15 degrees F (9.4 degrees C) per minute. It shall connect via two wires to the fire alarm control panel signaling line circuit. Up to 99 intelligent heat detectors may connect to one SLC loop.
- L. Intelligent Duct Smoke Detector:
1. The in-duct smoke detector housing shall accommodate either an intelligent ionization detector or an intelligent photoelectric detector, of that provides continuous analog monitoring and alarm verification from the panel.
 2. When sufficient smoke is sensed, an alarm signal is initiated at the FACP, and appropriate action taken to change over air handling systems to help prevent the rapid distribution of toxic smoke and fire gases throughout the areas served by the duct system.
 3. Label all concealed duct smoke locations with a red phenolic label on ceiling.

- M. Addressable Dry Contact Monitor Module:
1. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional alarm initiating devices (any N.O. dry contact device) to one of the fire alarm control panel SLC loops.
 2. The monitor module shall mount in a 4-inch square, 2-1/8 inch deep electrical box.
 3. The IDC zone may be wired for Style D or Style B operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.
 4. For difficult to reach areas, the monitor module shall be available in a miniature package and shall be no larger than 2-3/4 inch x 1-1/4 inch x 1/2 inch. This version need not include Style D or an LED.
- N. Two Wire Detector Monitor Module:
1. Addressable monitor modules shall be provided to connect one supervised IDC zone of conventional 2-wire smoke detectors or alarm initiating devices (any N.O. dry contact device).
 2. The two-wire monitor module shall mount in a 4 in. square, 2-1/8 in. deep electrical box or with an optional surface backbox.
 3. The IDC zone may be wired for Class A or B (Style D or Style B) operation. An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.
- O. Addressable Control Module:
1. Addressable control modules shall be provided to supervise and control the operation of one conventional NACs of compatible, 24 VDC powered, polarized audio/visual notification appliances. For fan shutdown and other auxiliary control functions, the control module may be set to operate as a dry contract relay.
 2. The control module shall mount in a standard 4-inch square, 2-1/8 inch deep electrical box, or to a surface mounted backbox.
 3. The control module NAC may be wired for Style Z or Style Y (Class A/B) with up to 1 amp of inductive A/V signal, or 2 amps of resistive A/V signal operation, or as a dry contact (Form-C) relay. The relay coil shall be magnetically latched to reduce wiring connection requirements, and to insure that 100 percent of all auxiliary relay or NACs may be energized at the same time on the same pair of wires.
 4. Audio/visual power shall be provided by a separate supervised power loop from the main fire alarm control panel or from a supervised, UL listed remote power supply.
 5. The control module shall be suitable for pilot duty applications and rated for a minimum of .6 amps at 30 VDC.
- P. Isolator Module:
1. Isolator modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC loop. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop. At least one isolator module shall be provided for each floor or protected zone of the building.
 2. If a wire-to-wire short occurs, the isolator module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the isolator module shall automatically reconnect the isolated section.
 3. The isolator module shall not require any address-setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator module after its normal operation.
 4. The isolator module shall mount in a standard 4-inch deep electrical box or in a surface mounted backbox. It shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

- Q. LCD Alphanumeric Display Annunciator:
1. The alphanumeric display annunciator shall be a supervised, back-lit LCD display containing a minimum of 80 characters for alarm annunciation in clear English text.
 2. The LCD annunciator shall display all alarm and trouble conditions from either the network node or complete network, via the INA.
 3. Up to 32 LCD annunciators may be connected to a specific (terminal mode) EIA 485 interface. LCD annunciators shall not reduce the annunciation capacity of the system. Each LCD shall include vital system wide functions such as, system acknowledge, silence and reset.
 4. LCD display annunciators shall mimic the local control panel 80 character display or network annunciator and shall not require special programming.
 5. Annunciator shall provide all functions of the FACP. Provide a hand held microphone in the annunciator cabinet.
- R. Batteries and External Charger:
1. Battery:
 - a. Batteries shall be 12 volt, Gell-Cell type.
 - b. The battery shall have sufficient capacity to power the fire alarm system for not less than 60 hours plus 10 minutes of alarm upon a normal AC power failure.
 - c. The batteries are to be completely maintenance free. No liquids are required. Fluid level checks for refilling, spills and leakage shall not be required.
- S. Speaker/Strobe Units:
1. One-way Tone/Voice Communication:
 - a. The evacuation alarm and alert signals shall be capable of being initiated automatically from the fire alarm control panel (FACP) and transmitted to any speaker circuit, selected speaker circuits or all speaker circuits. Provide female voice to meet code.
 - b. The alarm signal, alert signal and live voice announcements shall be capable of manual transmission from the FACP to any speaker circuit, selected speaker circuits or all speaker circuits by manual selection of the associated speaker circuit control switches.
 - c. Live voice announcements, via the hand-held microphone or patched in warden phone, by use of speaker control switches, shall take priority over all previously activated alarm inputs. In addition to NFPA 72 requirements, the system shall be capable of priority live voice announcements over subsequent alarm conditions. In no case shall subsequent alarms disrupt emergency live voice announcements.
 - d. Alarm speaker amplification equipment shall be sized, as a minimum, to provide the following wattage levels for each location type of alarm speaker:
 - 1) Each floor alarm speaker: Provide one watt of input power.
 - 2) Each toilet alarm speaker: Provide one-half watt of input power.
 - 3) Each mechanical room alarm speaker: Provide two watts of input power.
 - 4) Each stairwell alarm speaker: Provide one-half watt of input power.
 - 5) Each elevator cab alarm speaker: Provide one-quarter watt of input power.
 - e. As a minimum, alarm speaker amplification equipment shall be sized to provide the above indicated wattage of input power to each location type of alarm speaker shown on the Drawings, plus 25 percent spare capacity to permit the addition of future alarm speakers.
 - f. Alarm speaker amplifiers shall be paired to provide 100 percent redundancy. One back-up alarm speaker amplifier shall be provided for each primary alarm speaker amplifier. If any primary alarm speaker amplifier fails, its function shall be taken over by its backup amplifier. Provide dedicated power amplifiers for each speaker circuit (minimum of four) with one dedicated backup.

- g. Alarm tone and alert tone oscillators and pre-amplifiers shall be paired to provide 100 percent redundancy.
- h. As a minimum, each stairwell shall be provided with a dedicated notification appliance circuit.
- i. As a minimum, the system shall be configured as a two channel voice system.
- j. Within the individual assembly occupancies in this project, an alarm received during a program occupancy shall sound an alert alarm at a constantly attended location and perform the following actions:
 - 1) Deliver a field programmable, digitized custom evacuation message to the occupants, detailing evacuation instructions.
 - 2) A simultaneous message shall be delivered via all alarm speakers installed in remainder of the building directing evacuation using exits other than the assembly occupancy exit path.
 - 3) Perform all control functions as detailed elsewhere in this specification
 - 4) An automatic announcement or tone evacuation signal shall be capable of interruption by the operation of the system microphone to give voice evacuation instructions overriding the pre-programmed sequences
- k. Visual Unit (Xenon Strobe):
 - 1) Combination speaker strobe units - Provide Truealert Non-Addressable 75 Cd, Red Sync. 2-Wire. Comprised of a 24 VDC Xenon Flash Tube entirely solid state. The unit shall require a sync. Control module. Provide True 75 Cd from all axis. Provide white finish.
 - 2) Combination speaker strobe units - Provide Truealert Non-Addressable 110 Cd, Red Sync. 2-Wire. Comprised of a 24 VDC Xenon Flash Tube entirely solid state. The unit shall require a sync. Control module. Provide True 110 Cd from all axis. Provide white finish.
 - 3) Visual only – Provide Truealert Non-Addressable 15 Cd, Red Sync. 2-Wire comprised of a 24 VDC Xenon flash tube entirely solid state. Provide white finish.
- T. FACP to include "UDACT" digital dialer communicator with point ID to report by device.
- U. Exterior Strobe-unit:
 - 1. Provide wall mounted, 24 VDL strobe, color red with WRR wall bracket.
- V. Provide clear plastic covers without local audible alarm for pull stations in gym.
- W. Magnetic Door Holders:
 - 1. Provide Semi-Flush Wall Mounted, or Floor Mounted, 24 V.D.C. with catch plate.
- X. Key Repository Box:
 - 1. Provide a key repository box (es) in accordance with fire department requirements.
- Y. Graphic Map: Provide graphic map to the fire department and engineer for review and approval.

Z. Field Quality Control

1. Manufacturer's Field Services: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system.
2. Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of fire alarm systems. Examples of qualified personnel shall be permitted to include, but shall not be limited to, individuals with the following qualifications:
 - a. Factory trained and certified.
 - b. National Institute for Certification in Engineering Technologies (NICET) fire alarm certified.
 - c. International Municipal Signal Association (IMSA) fire alarm certified.
 - d. Certified by a state or local authority.
 - e. Trained and qualified personnel employed by an organization listed by a national testing laboratory for the servicing of fire alarm systems.
3. Pretesting: Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved.
4. Final Test Notice: Provide a ten-day minimum notice in writing when the system is ready for final acceptance testing.
5. Minimum System Tests: Test the system according to the procedures outlined in NFPA 72.
6. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the Specifications and complies with applicable standards.
7. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log.
8. Provide a point list with address devices to be reviewed and approved by the fire department and engineer prior to programming the system.
9. Perform Db level testing prior to fire department test.
10. Final Test, Certificate of Completion, and Certificate of Occupancy:
 - a. Test the entire system 100 percent devices in accordance with the Authority Having Jurisdiction in order to obtain a certificate of occupancy.
11. Provide 8 hours of customer training.

2.17 SURGE PROTECTION DEVICES

A. Scope

1. This section describes the materials and installation requirements for surge protective devices (SPD) for the protection of all main service and panelboards.

B. Submittals

1. Submit shop drawings and product information for approval and final documentation in the quantities listed according to the Conditions of the Contract. All transmittals shall be identified by customer name, customer location, and customer order number.
2. Submittals shall include UL 1449 3rd Edition Listing documentation verifiable by visiting www.UL.com, clicking "Certifications" link, searching using UL Category Code: VZCA and VZCA2:
 - a. Short Circuit Current Rating (SCCR)
 - b. Voltage Protection Ratings (VPRs) for all modes
 - c. Maximum Continuous Operating Voltage rating (MCOV)
 - d. I-nominal rating (I-n)
 - e. SPD shall be UL listed and labeled as Type 1 or Type 4 intended for Type 1 or Type 2 applications
3. Upon request, an unencapsulated but complete SPD formally known as TVSS shall be presented for visual inspection.
4. Minimum of ten year warranty

C. Related Standards

1. IEEE C62.41.1, IEEE Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits,
2. IEEE C62.41.2, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits,
3. IEEE C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
4. National Electrical Code: Article 285
5. UL 1283 - Electromagnetic Interference Filters
6. UL 1449, Third Edition, effective September 29, 2009 – Surge Protective Devices

D. Quality Assurance

1. Manufacturer Qualifications: Engage a firm with at least five years experience in manufacturing transient voltage surge suppressors.
2. Manufacturer shall be ISO 9001 or 9002 certified.
3. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of ten years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
4. The SPD shall be compliant with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC.

E. Delivery, Storage and Handling

1. Handle and store equipment in accordance with manufacturer's Installation and Maintenance Manuals. One copy of this document to be provided with the equipment at time of shipment.

F. Manufacturers

1. Provide an internally mounted Surge Protective Devices (SPD) formerly called Transient Voltage Suppressor (TVSS) by:
 - a. Siemens Industry.
 - b. Current Technology
 - c. LEA
 - d. Liebert
 - e. APT
 - f. Cutler Hammer
 - g. Or equal

G. Electrical Distribution Equipment

1. Service Entrance

- a. SPD shall be UL 1449 labeled as Type 1 or Type 4 intended for Type 1 or Type 2 applications, verifiable at UL.com, without need for external or supplemental overcurrent controls. Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal overtemperature controls. SPDs relying upon external or supplementary installed safety disconnectors do not meet the intent of this specification.
- b. SPD shall be factory installed integral to electrical distribution equipment.
- c. SPD shall be UL labeled with 20kA I-nominal (I-n)
- d. SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR).
- e. Standard 7 Mode Protection paths: SPD shall provide surge current paths for all modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
- f. True 10 Mode Protection paths: SPD shall provide "directly connected protection elements" between all possible modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
- g. SPD shall be connected external of the distribution equipment with an appropriately sized 200kA SCCR rated disconnect.
- h. SPD shall meet or exceed the following criteria:
 - 1) Maximum 7-Mode surge current capability shall be [300kA] [400kA] [500kA] per phase.
 - 2) Maximum 10-Mode surge current capability shall be [300kA] [450kA] per phase.
 - 3) UL 1449 - Third Edition Revision; effective September 29, 2009 Voltage Protection Ratings shall not exceed the following:

<u>VOLTAGE</u>	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>	<u>L-L</u>	<u>MCOV</u>
208Y/120	800V	800V	800V	1200V	150V
480Y/277	1200V	1200V	1200V	2000V	320V

- i. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

<u>System Voltage</u>	<u>Allowable System Voltage Fluctuation (percent)</u>	<u>MCOV</u>
208Y/120	25 percent	150V
480Y/277	15 percent	320V

- j. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
- k. Suppression components shall be heavy duty 'large block' MOVs, each exceeding 30mm diameter.
- l. SPD shall include a serviceable, replaceable module.
- m. SPD shall be equipped with the following diagnostics:
 - 1) Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
 - 2) Audible alarm with on/off silence function and diagnostic test function (excluding branch).
 - 3) Form C dry contacts
 - 4) Optional – Surge Counter
 - 5) No other test equipment shall be required for SPD monitoring or testing before or after installation.
- n. SPD shall have a response time no greater than 1/2 nanosecond.
- o. SPD shall have a 10 year warranty.

2. Distribution Panel

- a. SPD shall be UL 1449 labeled as Type 4 intended for Type 1 or Type 2 applications, verifiable at UL.com, without need for external or supplemental overcurrent controls. Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal overtemperature controls. SPDs relying upon external or supplementary installed safety disconnectors do not meet the intent of this specification.
- b. SPD shall be factory installed integral to electrical distribution equipment.
- c. SPD shall be UL labeled with 20kA I-nominal (I-n)
- d. SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR).
- e. Standard 7 Mode Protection paths: SPD shall provide surge current paths for all modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
- f. SPD shall be connected to the buss of the distribution equipment with an appropriately sized 200kA SCCR rated disconnect.
- g. SPD shall meet or exceed the following criteria:
 - 1. Maximum 7-Mode surge current capability shall be 100kA per phase.
 - 2. Maximum 10-Mode surge current capability shall be 150kA per phase.
 - 3. UL 1449 - Third Edition Revision; effective September 29, 2009, Voltage Protection Ratings shall not exceed the following:

<u>VOLTAGE</u>	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>	<u>L-L</u>	<u>MCOV</u>
208Y/120	800V	800V	800V	1200V	150V
480Y/277	1200V	1200V	1200V	2000V	320V
- h. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

<u>System Voltage</u>	<u>Allowable System Voltage Fluctuation (percent)</u>	<u>MCOV</u>
208Y/120	25 percent	150V
480Y/277	15 percent	320V
- i. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
- j. Suppression components shall be heavy duty 'large block' MOVs, each exceeding 30mm diameter.
- k. SPD shall include a serviceable, replaceable module.
- l. SPD shall be equipped with the following diagnostics:
 - 1) Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
 - 2) Audible alarm with on/off silence function and diagnostic test function (excluding branch).
 - 3) Form C dry contacts
 - 4) Optional – Surge Counter
 - 5) No other test equipment shall be required for SPD monitoring or testing before or after installation.
- m. SPD shall have a response time no greater than 1/2 nanosecond.
- n. SPD shall have a ten year warranty.

3. Branch Panels

- a. The panelboard shall be UL 67 Listed and the SPD shall be UL 1449 labeled as Type 1 or as Type 4 intended for Type 1 or Type 2 applications.
- b. The unit shall be top or bottom feed according to requirements. A circuit directory shall be located inside the door.
- c. SPD shall meet or exceed the following criteria:
 - 1) Maximum 7-Mode surge current capability shall be 100kA per phase.
 - 2) Maximum 10-Mode surge current capability shall be 150kA per phase.
 - 3) UL 1449 - Third Edition Revision; effective September 29, 2009, Voltage Protection Ratings shall not exceed the following:

<u>VOLTAGE</u>	<u>L-N</u>	<u>L-G</u>	<u>N-G</u>	<u>L-L</u>	<u>MCOV</u>
208Y/120	800V	800V	800V	1200V	150V
480Y/277	1200V	1200V	1200V	2000V	320V

- d. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

<u>System Voltage</u>	<u>Allowable System Voltage Fluctuation (percent)</u>	<u>MCOV</u>
208Y/120	25 percent	150V
480Y/347	15 percent	320V

- e. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of - 50dB at 100 kHz.
- f. Suppression components shall be heavy duty 'large block' MOVs, each exceeding 30mm diameter.
- g. SPD shall include a serviceable, replaceable module.
- h. SPD shall be equipped with the following diagnostics:
 - 1) Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
 - 2) Audible alarm with on/off silence function and diagnostic test function (excluding branch).
 - 3) Form C dry contacts
 - 4) Optional – Surge Counter
 - 5) No other test equipment shall be required for SPD monitoring or testing before or after installation.
- i. SPD shall have a response time no greater than 1/2 nanosecond.
- j. SPD shall have a 10 year warranty.
- k. The unit shall have removable interior.
- l. The main bus shall be [copper] [aluminum] and rated for the load current required.
- m. The unit shall include a 200 percent rated neutral assembly with copper neutral bus.
- n. The unit shall be provided with a safety ground bus.
- o. The field connections to the panelboard shall be main lug or main breaker.
- p. The unit shall be constructed with flush or surface mounted trim and shall be in a NEMA Type 1 enclosure.

H. Installation

- 1. Install per manufacturer's recommendations and contract documents.

I. Adjustments and Cleaning

- 1. Remove debris from installation site and wipe dust and dirt from all components.
- 2. Repaint marred and scratched surfaces with touch up paint to match original finish.

- J. Testing
 - 1. Check tightness of all accessible mechanical and electrical connections to assure they are torqued to the minimum acceptable manufacturer's recommendations.
 - 2. Check all installed panels for proper grounding, fastening and alignment.

- K. Warranty
 - 1. Equipment manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment.

2.18 AUTOMATED LIGHTING CONTROL SYSTEM

- A. General: Summary
 - 1. Section Includes:
 - a. Addressable Networked Light Management System.

- B. References
 - 1. National Fire Protection Association (NFPA)
 - 2. cULus Listing/Certification
 - a. Certified as Energy Management Equipment (UL 916)
 - b. Certified as Emergency Lighting Equipment (UL 924)
 - c. Meet Heat and Smoke Release for Air-Handling Spaces (UL 2043)
 - 3. Federal Communications Commission (FCC) / Industry Canada (IC)
 - 4. California Energy Commission (CEC)
 - 5. Local Building Codes

- C. System Description
 - 1. Lighting Control System includes computer-based software that provides control, configuration, monitoring and reports. System includes the following components:
 - a. Central Control Unit
 - b. System Server
 - c. 0-10V Dimming, Fixed Output Ballasts or 0-10V LED Drivers
 - d. System Field Devices (Input and Output Modules)
 - e. Lighting Control System Software
 - f. Lighting Controllers
 - g. Communication Wire
 - h. Occupancy sensors
 - i. Photo sensors
 - j. Power packs
 - k. Lighting control panels
 - l. Interface to audio visual equipment
 - m. Interface to BACnet
 - n. Interface to Tridium Niagara
 - o. Incandescent low-voltage dimming modules

- D. Submittals
 - 1. General: Provide submittals per 1.4 (B – J) below:
 - 2. Bill of Materials: Complete list of all parts needed to fully install selected system components.
 - 3. Product Data: For each type of product indicated.
 - 4. Shop and Wiring Drawings: Submit shop drawings detailing control system, as supplied, including one-line diagrams, wire counts, coverage patterns, interconnection diagrams showing field-installed wiring and physical dimensions of each item.

5. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
 - a. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
 - b. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.
 6. Software Operational Documentation:
 - a. Software operating and upgrade manuals.
 - b. Program Software Backup: On compact disc or DVD, complete with data files.
 - c. Printout of software application and graphic screens, or upon request, a live demonstration of Control, Configure and Analyze functionality or a video demonstrating above stated system capabilities.
 7. Installation Instructions: Manufacturer's installation instructions.
 8. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.
 9. Warranty: Copy of applicable warranty.
- E. Quality Assurance
1. Installer Qualifications: Installer shall be one who is experienced in performing the work of this section, and who has specialized in installation of work similar to that required for this project.
 2. Manufacturer Requirements: The manufacturer shall have a minimum of 10 years experience manufacturing networked lighting control systems and shall provide 24/7 telephone support by qualified technicians.
 3. Contractor shall ensure that lighting system control devices and assemblies are fully compatible and can be integrated into a system that operates as described in the lighting control notes on drawings and as described within this specification. Any incompatibilities between devices, assemblies, and system controllers shall be resolved between the contractor and the system provider to ensure proper system operation and maintainability.
 4. Performance Requirements: provide all system components that have been manufactured, assembled, and installed to maintain performance criteria stated by manufacturer without defects, damage, or failure.
 5. Performance Testing Requirements
 - a. Manufacturer shall 100 percent test all equipment prior to shipment. Sample testing is not acceptable.
 6. Code Requirements
 - a. System Control Unit and System Field Devices shall be cULus listed and certified.
 - b. All system components shall be FCC /IC compliant.
 - c. All system components shall be installed in compliance with National Electrical Codes and Canadian Electrical Code.
 - d. Building Codes: All units shall be installed in compliance with applicable, local building codes.
 7. ISO Certification: System components shall be manufactured at ISO-9000 certified plants.
- F. COORDINATION
1. Coordinate lighting control components to form an integrated interconnection of compatible components.
 - a. Match components and interconnections for optimum performance of lighting control functions.
 - b. Display graphics showing building areas controlled; include the status of lighting controls in each area.

- G. Delivery, Storage & Handling
 - 1. Ordering: Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
 - 2. Delivery: Deliver materials in manufacturer's original, unopened, undamaged packaging with intact identification labels.
 - 3. Storage and Protection: Store materials away from exposure to harmful weather conditions and at temperature and humidity conditions recommended by manufacturer.

- H. Warranty
 - 1. On-going system expansion, service and support shall be available from multiple factory certified vendors. Recommended service agreements shall be submitted at the time of bid complete with manufacturers suggested inventory and pricing for system parts and technical support labor.
 - 2. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship within specified warranty period.
 - 3. Manufacturer's Warranty: All equipment shall be warranted free of defects in materials and workmanship.
 - a. Warranty Period: All system hardware components shall have full warranty (non-prorated) for at least four years and all software components shall carry a warranty of 90 days from date of installation.
 - b. Owner Rights: Manufacturer's warranty is in addition to, not a limitation of, other rights the Owner may have under contract documents, or warranties of third party component manufacturers.

- I. Basis of Design Products
 - 1. Controls: ENCELIUM Energy Management System by OSRAM SYLVANIA
 - 2. Sensors: ENCELIUM Sensors by OSRAM SYLVANIA & Hubbell Building Automation, Inc.

- J. Acceptable Alternate Manufacturers
 - 1. Controls: Lutron, Sensor Switch, Crestron, Philips, Cooper, or equal.
 - 2. Sensors: Lutron, Sensor Switch, Watt Stopper, Leviton, Cooper or equal.

- K. System Performance Requirements
 - 1. This specification is intended to fully describe all of the design, engineering, programming, hardware, software, ancillary devices and associated technical services required to provide a building-wide networked lighting control system. This system is specified to perform scheduled and automated lighting control sequences.
 - 2. The lighting control "system" shall include a fully distributed WAN/LAN network of global controller/routers, individually addressable System Field Devices, sensors, switches, relays and other ancillary devices required for a complete and operable system. The system WAN/LAN shall be commissioned by ENCELIUM personnel or other ENCELIUM certified commissioning contractors.
 - 3. The basis of system design shall utilize non-propriety industry standard 0-10V dimming or fixed output ballasts and/or 0-10V LED drivers, occupancy sensors, and daylight sensors.
 - 4. On-going system expansion, service and support shall be available from multiple factory certified vendors. Recommended service agreements may be submitted at the time of bid complete with manufacturers suggested inventory and pricing for system parts and technical support labor.

5. Lighting Control Software: The system shall offer two separate levels of lighting control: one personal lighting control for the average building occupant to control and adjust basic lighting functions in their workspace, and two central lighting control for the facility lighting administrator to perform energy management, configuration maintenance, monitoring operations, and providing support to building occupants.
 - a. Native central control software shall be utilized for energy reporting status and complete programming without the need for any third party hardware or software. Systems that require any third party linked software or graphics shall be unacceptable.
 - b. Software shall provide information on general system settings via mouse click on a floor plan. Left clicking over a device on the graphical software interface shall show a description of the selected device/function attribute.
6. Central Lighting Control:
 - a. Shall provide an Interactive, Web-based graphical user interface (GUI) showing floor plans and lighting layouts that are native to the lighting control software. The only means required to program and operate the lighting control system shall be programmed and operated from a user interface that is based on a plan view graphical screen on the user's computer or the lighting control system's main computer. Shall include the navigational features listed below to allow for user's orientation within the controlled space, geographic heading and/or landmarks:
 - 1) Interactive
 - 2) Vector based
 - 3) Zoom
 - 4) Rotate
 - 5) Pan
 - 6) Tilt
 - b. Shall allow building operator to navigate through an entire facility both in two-dimensional and three-dimensional multi-floor view, allowing for fast and easy navigation.
 - c. Three-dimensional view shall exclude walls and other structural features to avoid shadowing and cluttering of the plan view.
 - d. All programming, assignments of lighting loads to control strategies, lighting status and lighting energy reporting shall be native to the software and executed from this GUI. Editing shall be available from this GUI in a drag and drop format or from drop down menus without the need for any third party software. Systems that utilize or require third party linked graphics are unacceptable. The GUI shall continuously indicate the status of each connected device on the system and a warning indicator on the software if a device goes offline. Systems requiring spreadsheet editing for programming and that don't offer real time feedback are not acceptable.
 - e. Software settings and properties shall be selectable per individual device, room based, floor based or global building based.
 - 1) Lighting Control Software interface shall provide current status and enable configuration of all system zones including selected individual fixture availability, current light level, maximum light level, on/off status, occupancy status, and emergency mode (response to an emergency signal) status.
 - f. Shall have the ability to display various lighting system parameters such as Lighting status (ON/OFF); Lighting levels, Load shedding status, or Lighting energy consumption, Occupancy status in a colorized gradient ("weather" map) type of graphical representation.
 - g. Energy Analysis data shall be exportable in a CSV or similar format.
 - h. Shall allow import of native AutoCAD files.

7. Reports: Reporting feature shall be native to the lighting control software and capable of reporting the following parameters for each device and zone individually without requiring any third party hardware and software:
 - a. Energy consumption broken down by energy management strategy.
 - b. Energy demand broken down by energy management strategy.
 - c. Occupancy data by zone.
 - d. Building wide occupancy status
 - e. Lighting energy consumption in a color gradient ("weather map" type) view
 - f. Energy performance reports shall be printable in a printer friendly format and downloadable for use in spreadsheet applications.
8. Personal Lighting Controls: The Personal Control Software interface shall provide current status and enable each user with the ability to dim and brighten lights, and turn them on and off by individual fixture or zone. The Software shall offer user configurable light scenes, which may be programmed and then selected via the Software. Personal lighting control shall be available in open/private office environments.
9. Daylight Harvesting (Light Regulation Averaging): In a photo sensor-equipped system, the Central Controller Unit shall rationalize changes to light levels when ambient (natural) light is available and shall maintain a steady light level when subjected to fluctuating ambient conditions where dimming ballasts and/or drivers exist. Areas equipped with fixed output ballasts and/or drivers shall energize when natural light falls below foot-candle levels specified. System shall utilize light level inputs from common and/or remote sensor locations to minimize the number of photo sensors required. The System shall operate with multiple users in harmony and not react adversely to manual override inputs.
10. Time Clock Scheduling: The system shall be programmable for scheduling lights on or off via the Lighting Control Software interface.
 - a. Support for BACnet Time Schedule Object: This allows the export of Lighting Control time schedules to BACnet devices and vice versa in the event of Lighting Control System's integration with BACnet.
 - b. Override: Manual adjustments via lighting controllers or personal control software shall temporarily override off status imposed by time clock schedule.
 - c. Response to Power Failure: In the event of a power failure, the time clock shall execute schedules that would still be in progress had they begun during the power outage.
 - d. Flick Warning: Prior to a scheduled lights-off event or expiry of a temporary override, the system shall provide two short light level drops as a warning to the affected occupants. Flick warning time shall have the ability to be programmed via software between one and five minutes.
11. Load Shed Mode: An automatic load shedding mode shall be available where, when activated through the system, the control unit will reduce its output to a programmable maximum electrical demand load. The system shall not shed more load than required and load shedding priority shall be centrally configurable by control zone or by common uses (i.e., all hallways can be treated as one load shed group), with subsequent load shed priority groupings being utilized until the required defined load has been shed, for either a defined period, or until the demand response input has been removed. Systems that simply select a "load shed scene" whereby there is no guarantee that the defined required load will actually be shed are not acceptable.
12. Emergency Mode: There shall be a mode, when activated through the system, that will immediately adjust lights to full light output and retain that level until the mode is deactivated in the event of an emergency. This setting shall override all other inputs. The system shall interface with the building of life safety transfer switch, fire alarm control panel, and security system control panel.

13. Addressing: All ballasts and/or drivers shall be centrally addressable, on a per fixture or multiple fixtures/zone basis, through the Central Control Software. The basis of design shall utilize industry standard 0-10V Dimming, Fixed Output Ballasts and/or 0-10V LED Drivers connected to an Output Module. To simplify ongoing maintenance, the system shall not require manual recording of addresses for the purpose of commissioning or reconfiguration.
14. Programmable Task Tuning: Maximum light level programmability shall be available by individual fixture.
15. Unoccupied State: The system shall provide two states when occupancy status is vacant as per an occupancy sensor: lights turn off or lights adjust to configurable (dimmed) light level.
16. Occupied State: The system shall be capable of creating "comfort" or "support" zones to ensure that occupants are not isolated by turning off lights in adjacent areas for occupant comfort and safety, such as a hallway path to exit the premises.
17. The Automated Lighting Control System (ALCS) BACnet Interface shall share the following information with the BACnet enabled Building Automation System and other systems listed below:

<u>Property</u>	<u>BACnet Type</u>	<u>Description</u>
Lighting Load	Analog Value*	Reports the total lighting load of the ALS, defined in Watts
Light Zone State	Binary Value*	State of the defined lighting zone - ON or OFF
Light Zone Dimming	Analog Value*	Light output level of the defined lighting zone, from 100 percent (maximum light output) to 0 percent (minimum light output)
Emergency System State	Binary Input	State of the emergency alarm system: alarm activated or alarm not activated
Fire Alarm State	Binary Input	State of the fire alarm system: alarm activated or alarm not activated
Security System State	Binary Input	State of security alarm system: alarm activated or alarm not activated

Occupancy State	Binary Output	State of the defined occupancy sensor – occupancy detected or not detected
Sheddable Load	Analog Output	Reports the total lighting load available for load reduction according to ALS, defined in Watts
Shed Status	Analog Output	Reports the total current load reduction achieved according to ALS defined prioritization, defined in Watts
Shed Request	Analog Input	Requested total amount of load reduction, defined in Watts or as a percentage of sheddable load
Sheddable Load (Group)	Analog Output	(As above, unprioritized for the selected group)
Shed Status (Group)	Analog Output	(As above, unprioritized for the selected group)
Shed Request (Group)	Analog Input	(As above, unprioritized for the selected group)

18. LAN Operations: System shall be capable of operating independent of building's existing network infrastructure if desired and shall not rely on tenant supplied PCs for operation. Network infrastructure shall only be utilized for Personal Control Software.
19. Firewall Security: Firewall technology shall be utilized to separate tenants from the lighting control network.
20. Lamp Burn In: The system software shall not permit dimming of new lamps prior to completion of lamp manufacturer 100 hour recommended accumulated operation at full brightness.
21. Re-configurability: The assignment of individual fixtures to zones shall be centrally configurable by Central Control Software such that physical rewiring will not be necessary when workspace reconfiguration or re-zoning is performed. Removal of covers, faceplates, and ceiling tiles. shall not be required.
22. Automatic Control Parameters: Occupancy sensor time delays shall be configurable through software. Light level sensor parameters shall be configurable through software.
23. Automatic Time Adjustment: System shall automatically adjust for leap year and daylight savings time and shall provide weekly routine and annual holiday scheduling.
24. Contact closure input: System shall be capable of receiving a momentary and sustained contact closure input from third party sources to control lighting zones.

25. The light management system shall interface digitally with the building automation system via BACnet/IP and Tridium Niagara AX interface. The lighting control system shall communicate the status of output devices (lighting loads) as well as input devices (dry contacts, switches, occupancy sensors, vacancy sensors, and photocells) over this connection allowing the building automation system to utilize lighting control system input devices such as occupancy sensors to determine if mechanical control zones are occupied for climate adjustments.
 26. The system software shall provide a web based energy dashboard to show real time energy savings data and carbon footprint reductions.
 27. Migration Plan to Control LED Fixtures
 - a. System shall be capable of migrating from the control of 0-10V Ballasts to 0-10V LED Drivers utilizing the same Output Modules without the need to change control hardware.
- L. Lighting Controllers
1. Description: The system shall include separate lighting controllers for each of the listed functionalities and at minimum meet listed electromagnetic, mechanical, electrical and data specifications:
 - a. Software configurable lighting controller that provides on/off switching and dimming control for up to three lighting zones/scenes per controller or more with allowable multi-gang configurations. Status is indicated by an LED display to indicate function, scene or zone. Allows manual override of the time schedule.
 - b. Manual dimming and/or switching lighting controller that provides local on/off and dimming control over at least three lighting zones. Allows manual dimming of light levels and override of the time schedule.
 - c. Scenes in the central control software shall be synchronized with the buttons on the lighting controller.
 - d. Lighting controllers shall fit in a standard Decorator style wall plate and may be ganged together.
 2. General
 - a. Addressing: All controllers shall be individually addressable & reconfigurable via Central Control Software.
 - b. Shall provide local on/off or dimming control over lighting zones
 - c. Shall utilize a standard single-gang or multi-gang form factor
 - d. Shall have a terminal block that connects to lighting system with 18 AWG, polarity independent, CMP rated and low voltage wire
 - e. Shall be manufactured with push-in wire receptacles
 - f. LED's: All controllers shall feature LED's to indicate light on and light off status.
 - g. Color: All controllers shall meet NEMA WD1 color specifications.
 - h. Style: All controllers shall feature Decorator styling wall plates.
 - i. Lighting scenes reconfigure automatically based on scene changes from personal control software.
 - j. Industrial lighting controllers shall also be available for damp location applications.
 - k. Shall comply or exceed the following electromagnetic requirements:
 - 1) EN 61000-4-2
 - 2) EN 61000-4-4
 - 3) EN 61000-4-5
 - 4) FCC Part 15/ICES-003
 3. Mechanical Specifications:
 - a. Dimensions: Shall meet NEMA WD-6 spec.
 - b. Maximum Operating Ambient Temperature: 60 deg C.
 - c. Mounts in standard size wall box suitable for multi gang installation or alternative of Low Voltage mounting bracket.
 - d. Suitable for use with Decorator style wall plates.

4. Electrical Specifications:
 - a. Class 2 Low Voltage device.
 - b. Power through interconnected 18 AWG cable with 2-pin header
 5. Data Specifications:
 - a. Class 2 communication bus that uses prefabricated 18 AWG cable.
- M. System Field Devices (Input and Output Modules)
1. General: Input Modules provide a common interface to low voltage occupancy sensors and photo sensors while Output Modules provide a common interface to 0-10V Dimming, Fixed Output Ballasts and/or 0-10V LED Drivers and analog dimming devices such as incandescent low-voltage dimming modules. These modules automatically self address and detect the type of devices they are connected to (i.e., photo sensor, occupancy sensor, 0-10V ballast, 0-10V LED drivers or incandescent dimming module) and establish two-way communication between the system Control Unit (CU) and themselves. These individually addressable modules enable each lighting component to be independently controlled and configured to best meet the needs of the facility.
 - a. Addressing: System Field Devices shall be individually addressable via Central Control Software.
 - b. System shall automatically address individual nodes during system commissioning thus eliminating the need to pre-address devices or record serial numbers during installation.
 - c. Modules shall at minimum meet the listed general, mechanical and environmental specifications set at below.
 2. Air Gap Off
 - a. Definition: Air Gap Off shall refer to the physical disconnection of AC power to the ballast or driver when "OFF" is selected either automatically or manually, thus ensuring maximum energy savings by eliminating off-state phantom power losses as well as ensuring that no potentially lethal high-voltage is present at the ballast or driver when the lights appear to be off (for life-safety reasons).
 - b. Provisions: Provide an air-gap off relay for each control zone in the system. Where each fixture is to be controlled (dimmed and/or switched) independently, provide one relay per fixture. Where multiple fixtures are to be controlled (dimmed and/or switched), provide one relay per control zone, sized to handle both the inrush current as well as the maximum connected load, at the specified voltage.
 3. General Specifications:
 - a. Shall supply 12VDC (up to 24VDC) to sensors.
 - b. Shall have 2 ports that accept 18 AWG, pre-fabricated, polarity independent quick connecting Class 2 communication bus that supplies 24 VDC.
 - c. Two models, one rated for regular indoor use and other for use in damp locations such as basements, cold storage areas. shall be available.
 - d. Memory: Retains all system settings in non-volatile memory.
 4. Mechanical Specifications:
 - a. Wiring: The System Field Device shall not require wiring connections to the System apart from pre-terminated, quick connecting 18 AWG, polarity independent quick connecting Class 2 communication bus.
 5. Environmental Specifications:
 - a. Operating Temperature Range: -40 deg C to +55 deg C.
 - b. Humidity: 0 percent to 100 percent RH condensing rated for damp locations.
0 percent to 95 percent RH non-condensing rated for indoor locations.

N. Energy Control Unit

1. General: The Energy Control Unit (ECU) is a rack or wall mounted lighting control device that collects, processes and distributes lighting control information to System Field Devices and lighting controllers over a Class 2 communication bus. Each ECU has multiple Class 2 communication channels and can control a large quantity of nodes (sensors, lighting controllers, 0-10V Dimming, Fixed Output Ballasts and 0-10V LED Drivers.) per channel, per the manufacturers recommended maximum. The ECU is the central intelligence point for the area that it controls, collecting signal information from sensors, lighting controllers and personal control software and determining appropriate brightness levels or on/off status for each fixture or zone. Each ECU has an Ethernet connection for communication with a facility's or tenant's Local Area Network (LAN) to enable desktop personal control.
 - a. Shall interconnect with other ECUs and System Server Unit (SSU) using standard Ethernet connection that employs TCP/IP protocol.
 - b. Control units shall at minimum meet the mechanical, electrical, data, electromagnetic and environmental specifications listed below.
2. Mechanical Specifications:
 - a. Shall mount in a standard 1 inch rack (1U width), or alternatively where no rack is shown, via an individual wall mount.
3. Electrical Specifications:
 - a. Power Supply: 120V/60Hz/200W. Provide dedicated 120V receptacle fed from a dedicated normal power circuit; do not connect to a UPS or normal/emergency power source.
4. Data Specifications:
 - a. Shall have 8 ports that accept 18 AWG, pre-fabricated, polarity independent quick connecting Class 2 communication bus that supplies 24 VDC
 - b. Each ECU channel shall support up to 100 nodes or 800 nodes in total.
 - c. Each ECU shall have two Ethernet 10/100Base - Tx Cat 5 RJ45 ports that employs TCP/IP protocol:
 - 1) Lighting Control Network
 - 2) Tenant LAN Access Point
 - d. Shall have a status LED on front of unit.
 - e. Shall have configuration stored in non-volatile flash memory.
5. Shall comply or exceed the following electromagnetic requirements:
 - a. EN 61000-4-2
 - b. EN 61000-4-4
 - c. EN 61000-4-5
 - d. FCC Part 15/ICES-003
6. Environmental Specifications:
 - a. Operating Temperature Range: -20 deg C to +40 deg C.
 - b. Humidity: 0 percent to 95 percent RH non-condensing.

O. System Server Unit

1. General: System Server Unit (SSU) shall host the lighting control system database for all the lighting control devices. Server shall have the ability to:
 - a. Remotely access a system in order to change system settings or configuration;
 - b. Analyze system performance or energy data or generate system report;
 - c. Record energy consumption with average sampling every 5 minutes for unlimited duration;
 - d. Host the web interface required for the web enabled Personal Control Software or web based Central Control Software;
 - e. Optionally can reside on a client server (virtual server) thus eliminating the need for dedicated physical hardware if desired;

- f. Interconnect with ECUs over standard Ethernet connection that employs TCP/IP protocol;
 - 2. Hardware based servers shall at minimum meet the specifications listed below:
 - a. Specifications:
 - 1) Mechanical Specifications:
 - a) Shall mount in a standard 19 inch rack (1U width), or alternatively where no rack is shown, via an individual wall mount.
 - b. Electrical Specifications:
 - 1) Power Supply: 120V/60Hz/200W. Provide dedicated 120V receptacle fed from a dedicated normal power circuit.
 - c. Regulatory:
 - 1) FCC (US only) Class A.
 - 2) DOC (Canada) Class A.
 - 3) UL 60950.
 - 4) CAN/CSA-C22.2 No. 60950.
- P. Communication Wire
- 1. Wiring: 18 AWG, pre-fabricated, polarity independent quick connecting wiring. The system shall have the capability to use both Class 1 and Class 2 wiring. The maximum connected length of wiring shall be 2500 ft. per channel.
 - 2. Field Bus: Integrates peripheral devices such as 0-10V ballasts and/or 0-10V LED drivers, occupancy sensors, photo sensors, relay-based controls, power packs and low voltage wall controls into a complete, networked programmable lighting control system. Provides power to photo sensors, PIR occupancy sensors and dual-technology occupancy sensors. Devices may be connected randomly on the network and special termination of each network channel is not required.
 - 3. Field bus shall at minimum meet the specifications listed below:
 - a. Specifications:
 - 1) Class 2 communication bus.
 - 2) Prefabricated one ft., five ft., ten ft., 15 ft., 20 ft., 25 ft. and 50 ft. lengths.
 - 3) Daisy chain topology
 - 4) Prefabricated with 2-wire connectors.
 - 5) Flame rated jacket for plenum use NFPA 262 (UL: FT6, CSA: CMP).
 - 6) Power Supply: 12 VDC (up to 24 VDC) to sensors.
- Q. Conductors and Cables
- 1. Class 2 Control Cable: Multi-conductor cable with stranded-copper conductors not smaller than No. 18 AWG.
- R. Lighting Control Panels
- 1. General
 - a. Addressing: All lighting control panels shall be individually addressable via Central Control Software.
 - b. Communication: All lighting control panels shall communicate via the same prefabricated, quick connecting low voltage wiring as all other devices.
 - c. Wiring: Relay control panels shall be interconnected on the same field bus as all other system components.

S. Lighting Control System Software

1. Personal Control Software: Enables individuals in a building to control lighting levels in their workspace from their own desktop PC. User can control the light level of each fixture in their workspace or can control all of the fixtures together as a group. Preset lighting scenes may be stored, recalled and modified. This software shall have the capability of acting as a "virtual occupancy sensor" for the system by detecting keyboard or mouse activity on each PC for incremental occupancy status data.
 - a. Technical Information:
 - 1) TCP/IP network traffic < 2kb/s.
2. Web based Personal Control Software: This feature allows individuals to control lighting levels in their workspace without the requirement for installation of software on client PCs. Individuals can access the interface through the web browser and perform individual fixture dimming control, on/off switching, modify and save preset lighting scenes.
3. Technical Information: Adobe Flash ® based user interface.
 - a. System Requirements:
 - 1) Internet web browser with Flash® Player 8 or later.
 - 2) Internet/Intranet connection.
 - 3) SSU enabled and configured to host dynamic website.
 - 4) Network connection with access to a network-enabled CU.
4. Web based Central Control Software: Central control software application is used to commission, configure and manage the system. Every system parameter in a building (or campus of buildings) is configured for each individual user or space and baseline settings are established for each of the following (depending on the basis of design) system features:
 - a. Daylight harvesting.
 - b. Occupancy control.
 - c. Smart time scheduling.
 - d. Task tuning.
 - e. Personal control.
 - f. Load shedding.

Software utilizes a web based interface that permits a user to easily navigate between zones, floors or different buildings and allows a user to zoom in or zoom out of specific areas of a building. Both 3-dimensional and 2-dimensional multi-floor views shall be available. System features such as creation of zone hierarchies, overlapping and support zone definitions, user access rights, timeout settings for occupancy sensors, calibration of light levels for daylight harvesting and the configuration of multiple time schedule profiles shall be available. A web based Graphical User Interface (GUI) application integral to the system will be used to develop a dynamic, real-time, point-and-click graphic of each floor plan with representation of all light fixtures, lighting controllers, sensors, and switches. A central system server will be provided to support system data base and enterprise control management.

5. System Requirements:
 - a. Software must be able to run on a Windows Operating systems (Windows XP or newer) and also on Apple Mac Intel PCs (Mac OS 10.4 or newer).
 - b. Must support all common browsers, i.e.,
 - 1) Internet Explorer 6.0 or later
 - 2) Mozilla Firefox 3.0 or later
 - 3) Safari
 - 4) Google Chrome
 - c. Network connection with access to network-enabled CUs.

- d. Color gradient (“weather map” type) data view (see below for an example) shall be available to display the following criteria:
 - 1) Current energy consumption
 - 2) Current energy savings
 - 3) Current fixture brightness
 - 4) Current fixture status
 - 5) Current occupancy data
 - 6) Current load shedding status
 - 7) Other custom modes that may be specified elsewhere

- T. Photo Sensor:

Photo sensors shall at minimum meet the specifications listed below:

 1. General Specifications:
 - a. Shall be Class 2, low voltage.
 - b. Ambient light sensor designed to interface directly with the analog input of the Lighting Control System.
 - c. Sensor shall supply an analog signal to the ALCS proportional to the light measured.
 - d. Sensor output shall provide for zero or offset based signal.
 - e. Sensor shall be capable of a fully adjustable response in the range between 0 and 10,000 foot candles with a +/- 1 percent accuracy at 70 deg F.
 - f. Input: 10VDC.
 - g. Minimum Output: 0 VDC.
 - h. Maximum Output: 10 VDC.
 - i. Sensor housing shall be flame retardant and meet UL 94 HB standards.
 - j. Operating Temp: -10 deg C to 60 deg C.
 - k. The sensitivity adjustments shall be at sensor body, and outside of the sensor’s viewing angle.
 - l. The sensor housing shall be flame retardant and meet UL 94HB standards
 2. Interior:

Indoor sensors shall have a Fresnel lens, with a 60 degree cone of response. The indoor sensor range shall be between 0 and 750 FC.
 3. Exterior:
 - a. Outdoor models shall have a hood over the aperture to shield the sensor from direct sunlight. The outdoor sensor circuitry shall be completely encased in an optically clear epoxy resin. Outdoor sensors shall mount to a standard threaded 1/2 in. conduit or fit a 1/2 in. knockout. The Outdoor sensor range shall be between 0 and 750 FC.
 4. Atrium:
 - a. The Atrium sensors shall have a translucent dome with a 180 degree field of view. Atrium sensor shall mount to a standard treaded 1/2 in. conduit or fit a 1/2 in. knockout. Atrium sensor range shall be from 2 to 2,500 FC.
 5. Skylight:
 - a. The Skylight sensors shall have a translucent dome with a 180 degree field of view. Skylight sensor shall mount to a standard treaded 1/2 in. conduit or fit a 1/2 in. Skylight sensor range shall e between 10 and 7,500 FC.

- U. Occupancy Sensors
 1. Environmental:

Operating Temperature Range: 0°C to 40°C

 - a. Relative Humidity: 0 percent to 95 percent non-condensing
 - b. Ceiling Mount Occupancy/Vacancy Sensors
 - 1) Sensing mechanism:
 - 2) Dual technology (ultrasonic / passive infrared):

- 3) Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
- 4) Utilize an operating frequency of 32kHz or 40kHz that shall be crystal controlled to operate within plus or minus 0.005 percent tolerance.
- 5) Electrical: Rating: 12 VDC input voltage, up to 40 mA current draw.
- 6) Sensors shall turn off or reduce lighting automatically after reasonable time delay when a room or area is vacated by the last person to occupy the space
- 7) Sensor shall accommodate all conditions of space utilization and all irregular work hours and habits.
- 8) Sensors shall be UL listed.
- 9) Sensors shall be fully adaptive and adjust their sensitivity and timing to ensure optimal lighting control for any use of the space
- 10) Sensors shall have field adjustable controls for time delay and sensitivity to override any adaptive features. Sensor timeouts shall be configurable by System software.
- 11) Power failure memory:
- 12) Controls incorporate non-volatile memory. Should power be interrupted and subsequently restored, settings and learned parameters saved in protected memory shall not be lost.
- 13) Provide all necessary mounting hardware and instructions.
- 14) Sensors shall be Class 2 devices.
- 15) Indicate viewing directions on mounting bracket for all Ceiling mount sensors.
- 16) Provide customizable mask to block off unwanted viewing areas for all ceiling mounted sensors using infrared technology. Field prepare proper maskings for each space to eliminate unnecessary sensing beyond the space in which the sensor is located.
- 17) Provide an internal additional isolated relay with Normally Open, Normally Closed and Common outputs for use with HVAC control, Data Logging and other control options.

V. Power Packs

1. General:

- a. Power pack shall be a self-contained transformer and relay module.
- b. The internal relay shall control up to 20A for 120, 230, 277VAC or 347VAC ballast loads and 120VAC incandescent loads.
- c. Power packs shall provide a 24 VDC, 150 mA output.
- d. Power packs shall be capable of parallel wiring without regard to AC phases on primary.
- e. Power pack can be used as a standalone, low voltage switch, or can be wired to sensor for auto control.
- f. Construction shall be high impact, UL rated plastic case
- g. Power pack shall be UL/CUL Listed, FCC Certified, UL 2043 plenum rated and meets ASHRAE 90.1 requirements
- h. To ensure quality and reliability, power and auxiliary relay packs shall be manufactured by an ISO 9002 certified manufacturing facility and shall have a defect rate of less than 1/3 of 1 percent.
- i. Shall at minimum meet the following environmental specifications:
 - 1) Operating Temperature Range: 0 deg. C to 40 deg. C
 - 2) Relative Humidity: 0 percent to 95 percent non-condensing

W. Examination

1. Site Verification: Verify that wiring conditions, which have been previously installed under other sections or at a previous time, are acceptable for product installation in accordance with manufacturer's instructions.
2. Inspection: Inspect all material included in this contract prior to installation. Manufacturer shall be notified of unacceptable material prior to installation.

X. Installation

1. The Electrical Contractor, as part of the work of this section, shall coordinate, receive, mount, connect, and place into operation all equipment. The Electrical Contractor shall furnish all conduit, wire, connectors, hardware, and other incidental items necessary for properly functioning lighting control as described herein and shown on the plans (including but not limited to System Field Devices, 0-10V dimming ballasts, fixed output ballasts, 0-10V LED drivers and communication wire). The Electrical Contractor shall maintain performance criteria stated by manufacturer without defects, damage, or failure.
2. Power: The contractor shall test that all branch load circuits are operational before connecting loads to sensor system load terminals, and then de-energize all circuits before installation.
3. Related Product Installation: Refer to other sections listed in Related Sections for related products' installation.

Y. Sensor Installation

1. Adjust sensitivity to cover area installed
2. Set time delay on occupancy sensors that are connected to the lighting control system to the minimum. Time delays shall be controlled via Central Control Software.
3. Sensor shall be powered through Input Module. No external power packs shall be used for powering sensors.
4. Install occupancy sensors on vibration free stable surface.
5. Install atrium and skylight light sensor facing toward window or skylight.
6. Install interior light sensor in ceiling facing the floor.

Z. Wiring Installation

1. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 3/4 inch.
2. Wiring within Enclosures: Comply with NEC & CEC. Separate power-limited and non power-limited conductors according to conductor manufacturer's written instructions.
3. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

AA. Software Installation

1. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current site licenses for software.

BB. Field Quality Control

1. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
2. Perform the following field tests and inspections with the assistance of a factory-authorized service representative:
 - a. Operational Test: After installing lighting controllers and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Lighting control devices will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

CC. Commissioning Requirements

1. Commissioning: The manufacturer shall supply factory trained representatives for a minimum of 24 hours to commission the lighting control system. Manufacturer shall start up all lighting control equipment and verify that it meets the requirements of this specification.
2. Training: As part of the standard commissioning process, the manufacturer shall train the owner's representatives in the operation of the system to a maximum of 4 hours per building. Manufacturer shall also provide owner's representatives with system operating manuals together with a system training video.
3. Technical Support: The manufacturer shall supply 24/7 technical telephone support to the client. If the manufacturer does not provide 24/7 support, they must provide a list of contacts (names and cell phone numbers) in the event of a system failure during non-business hours.
4. Replacement components: The manufacturer shall be able to ship replacement parts within 24 hours for any component that fails during the warranty period.
5. Extended Service Coverage: Maintenance agreements shall be available from the manufacturer to provide service for the system both during and after the warranty period.
6. Requests for commissioning shall be at least two weeks prior to date desired for commissioning.
7. Electrical contractor shall perform functional testing under the guidance of commissioning agent and in accordance with factory specified guidelines.
8. Factory appointed personnel shall provide commissioning services for the lighting control system.
 - a. Verify proper communication over control wires.
 - b. Map addresses of occupancy sensors (via Input Modules), light level sensors (via Input Modules), lighting controllers to control units and system server.
 - c. Map all system data to appropriate BACnet points and assist BMS sub-sub-contractor in programming all points into the BMS system and verifying their proper functionality.
 - d. Verify communication to control units and system server.
 - e. Configure occupancy sensors, light level sensors, lighting controllers and other contacts to suit design specifications.
 - f. Configure and program lighting control sequences as described on contract documents.
 - g. Demonstrate to Owner and Engineer proper operation of all areas the system is installed.

DD. Testing

1. Upon completion of all line, load and interconnection wiring, and after all fixtures are installed and lamped, a qualified factory representative shall completely configure and test the system.
2. At the time of checkout and testing, the owner's representative shall be thoroughly instructed in the proper operation of the system.

EE. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel and building supervisors to adjust, operate, utilize, troubleshoot, conduct software installation, and maintain lighting controls and software training for PC-based control systems. Provide up to eight hours of on-site training with audio and video recorded. Provide a hard copy of manuals, instructional videos, and recorded training session(s) on CD or DVD.

2.19 LADDER TRAY/WIREWAYS

A. Provide 12 in. wide aluminum ladder tray with 6 in. rung spacing with 4 in. side rail. Ladder tray shall be as manufactured by B-Line. "Ladder Type". Provide all hangers required.

B. Acceptable Manufacturers:

1. B-Line
2. Chalfant
3. Chatsworth
4. Mono Systems
5. PW Industries
6. Or equal

C. Wireway:

1. This specification covers NEMA type 1 wireway used to house and protect communication cable. The wireway system shall consist of wireway and appropriate fittings to complete the installation per the electrical drawings.
2. Metal wireway (NEMA type 1) is to be utilized in dry interior locations only as covered in article 362 part a of the national electrical code, as adopted by the national fire protection association and as approved by the American National Standards Institute. The wiremold "c" or "sp" series is listed by underwriters' laboratories under file no. E137690 guide zoyx.
3. The wireway system specified herein shall be the "c" or "sp" system as manufactured by the wiremold company. Systems of other manufacturers may be considered equal if, in the opinion, and the written approval of the engineer, they meet all the performance standards specified herein.
4. The wireway and all system components must be UL Listed in full compliance with their standard UL870, "electrical wireways, auxiliary gutters and associated fittings". It shall be manufactured from 16-gauge cold rolled steel, finished in ASA 61 gray powder coat paint. All sizes larger than 6 in. x 6 in. shall be manufactured from 14-gauge cold rolled steel, finished in ASA 61 gray powder coat paint. A factory installed divider shall be available to separate power and low voltage wiring housed in the same wireway sections.
5. A full complement of fittings for the raceway shall be available including, but not limited to, 45° and 90° flat, vertical inside and outside elbows, tee and cross fittings, couplings for joining sections of wireway, reducers, hangers, end blanks, a field installed divider and all other components necessary to make the system workable. The fittings shall have an ASA 61 gray powder coat paint finish to match the wireway.

6. Prior to and during installation, refer to system layout drawing containing all elements of the system. Installer shall comply with detailed manufacturer's instruction sheets which accompany system components as well as complete system instruction sheets, whichever is applicable.
7. All wireway systems shall be mechanically continuous and connected to all electrical boxes and cabinets, in accordance with manufacturer's installation sheets.
8. All connections shall be checked to make sure they are correctly tightened and to insure that all wireway shall be electrically continuous and bonded in accordance with the national electric code for proper grounding.
9. All wireway systems shall be installed complete. Work shall include fastening all wireway and appropriate fittings to install a complete wireway system as indicated on the electrical and/or communication drawings and in the applicable specifications

2.20 SEALS

A. Water Tight Seals:

1. Conduits entering from the exterior or below grade shall have water tight fittings on the outside and on the inside of the conduit.
 - a. Fittings on the outside of the conduit shall be O-Z Gedney type FSK or approved equal. Provide type WSK if penetration is within two feet of the high water table. Provide grounding attachment.
 - b. Fittings on the inside of the conduit shall be O-Z Gedney type CSBI or approved equal. Provide type CSBG if penetration is within two feet of the high water table. Provide a blank fitting to seal spare or empty conduits.
 - c. O-Z Gedney type CSM fitting may be used when sealing within a sleeve or cored hole.
2. Submit on seals to be used.

B. Environmental Seals:

1. Provide seals on raceways exposed to widely different temperatures, as in refrigerating or cold storage areas. Install seal to prevent circulation of air from warmer to colder sections through the raceway.

C. Hazardous Area Seals:

1. Provide explosion proof seals required by the Electric Code for the following areas.
 - a. Explosion proof exhaust fans.

D. Smoke and Fire Stopping Seals:

1. Provide a seal around raceways or cables penetrating full height walls (slab to slab), floors or ventilation or air handling ducts so that the spread of fire or products of combustion shall not be substantially increased.
2. Penetrations through fire-resistant-rated walls, partitions, floors or ceilings shall be firestopped using approved methods and NRTL listed products to maintain the fire resistance rating.
3. Fire stopping in sleeves or in areas that may require the addition or modification of installed cables or raceways shall be a soft, pliable, non-hardening fire stop putty. Putty shall be water resistant and intumescent. Provide for all sleeves and raceways.
4. Firestopping in locations not likely to require frequent modification shall be NRTL listed putty, caulk or mortar to meet the required fire resistant rating.
5. Box penetrations into a fire rated wall or shaft shall have a fire stopping pad installed on the back of the box.
6. Firestopping of cable trays or busways through walls shall be with a non-hardening putty or with seal bags.

7. Firestopping materials shall be NRTL listed to UL 1479 (ASTM E814). Installation methods shall conform to a UL firestopping system. Submit specifications and installation drawings for the type of material to be used. Firestopping materials shall be as manufactured by 3M, International Protective Coatings Corp., RayChem or approved equal.

2.21 UNDERGROUND DUCTBANKS

- A. General: Furnish and install the ductbanks as herein specified and as shown on drawings.
- B. Division of Work:
 1. The General Conditions shall be responsible for the work and material required for the following:
 - a. Excavation
 - b. Backfill
 - c. Installation of handholes/manholes
 - d. Brick or concrete collars to bring handhole frames and covers up to grade. Installation of frames and collars which are to be furnished by the Electrical Contractor.
 - e. Concrete Encasement
 2. All other material, equipment, and labor required for the complete ductbank shall be furnished and installed by the Electrical Contractor under this Section, including the following:
 - a. Service raceways.
 - b. Grounding material.
 - c. Ductbank warning tape.
 - d. Furnishing pre-cast handholes/manholes.
 - e. Conduit spacers.
- C. Materials:
 1. Conduit: UL listed, schedule 40 PVC in accordance with NEMA standard TC-2. See BASIC MATERIALS SECTION.
 2. Conduit Supports (duct system): Shall be molded plastic with interlocking lugs and skeletonized structure, minimum separation 3 in.
 3. Tags: Non-ferrous metal or fibre, ¼ in. high letters.
 4. Warning tape shall be yellow polyethylene 4 mil thick, 6 in. wide terratape, similar to REEF Industries, Houston, Texas and shall be installed above all ductbanks both high and low tension.
- D. Duct System:
 1. The duct system shall consist of Schedule 40 PVC conduit except where otherwise specified. The size and number of conduits shall be as indicated on the drawings. Provide a pull wire in each conduit.
 2. The entire length between handholes and end of ductbank shall be excavated and graded before any conduit is laid.
 3. The ductbank shall be set on undisturbed earth.
 4. The conduit shall be installed so that top is a minimum of 36 in. below finished grade unless otherwise indicated, and shall be laid to a minimum grade of 4 in. for each 100 feet of length. Duct system shall drain to manholes/handholes.
 5. Changes in direction shall be made by long sweep bends, minimum radius 25 feet except that at the end of a run, within ten feet of termination. Manufactured ends may be used having a minimum radius of 36 inches.

6. Conduit base and intermediate spacers shall be installed a maximum of 5 feet on centers. Spacers shall not be placed one above the other, but shall be staggered a minimum of 6 in..
7. All conduit joints shall be made watertight by means of a sealing compound before the coupling is installed. Joints in conduit shall be staggered, minimum space between joints in adjacent conduit shall be 6 inches.
8. When the required number of conduits have been installed, securely tie the assembly together at distances not exceeding 7 ft. Tie shall consist of three turns of No. 18 iron wire. Separate ties required for low tension and high tension conduit runs.
9. Duct envelope shall be vibrated to eliminate voids.
10. Ductbanks shall not be covered until the conduit installation has been observed by the utility company and Architect.
11. Warning tape shall be installed during backfilling and shall be placed approximately 12 in. above the conduits.
12. After the installation is completed, each conduit shall be cleaned and identified. A standard flexible mandrel and a stiff bristle brush shall be pulled through each conduit. The mandrel shall not be less than 12 in. long and the diameter approximately ¼ in. less than the conduit.

2.22 VARIABLE FREQUENCY DRIVES

- A. The variable frequency drives (VFD's) shall be solid state, with a Pulse Width Modulated (PWM) output waveform (VVI, six-step, and current source drives are not acceptable). The VFD package as specified herein shall be enclosed in a NEMA 1 enclosure, completely assembled and tested by the manufacturer. The VFD shall employ a full wave rectifier (to prevent input line notching), DC Line Reactor, capacitors, and Insulated Gate Bipolar Transistors (IGBT's) as the output switching device (SCR's, GTO's and Darlington transistors are not acceptable). The drive efficiency shall be 97 percent or better at full speed and full load. Fundamental power factor shall be 0.98 at all speeds and loads.
- B. Specifications at 480 volts:
 1. Input VAC +/-10 percent (capable of operation to 550 VAC), 3 phase, 48-63Hz. Output 0 - Input Voltage, 3 phase, 0 to 500 Hz for drives up to 75 HP; 0 to 120 Hz for drives over 75 HP. Operation above 60 Hz. shall require programming changes to prevent inadvertent high speed operation. Environmental operating conditions: 0 to 40 C @ 3 klz switching frequency, 0 to 3300 feet above sea level, less than 95 percent humidity, non-condensing. Units shall be UL, CUL and CA approved.
- C. All VFD's shall have the following standard features:
 1. All VFD's shall have the same customer interface, including digital display, keypad and customer connections; regardless of horsepower rating. The keypad is to be used for local control, for stepping through the displays and menus.
 2. The VFD shall give the user the option of either (1) displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last reference revised, or (4) cause a Warning to be issued, if the input reference (4-20mA or 2-10V) is lost; as selected by the user. The VFD shall provide a programmable relay output for customer use to indicate the loss of reference condition.
 3. The VFD's shall utilize plain English digital display (code numbers and letters are not acceptable). The digital display shall be a 40-character (2 line X 20 characters/line) LCD display. The LCD shall be backlit to provide easy viewing in any angle. All set-up parameters, indications, faults, warnings and other information must be displayed in words to allow the user to understand what is being displayed without the use of a manual or cross-reference table.

4. The VFD's shall utilize pre-programmed application macro's specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time.
 5. The VFD shall have the ability to automatically restart after an overcurrent, overvoltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between reset attempts shall be programmable. If the time between reset attempts is greater than zero, the time remaining until reset occurs shall count down on the display to warn an operator that a restart will occur.
 6. The VFD shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).
 7. The VFD shall be equipped with an automatic extended power loss ride-through circuit which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be one-cycle, based on full load and not inertia. Removing power from the motor is not an acceptable method of increasing power loss ride-through.
 8. The customer terminal strip shall be isolated from the line ground.
 9. Prewired 3-position Hand-Off-Auto switch and speed potentiometer. When in "Hand", the VFD will be started, and the speed will be controlled from the speed potentiometer. When in "Off", the VFD will be stopped. When in "Auto", the VFD will start via an external contact closure, and its speed will be controlled via an external speed reference.
 10. The drive shall employ three current limit circuits to provide trip free operation:
 11. The Slow Current Regulation limit circuit shall be adjustable to 125 percent (minimum) of the VFD's variable torque current rating. This adjustment shall be made via the keypad, and shall be displayed in actual amps, and not as percent of full load. The Rapid Current Regulation limit shall be adjustable to 170 percent (minimum) of the VFD's variable torque current rating. The Current Switch-off limit shall be fixed at 255 percent (minimum, instantaneous) of the VFD's variable torque current rating. The overload rating of the drive shall be 110 percent of its variable torque current rating for 1 minute every 10 minutes, and 140 percent of its variable torque current rating for 2 seconds every 15 seconds, input line fuses standard in the drive enclosure. VFD shall have a DC Line Reactor to reduce the harmonics to the power line and to increase the fundamental power factor.
 12. The VFD shall be optimized for a 4 kHz carrier frequency to reduce motor noise and provide high system efficiency. The carrier frequency shall be adjustable by the start-up engineer in ACH 501 units. The VFD shall have a manual speed potentiometer in addition to using the keypad as a means of controlling speed manually.
- D. All VFD's to have the following adjustments:
1. Five programmable critical frequency lockout ranges to prevent the VFD from continuously operating at an unstable speed.
 2. PI Setpoint controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the VFD, using the microprocessor in the VFD for the closed loop control.
 3. Two programmable analog inputs shall accept a current or voltage signal for speed reference, or for reference and actual (feedback) signals for PI controller. Analog inputs shall include a filter; programmable from 0.01 to 10 seconds to remove any oscillation in the input signal. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0-20 MA and 0-10 Volts. Additionally, the reference must be able to be scaled so that maximum reference can represent a frequency less than 60 Hz, without lowering the drive maximum frequency below 60 Hz.

4. Six programmable digital inputs for maximum flexibility in interfacing with external devices. One digital input is to be utilized as a customer safety connection point for fire, freeze, and smoke interlocks (Enable). Upon remote, customer reset (reclosure of interlock), drive is to resume normal operation.
- E. The following operating information displays shall be standard on the VFD digital display. The display shall be in complete English words (alpha-numeric codes are not acceptable):
1. Output Frequency
 2. Motor Speed (RPM, percent or Engineering units)
 3. Motor Current
 4. Calculated Motor Torque
 5. Calculated Motor Power
 6. DC Bus Voltage
 7. Output Voltage
 8. Heatsink Temperature
 9. Analog Input Values
 10. Keypad Reference Values
 11. Elapsed Time Meter
 12. kWh meter
- F. Speed Command Input shall be via:
1. Keypad.
 2. Two Analog inputs, each capable of accepting a 0-20mA, 4-20mA, 0-10V, 2-10V signal. Input shall be isolated from ground, and programmable via the keypad for different uses.
 3. Floating point input shall accept a three-wire input from a Dwyer photohelic (or equivalent type) instrument.
- G. Accessories to be furnished and mounted by the drive manufacturer:
1. Customer Interlock Terminal Strip-provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external interlocks and start/stop contacts shall remain fully functional whether the drive is in hand, Auto or Bypass.
 2. All wires to be individually numbered at both ends for ease of troubleshooting.
 3. Door interlocked thermal magnetic circuit breaker which will disconnect all input power from the drive and all internally mounted options. The disconnect handle shall be thru-the-door type, and be padlockable in the "Off" position.
 4. Manual transfer to line power via contactors. Include motor thermal overload and fuse or circuit breaker protection while in bypass operation. A three position selector switch to control the bypass contactor and the drive output contactor is to be mounted on the enclosure door. When in the "Normal" mode, the bypass contactor is open and the drive output contactor is closed. In the "Test" position both contactors are open, and in the "Bypass" position, the drive output contactor is open, and the bypass contactor is closed. The drive output contactor shall also open when a stop command is given, isolating the motor from the drive. Start/stop signals and safety interlocks will work in drive and bypass modes.

Pilot or LED's lights shall be provided for indication of "Normal" operation, "Bypass" operation, and "External Fault". All pilot lights shall be push-to-test type.
 5. Service contactor (drive input contactor) which provides the ability to service the drive (electrically isolate the drive while in bypass operation without having to remove power from the motor). The service contactor shall open when the drive is switched to bypass, and also be controlled by a switch which is mounted inside the drive enclosure so that its access is limited to service personnel only.

6. A class 20 bimetallic thermal motor overload relay shall be provided to protect the motor in bypass.
- H. Compliance to IEEE – 519:
1. The VFD manufacturer shall provide calculations specified to this installation showing that the Total harmonic Distortion for the VFD's, reflected into the electrical distribution system is limited to the level defined by IEEE - 519 (latest edition) for general systems. Harmonic analysis shall be included with VFD submittal for approval by the engineer.
 2. The VFD manufacturer shall conduct on site harmonic measurements before and after start up of the VFD's. Results of the measurements, showing harmonic contribution of the VFD's, shall be provided to the engineer one month after start up.
 3. Three phase A. C. input line reactors shall be provided as a minimum, with all VFD's. The line reactors are to provide attenuation of line side voltage transients, thus preventing overload trips or other unnecessary V.F.D. shutdown, and provide a reduction in harmonic distortion.
 4. Line reactors shall have the following requirements:
 - a. Three (3) percent line impedance (line side of drive).
 - b. 150 percent continuous current rating for one minute.
 - c. Saturation rating no less than 2.5 times the continuous current rating.
 - d. U.L. recognized.
- I. General: Install variable frequency drives where indicated, in accordance with manufacturer's published installation instructions, complying with recognized practices to ensure that variable frequency drives comply with requirements and serve intended purposes.
- J. Access: Provide access space around control panels for service as indicated, but in no case less than that recommended by manufacturer.
- K. Support: Install drive control panels on walls where indicated on drawings. Provide necessary Unistrut and structural steel to provide adequate support.
- L. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electrical Installer.
1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.
- M. Start-Up:
1. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.
- N. Adjusting and Cleaning:
1. Alignment: Check compatibility of control panel to motor and where necessary, adjust frequency and provide necessary filters to assure noise free operation of motors. Verify response from control panel to motor to assure turn down ratio specified and that static pressure signals are being received and that drives are controlling as specified and within recommended tolerances by manufacturer. Provide start-up report prepared by manufacturers representative to assure operation is as specified.
 2. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

- O. Acceptable Manufacturers:
 - 1. Allen – Bradley
 - 2. ABB
 - 3. Siemens
 - 4. Square D
 - 5. Or equal

2.23 STANDBY ELECTRICAL SYSTEM

- A. Provide one new 350 KW, 437.5 kVA, 277/480V, 3 phase, 4 wire and one 80 kW, 100 kVA, 277/480V, 3 phase, 4 wire at .8 PF standby power rated natural gas generator sets mounted in perfect alignment on an all welded, fabricated steel sub-base which shall allow for attachment of all necessary engine and generator accessories.

SPECIAL NOTE: Generator shall be warranted by manufacturer to develop full load performance while operating at 7.0 inches of available gas pressure at the inlet to the generator factory connection.

- 1. Acceptable Manufacturers
 - a. Kohler
 - b. Caterpillar
 - c. Onan/Cummings
 - d. Or equal

- B. Engine:
 - 1. Water cooled with uni-mounted radiator. Provide starter and all field wiring required by approved manufacturer.
 - 2. Dry-type replaceable element air cleaners.
 - 3. 12 volt starting motor, 12 volt, three ampere battery charging alternator.
 - 4. Engine instrument panel to include ammeter, lube oil pressure gauge, lube oil temperature gauge, water temperature gauge, and hour meter.
 - 5. Engine-mounted safety control to provide alarm signals for engine shutdown in event of low oil pressure, high coolant temperature, overspeed, over crank, and pre-alarms for high water temperature and low oil pressure.
 - 6. Jacket water heater, 2000 watt, 120 or 208 volt, single phase or as recommended by generator manufacturer.
 - 7. Full flow lube oil filters and bypass oil filter.

- C. Generator: 350 KW, 437.5 kVA, 277/480 volt, 3 phase, 4 wire, 60 Hz, 1800 RPM revolving field type main generator with brushless exciter.
Voltage regulation + 1 percent.

- D. Cooling System: Unit-mounted radiator with flange attached.

- E. Starting System: 12 volt heavy duty lead acid storage battery, connected for 12 volt DC output.
Battery rack, cables, and connectors shall be provided.
Provide a 10 ampere battery charger fed from a 120 volt, single phase, 60 Hz service. Battery charger to include high and low battery voltage alarm relays for derangement panel. Battery charger shall meet NFPA 110 standards.

- F. Exhaust System: Furnish one Maxim M-51 3 in. critical silencer, 3 in. side inlet, and one 3 in. end outlet complete with two 3 in. companion flanges. Generator shall be Tier 3 compliant and meet all applicable emission standards.
- Furnish one 3 in. x 18 in. flexible stainless steel exhaust connector, flanged on one end, threaded nipple on opposite end.
- G. Vibration Isolators: Set of four Korfund rubber type vibration isolators for installation between steel base and concrete foundation.
- H. Generator Control Panel:
1. To completely control operation of engine generator set. Panel to have automatic start control, AC volt meter, AC ammeter, pointer type frequency meter, volt meter, ammeter and selector switch. Alarm signals to indicate pre-low oil pressure, pre-high coolant temperature, and alarm signals to shut down engine in event of a low oil pressure, high coolant temperature, engine overspeed, or overcrank. Lights on face of panel to indicate failure. Provide dry contacts for remote disarrangement signal & louvers.
 2. Terminal strip shall be included with alarms and prewarning devices prewired for remote annunciator specified herein. Provide wiring between generator and remote annunciator panel. Generator control switch shall be mounted on control panel face. A flashing light for selector switch "OFF" shall be included.
 3. Provide molded case line circuit breakers mounted on generator in oversized terminal box.
 4. Life safety circuit breaker shall be LSIG type. Life safety branch from generator shall be selectively coordinated.
- I. Automatic Transfer Switch:
1. Provide automatic transfer switches as shown on drawings for operation on 277/480 volts, three phase, four pole wire operation. Units to be housed in a NEMA 1 enclosure and shall be four pole. Entire switch shall be listed under UL 1008 and shall be rated for 42,000 AIC and fed from a current limiting breaker on the normal side.
 - a. Acceptable Manufacturers:
 - 1) ASCO
 - 2) Kohler
 - 3) Russ Electric
 - 4) Onan
 - 5) Or equal
 2. Unit shall be provided with standard and optional accessories as follows.
 - a. Voltage and Frequency Sensing:
 - 1) Close differential voltage sensing on all phases of normal pickup adjustable 85-100 percent. Dropout 75-98 percent
 - 2) Voltage sensing of emergency source. Adjustable pickup 85-100 percent.
 - 3) Frequency sensing of emergency source. Adjustable pickup 90-100 percent.
 - b. Time Delays:
 - 1) Time delay to override momentary normal source outages. Adjustable 0.5 to 6 seconds.
 - 2) Retransfer to normal with 5 minute cooldown timer.

- c. Engine Control:
 - 1) Contact to close when normal source fails.
 - 2) Contact to open when normal source fails.
 - 3) Test switch to simulate normal source failure.
- d. Indicators: Pilot lights to indicate switch in normal position or emergency position.
- e. Auxiliary Contacts: Two to close on normal. Two to close on emergency.
- 3. Accessories:
 - a. Plant exerciser.
 - b. Fused output for damper operators.
 - c. Option 27 – in-phase monitor (motor load transfer).
 - d. Option 6A – manual transfer to normal source.
 - e. Number 31A – elevator control transfer module. A load control circuit consists of two sets of single pole, double throw contacts that operate 3 seconds before transfer in either direction. Contacts rated 3 amperes, 208 volts AC or 10 amperes, 32 VDC, for signal to elevator of generator power available. Provide 2 #14AWG conductors in ¾ in. conduit, interlock wiring to each elevator controller from each switch controlling elevator power.
 - f. Form “C” contact closure for remote monitoring by Building Management System.
- J. Remote Annunciator Panel: A flush mounted panel shall include a visual signal that battery charger is functioning properly and both audible and visual signals. Annunciator shall meet NFPA 110 Standards:
- K. Audible signal shall have a silencing switch. A lamp test button shall be provided.
- L. Factory Testing: A certified factory test to be conducted at 1.0 power factor.
 - 1. Factory test generator for four hours, one hour each at 25 percent, 50 percent, 75 percent and 100 percent load. Take standard readings and submit test reports for approval prior to shipment.
 - 2. Perform a field test with a load bank for four hours, one hour each at 25 percent, 50 percent, 75 percent, and 100 percent. Take standard readings and submit test report for review and approval.
 - 3. Submit NFPA 110 Test Report for review and approval.
- M. Miscellaneous: Necessary lube oil and anti-freeze.
- N. Equipment Testing and Instruction Manual and Drawings:
 - 1. Operating instruction and maintenance manuals shall contain the following information:
 - a. Operating Instruction
 - b. Replacement Parts
 - c. Wiring Diagram
 - d. Maintenance
 - 2. The entire emergency system shall be field test operated for two hours. A normal power failure shall be simulated. The engine generator unit shall automatically start, come up to speed, and assume full emergency load.
 - 3. Custodians of the equipment shall be present during test. At that time they shall be instructed in operation and maintenance.

4. Upon completion of tests, written reports containing results shall be submitted. Test reports shall contain readings taken at 30 minute intervals along with all other pertinent test information.
 - a. Ambient Temperature
 - b. Oil Pressure
 - c. Battery Charge Rate
 - d. AC Volts
 - e. AC Amperes All Phases
 - f. Frequency
 - g. Kilowatts
 - h. Power Factor

- O. Generator Outdoor Housing
 1. The engine generating set shall be factory installed in a weatherproof outdoor housing. The housing shall provide year round generating set protection against adverse weather and environmental conditions. The enclosure shall be sound attenuated and meet Federal Specifications.
 2. The weatherproof shelter shall be constructed or welded and bolted reinforced aluminum, 14 gauge walls and 14 gauge floor plate minimum. All metal parts shall be prime coated and finished painted.
 3. The shelter assembly shall have shuttered air openings on front and sides with mesh screens covering side shutters. The air shutters shall be opened by four 22 volt AC motors when the generating set operates. Motors shall be spring loaded to close shutters when set stops.
 4. Hinged double doors on each side and one door in rear of the shelter shall allow easy access to engine generator and controls. All door handles shall be key lock design.
 5. Vibration isolators of the open coil spring type, selected for 3 inch (76mm) static deflection, shall be furnished and installed. The number of isolators shall be as recommended by the generator set manufacturer, and complete details shall be included in the Submittals. Anchor bolts, nuts and sleeves shall be supplied with recommended Foundation Plan.
 6. The weatherproof housing shall allow installation of the silencer outside the enclosure. Provide critical type silencer.
 7. Provide sound deadening materials, baffles, hoods, required. to reduce noise levels to 75DBA at 3 meters in any direction.

- P. Owner Training: Provide four hours of Owner training after testing of unit.

- 2.24 UNINTERRUPTIBLE POWER SUPPLY, UPS
 - A. General
 1. This specification describes a continuous duty, three-phase, solid-state, static Uninterruptible Power System (UPS) hereafter referred to as the UPS. The UPS shall contain a full rated input rectifier / boost converter (hereafter referred to as Input Converter), output inverter, and 10 percent battery charging circuit. The system shall also contain a continuous duty bypass static switch, internal mechanical bypass, removable hot swap battery plant, and LCD interface display. All of the above system components are housed in a single enclosure. Maintenance bypass and extended battery is required to meet this specification shall be contained in matching enclosures with all interconnecting cabling included. All programming and miscellaneous components for a fully operational system as described in this specification shall be provided as part of the UPS.

B. Standards

1. The UPS shall meet the requirements of the following standards:
 - a. IEEE 587-1980/ANSI C62.41 1980 Standards for Surge Withstand Ability.
 - b. FCC rules and regulations of Part 15, Subpart J, Class A.
 - c. UL listed under 1778, Standards for Uninterruptible Power Supply Equipment.
 - d. UL Canada (cUL).
 - e. NEMA PE 1 (National Electrical Manufacturers Association) - Uninterruptible Power Systems.
 - f. NEMA 250 (National Electrical Manufacturers Association) – Enclosures for Electrical Equipment (1000 Volts Maximum).
 - g. IEEE 519-1992 Standard Practices and Requirements for Harmonic Control in Electrical Power Systems
 - h. NFPA 70 – National Electrical Code.
 - i. ISO 9001.
 - j. ISO 14001
 - k. Occupational Safety & Health Administration (OSHA).

C. Submittals

1. Submittals shall contain the following documentation:
 - a. Installation Drawings: Indicate electrical characteristics and connection requirements. Provide cabinet dimensions; battery type, size, dimensions, and weight; detailed equipment outlines, weight, and dimensions; location of conduit entry and exit; single-line diagram, control, and external wiring requirements; heat rejection, full and part load efficiencies and air flow requirements.
 - b. Product Data: Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements.

D. Warranty

1. UPS Module: The UPS shall be covered by a full parts and labor warranty from the manufacturer for a period of 12 months from date of acceptance by customer.
2. Battery: The battery manufacturer's warranty shall be passed through to the final customer and shall have a minimum period of one year.

E. Maintenance, Accessibility and Self Diagnostics

1. All UPS subassemblies, as well as the battery, shall be accessible from the front. UPS design shall provide maximum reliability and minimum MTTR (mean time to repair). To that end, the UPS shall be equipped with a self-test function to verify correct system operation. The self-test function shall identify the subassembly-requiring repair in the event of a fault. The electronic UPS control and monitoring assembly shall therefore be fully microprocessor based, thus doing away with all potentiometer settings. This shall allow:
 - a. Auto-compensation of component drift;
 - b. Self-adjustment of replaced subassemblies;
 - c. Extensive acquisition of information vital for computer-aided diagnostics (local or remote);
 - d. A socket for connection to a computer-aided diagnostics system.
2. The UPS shall be repairable by replacing standard subassemblies requiring no adjustments or settings. Communication with a remote maintenance system shall be possible.

- F. System Description and Operation
1. Acceptable Manufacturer(s): The specified equipment shall be manufactured by American Power Conversion (APC) or approved manufacturer in compliance with specifications. Liebert, Mitsubishi are acceptable equals.
 2. UPS Design Requirements.
 - a. Output Power Continuous Rating: The continuous output power rating of the UPS shall be shall be 24KW, 30.0 KVA at a 0.8 lagging power factor.
 - b. Input Voltage: 208 VAC – 25 percent / +15 percent, 3 phase, 4 wire plus ground.
 - c. Output voltage: 208 VAC 3 phase, 4 wire plus ground.
 - d. Battery Autonomy: The UPS shall have battery strings such that it shall be capable of operating at full load for 7 minutes at 0.8 PF output at a temperature of 25 deg. C on battery power.
 - e. Battery Type: Hot swappable valve regulated sealed lead acid (VRLA).
 3. AC Input Characteristics.
 - a. Input Frequency: 60 Hz (- 25 percent to + 15 percent)
 - b. Maximum Input Current at Low Line Voltage: 35 A with 125 percent continuous overload.
 - c. Input Power Factor: > .98 lagging for loads greater than 50 percent and > .95 for loads greater than 15 percent.
 - d. Harmonic Distortion of Input Current Wave Form: less than 5 percent at full load.
 - e. Power walk-in: Linear 0 to 100 percent over a 15-second period.
 - f. Magnetizing Inrush Current: Less than nominal input current for less than one cycle.
 4. AC Output Characteristics.
 - a. Voltage Regulation: + 1.0 percent for balanced load; + 1.75 for 50 percent unbalanced load; + 2.5 percent for 100 percent unbalanced load
 - b. Frequency: 60 Hz +1 percent (or selectable up to 4 percent). 60 Hz + 0.1 percent when free running.
 - c. Voltage Distortion: Maximum 2 percent total (THD) and 1 percent any single harmonic on 100 percent linear loads.
 - d. Voltage Transient (Step Load) Response:
 - 1) + 3 percent for 50 percent step load change
 - 2) + 5 percent for 100 percent step load change
 - 3) + 1 percent for loss or return of AC input power or manual transfer at full load.
 - e. Voltage Recovery Time: Return to within 1 percent of nominal value within 50 milliseconds.
 - f. Phase Angle Displacement: 120 deg. + 1 degrees for balanced load; 120 deg. + .3 degrees for 100 percent unbalanced load
 - g. Non-Linear Load Capability: Output voltage total harmonic distortion shall be less than 3 percent when connected to a 100 percent non-linear load with a crest factor not to exceed 3.0.
 - h. Slew Rate: 1 Hz/second maximum (or selectable up to 2.0 Hz/sec).
 - i. Power Factor: 0.8 at the rated volt-amperes (VA)
 - j. Inverter Overload Capability:
 - 1) 120 percent of rated load for 1 minute
 - 2) 145 percent of rated load for 30 seconds
 - 3) Bypass Overload Capability: > 800 percent for 500 milliseconds, 125 percent continuous.
 - 4) Overall AC to AC efficiency with fully charged battery 93.5 percent at full load and 92.5 percent at 50 percent load.

5. DC Bus.
 - a. Normal DC voltage 192VDC.
 - b. Maximum DC current at cutoff voltage will be 29 A.
 - c. End of discharge 152VDC
6. Modes of Operation.
 - a. The UPS module shall be designed to operate as a double conversion, on-line reverse transfer system in the following modes.

Normal: The input converter and output inverter shall operate in an on-line manner to continuously regulate power to the critical load. The input and output converters shall be capable of full battery recharge while simultaneously providing regulated power to the load for all line and load conditions within the range of the UPS specifications.
 - b. Battery: Upon failure of the AC input source, the critical load shall continue being supplied by the output inverter, which shall derive its power from the battery system. There shall be no interruption in power to the critical load during both transfers to battery operation and retransfers from battery to normal operation.
 - c. Recharge: Upon restoration of the AC input source, the input converter and output inverter shall simultaneously recharge the battery and provide regulated power to the critical load.
 - d. Static Bypass: The static bypass shall be used to provide transfer of critical load from the Inverter output to the bypass source. This transfer, along with its retransfer, shall take place with no power interruption to the critical load. In the event of an emergency, this transfer shall be an automatic function.
 - e. Internal Mechanical Bypass: As a standard feature, the UPS shall be equipped with an internal, make before break, bypass switch. This switch shall mechanically bypass the UPS for times where maintenance is required.
7. Component Description.
 - a. Rectifier / Battery Charger

The input power converters of the system shall constantly control the power imported from the mains input of the system, to provide the necessary UPS power for precise regulation of the DC bus voltage, battery charging, and Main Inverter regulated output power.:

 - 1) Soft-Start Operation: As a standard feature, the UPS shall contain soft-start functionality, capable of limiting the input current from 0-100 percent of the nominal input over a default 15 second period, when returning to the AC utility source from battery operation. The change in current over the change in time shall take place in a linear manner throughout the entire operation. ($di/dt = \text{constant}$)
 - 2) Input Current Total Harmonic Distortion: The input current THDI shall be held to 5 percent or less at full system, while providing conditioned power to the critical load bus, and charging the batteries under steady-state operating conditions. This shall be true while supporting loads of both a linear or non-linear type. This shall be accomplished with no additional filters, magnetic devices, or other components.
 - 3) The input converter shall control and limit the input current draw from utility to 150 percent of the UPS output. During conditions where input current limit is active, the UPS shall be able to support 100 percent load, charge batteries at 10 percent of the UPS output rating, and provide voltage regulation with mains deviation of up to +/-15 percent of the nominal input voltage
 - 4) Modular Assembly: The rectifier/battery charger assembly shall be constructed of modular design to facilitate rapid maintenance.
 - 5) Charging Levels: The battery charging shall keep the DC bus float voltage of +/- 220v, +/-1 percent

- 6) Battery Charge Current Limit: The UPS shall be capable of limiting the energy sourced from the mains for purposes of battery charging. As a default setting, the battery charge energy will be set to 100 percent of its nominal value. When signaled by a dry contact, (such as from an emergency generator) the UPS shall be capable of limiting the battery charge energy taken from the mains. This shall take place in user selectable increments of 75 percent, 50 percent, 25 percent, 10 percent and 0 percent of the nominal charge power. The selection shall be made from the UPS front panel display/control unit.
 - 7) Temperature Compensated Charging: The battery charger shall be equipped with a temperature probe to enable temperature compensated charging and adjust the battery float voltage to compensate for the ambient temperature using a negative temperature coefficient of 3 mV per cell per degree Celsius at a nominal temperature of 25 deg. C.
 - 8) Capacity: The rectifier/battery charger shall have sufficient capacity to support a fully loaded inverter and fully recharge the battery to 95 percent of its full capacity within 6-8 hours.
- b. Inverter.
 - 1) The UPS output shall be derived from a Pulse Width Modulated (PWM) IGBT inverter design. The inverter shall be capable of providing the specified precise output power characteristics (specified in section 2.2.C) while operating over the battery voltage range. The inverter assembly shall be constructed as a modular assembly to facilitate rapid maintenance.
 - c. Static Bypass.
 - 1) As part of the UPS, a system static bypass switch shall be provided. The system static bypass shall provide no break transfer of the critical load from the Inverter output to the static bypass input source during times where maintenance is required, or the inverter cannot support the critical bus. Such times may be due to prolonged or severe overloads, or UPS failure.
8. Uninterrupted Transfer: The static bypass transfer switch shall automatically cause the bypass source to assume the critical load without interruption after the logic senses one of the following conditions:
 - a. Inverter overload exceeds unit's rating.
 - b. Battery protection period expired and bypass current is available.
 - c. Inverter failure.
 9. Interrupted Transfer: If the bypass source is beyond the conditions stated below, the UPS will make an interrupted transfer (not less than 500 msec. in duration).
 - a. Bypass voltage greater than + 10 percent, -10 percent from the UPS rated output voltage.
 - b. Bypass frequency greater than + 2 Hz from the UPS rated output frequency.
 10. Automatic Uninterrupted Forward Transfer: The static bypass transfer switch shall automatically forward transfer power from the bypass to the rectifier / inverter, without interruption, after the UPS inverter is turned "ON", after an instantaneous overload-induced reverse transfer has occurred and the load current returns the UPSs nominal rating or less.
 11. Manual Transfer: A manual static transfer shall be initiated from the UPS Control Panel by turning the UPS inverter off.
 12. Overload Ratings: The static bypass transfer switch shall have the following overload characteristics after which time a thermal protection device will engage to protect the static bypass.
 - a. 800 percent of UPS output rating for 0.5 seconds (one cycle).
 - b. 150 percent for 30 seconds.
 - c. 125 percent of UPS output rating continuous.

13. Microprocessor Controlled Logic.
 - a. The full UPS operation shall be provided through the use of microprocessor controlled logic. All operation and parameters are firmware controlled, thus eliminating the need for manual adjustments or potentiometers. The logic shall include a self-test and diagnostic circuitry such that a fault can be isolated down to the printed circuit assembly or plug-in power assembly level. Every printed circuit assembly or plug-in power assembly shall be monitored. Diagnostics shall be performed via a PC through the local diagnostics port on the UPS.
 14. Standard Communication Panel.
 - a. The UPS will include a standard easy to use communication panel. Included will be a backlit, color graphic animated LCD display, LED's and audible indicators for UPS On line, UPS fault, UPS on battery and UPS off line. The UPS communication panel will include UPS "ON" and UPS "OFF" pushbuttons that will permit the user to safely command the UPS on or off without risk of load loss.
- G. System Controls and Indicators
1. Display Unit: A microprocessor controlled display unit shall be located on the front of the system. The display shall consist of an alphanumeric display with backlight, an alarm LED, and a keypad consisting of pushbutton switches. The following metered data, shall be available on the alphanumeric display:
 - a. Measurements, status indications and events.
 - 1) Bar-graphs and waveforms of the measured values.
 - 2) Personalization menu protected by a password, used to make specific settings.
 - 3) Event log with time stamping.
 - 4) Access to all measurements.
 2. System Parameters Monitored (data displayed): The visual display will display the following system parameters based on true RMS metering:
 - a. Measurements:
 - 1) Year, Month, Day, Hour, Minute, Second of occurring events.
 - 2) Source Input Voltage
 - 3) Input Frequency
 - 4) Output AC voltage
 - 5) Output AC current
 - b. Status indications and events:
 - 1) Static bypass switch on
 - 2) EPO Active
 - 3) Mechanical bypass activated
 - 4) External bypass switch (Q3) activated
 - 5) Battery discharged
 - 6) Return from low battery
 - 7) Low battery
 - 8) Load not powered from UPS
 - 9) UPS in bypass
 - 10) Runtime calibration aborted
 - 11) Runtime calibration started
 - 12) Runtime calibration complete
 - 13) Battery self test aborted
 - 14) Battery self test started
 - 15) Battery self test completed
 - 16) Number of battery modules decreased
 - 17) Number of battery modules increased
 - 18) Fan fault
 - 19) SBS fault

- 20) System not in sync.
 - 21) Bypass not available, frequency/voltage out of range
 - 22) Mains voltage/frequency out of range
 - 23) Site wiring fault
 - 24) Low battery voltage shut down
 - 25) Defective battery detected
 - 26) Runtime is below alarm threshold
 - 27) Load is above alarm threshold
 - 28) Battery over-voltage warning
 - 29) Battery over-temperature warning
 - 30) Emergency power supply fault
 - 31) Output overloaded
3. Display of operating curves: The graphical display shall be capable of displaying curves and bar graphs of the above-mentioned measured values for significant periods.
 4. Time-stamped historical events: This function shall time-stamp and store all important status changes, anomalies and faults and make this information available for automatic or user-requested consultation; it shall interpret the events and indicate remedial measures if applicable.
 5. Controls: The following controls or programming functions shall be accomplished by use of the display unit. Pushbutton membrane switches shall facilitate these operations.
 - a. Silence audible Alarm
 - b. Set the alphanumeric display language
 - c. Display or set the date and time
 - d. Enable or disable the automatic restart feature
 - e. Transfer critical load to and from static bypass
 - f. Test battery condition on demand
 - g. Set intervals for automatic battery tests
 - h. Adjust set points for different alarms
 - i. Program the parameters for remote shutdown.
 6. Front Panel Interface: The following shall make up the UPS front panel user interface.
 - a. Load On
When Green, this LED indicates the load is being supported by the UPS output
 - b. On Battery
When Yellow, this LED indicates the UPS is running from Battery power
 - c. Bypass
When Yellow, this LED indicates the load is being supported by static bypass/mechanical bypass
 - d. Bypass
When Yellow, this LED indicates the load is being supported by static bypass/mechanical bypass
 7. Push Button User Controls
 - a. Up Arrow
 - b. Down Arrow
 - c. Help Key
 - d. Escape Key
 - e. Enter Key

8. Emergency Power Off (EPO): The UPS shall be equipped with a local emergency power off button and dry contact input that can be used to command UPS shut down remotely. Activation of this command shall lead to the following actions:
 - a. inverter shutdown
 - b. opening of the static bypass switch and the battery circuit breaker
 - c. opening of an isolated dry contact on the programmable relay board
 9. RJ-45 Interface port for remote communications with a network via web browser or SNMP, or APC InfraStruXure Manager.
 10. Dry Contacts: The UPS shall be provided standard with a programmable input/output relay board. This board shall have eight dry contacts, i.e. six for input signals and two for output signals. Contacts shall be programmed as:
 - a. Low battery
 - b. Load on battery power
 - c. Load on automatic bypass
 - d. Load on UPS
 - e. Common Fault
 - f. UPS Off

The contacts will be programmable normally open or normally off and will change state to indicate the operating status. The contacts will be rated at 2.0 A (250 VDC / 30 VDC).
- H. Mechanical Design and Ventilation
1. Enclosure: The UPS shall be housed in a freestanding enclosure with dead front construction. The mechanical structure of the UPS shall be sufficiently strong and rigid to withstand handling and installation operations without risk. Access to UPS subassemblies shall be through the front or top. The sheet-metal elements in the structure shall be protected against corrosion by a suitable treatment, such as zinc electroplating, bichromating, epoxy paint or an equivalent.
 2. Cable Access: The standard UPS shall accommodate top or bottom entry cables.
 3. Cabinet Weights and Dimensions: The width of the UPS System is 32.8 (in Inches) and has an approximate weight of 1050 lbs.
 4. Ventilation and Heat Rejection: The UPS shall be designed for forced air-cooling. Air inlets shall be provided from the front bottom of the UPS enclosure. Air exhaust shall be from the top rear portion of the unit. Full load heat rejection is 4777 BTU /hour.
- I. Battery
1. The UPS battery shall be of modular construction made up of user replaceable, hot swappable, fused, battery modules. Each battery module shall be monitored to determine the highest battery unit temperature for use by the UPS battery diagnostic, and temperature compensated charger circuitry.
 2. The battery jars housed within each removable battery module shall be of the Valve Regulated Lead Acid (VRLA) type.
 3. The UPS shall incorporate a battery management system to continuously monitor the health of each removable battery module. This system shall notify the user in the event that a failed or weak battery module is found.

J. Accessories

1. External Control and Communications Devices
The following control and communications devices shall be provided in the UPS module.
2. Network Adaptor:
 - a. The Ethernet Web/SNMP Adaptor shall allow one or more network management systems (NMS) to monitor and manage the UPS in TCP/IP network environments. The management information base (MIB) shall be provided in DOS and UNIX "tar" formats. The SNMP interface adaptor shall be connected to the UPS via the RS232 serial port on the standard communication interface board.
 - b. The UPS, in conjunction with a network interface card, shall be capable of gracefully shutting down one or more operating systems during when the UPS is on reserve mode.
 - c. The UPS shall also be capable of using an RS232 port to communicate by means of serial communications to gracefully shut down one or more operating systems during an on battery situation.
3. Remote UPS Monitoring:
The following three methods of remote UPS monitoring shall be available:
 - a. Web Monitoring: Remote monitoring shall be available via a web browser such as Internet Explorer.
 - b. RS232 Monitoring: Remote UPS monitoring shall be possible via either RS232 or contact closure signals from the UPS.
 - c. Simple Network Management Protocol (SNMP): Remote UPS Monitoring shall be possible through a standard MIB II compliant platform.

K. Factory Assisted Start-Up

1. Factory trained service personnel shall perform the following inspections, test procedures, and on-site training:
 - a. Visual Inspection:
 - 1) Inspect equipment for signs of damage.
 - 2) Verify installation per manufacturer's instructions.
 - 3) Inspect cabinets for foreign objects.
 - 4) Inspect Battery Units.
 - 5) Inspect Power Module(s).
 - b. Mechanical Inspection:
 - 1) Check all UPS and external maintenance bypass cabinet internal power wiring connections.
 - 2) Check all UPS and external maintenance bypass cabinet terminal screws, nuts, and/or spade lugs for tightness.
 - c. Electrical Inspection:
 - 1) Verify correct input and bypass voltage.
 - 2) Verify correct phase rotation of all mains connections.
 - 3) Verify correct UPS control wiring and terminations.
 - 4) Verify voltage of all battery modules.
 - 5) Verify neutral and ground conductors are properly landed.

- d. Site Testing:
 - 1) Ensure proper system start-up.
 - 2) Verify proper firmware control functions.
 - 3) Verify proper firmware bypass operation.
 - 4) Verify proper maintenance bypass switch operation.
 - 5) Verify system set points.
 - 6) Verify proper inverter operation and regulation circuits.
 - 7) Simulate utility power failure.
 - 8) Verify proper charger operation.
 - 9) Document, sign, and date all test results.
 - e. On-Site Operational Training: During the factory assisted start-up, operational training for site personnel shall include key pad operation, LED indicators, start-up and shutdown procedures, maintenance bypass and AC disconnect operation and alarm information.
- L. Field Quality Control & Service Organization
- 1. Field Service Engineer Qualifications
 - a. The manufacturer must employ a 7 X 24 nation wide field service organization with rapid access to all regions of the nation. The responding service professionals must be factory-trained engineers with an accredited and proven competence to service three phase UPS systems.
 - 2. Spare Parts
 - a. Field Engineers must have immediate access to recommended spare parts with additional parts storage located in regional depots. Additional spare parts shall be accessible on a 7 x 24 basis from the national depot and must be expedited on a next available flight basis or via direct courier (whichever mode is quickest).
 - 3. Maintenance Training
 - a. The manufacturer shall make available to the customer various levels of training ranging from basic UPS operation to UPS maintenance.
 - 4. Maintenance & Service Contracts
 - a. The manufacturer shall offer preventative maintenance and service contracts covering both the UPS system and the battery bank. Accredited professional service engineers, employed exclusively in the field of critical power systems service shall perform all maintenance and service. The manufacturer shall also offer extended warranty contracts.
- M. Owner Training: Provide four hours of Owner training after system start-up.
- 2.25 FIRESTOP SYSTEMS:
- A. General: Provide firestopping at all new and existing fire-rated construction where penetrated by the Work of this Section.
 - B. Refer to Section 078400 - Firestopping, for all product requirements for maintaining integrity of fire-rated construction at penetrations.

2.26 STAGE LIGHTING AND DIMMING SYSTEM

- A. The Electrical Contractor, herein referred to as the EC, shall provide all labor, materials, services, and equipment to set, install, interconnect, and test the dimming and control systems as shown on the drawings and as specified herein for all auditorium, black box theater, and TV studio spaces Drawings, specifications, and other related documents shall apply to all work.
- B. Work of this Section includes, but is not limited to, the following:
1. Installation of wiring devices, back boxes, panels, conduits, wiring, dimmer racks and modules, signal cables, DMX splitters, and architectural processor provided by others, including:

Division of Responsibilities ITEM	Electrical Contractor		Stage Lighting Contractor, Sections 110610 and 110640	
	Furnish	Install	Furnish	Install
High voltage conduit and wire (Line Voltage)	X	X		
High Voltage wire terminations	X	X		
High voltage wire testing and labeling	X	X		
Stage Emergency Lighting Transfer switch		X	X	
Installation of stage ECR rack and power		X	X	
Conduit for ECR rack low voltage devices	X	X		
Labeling back boxes and conduit	X	X		
Dimming System Low voltage conduit and back boxes	X	X		
Low voltage wire for dimming system		X	X	
Termination of Dimming system low voltage wire			X	X
Dimming System Control wire continuity, testing and labeling			X	X
Low voltage wire for Fire alarms, security or other	X	X		
Conduit, raceways and interconnecting boxes	X	X		
Junction Boxes	X	X		
Provide power feed and termination to Batten Hoists	X	X		
Provide conduit for batten hoist controls	X	X		
Mount Batten hoist control stations		X	X	
Low voltage wire and controls for batten hoists	X	X		
Dimmer Racks or cabinets		X	X	
Provide terminations for all dimmer load circuits	X	X		
Control Devices			X	X
Architectural Control - House lighting back boxes		X	X	
Circuit Distribution Raceways and Boxes		X	X	
Mounting of Stage Circuit Raceways to battens		X	X	X
Lighting Fixture Installation and testing			X	X
Lighting Fixture Focus			X	X
Lighting Initial programming			X	X

2. Coordination with the System Integrator for a complete theatrical dimming system.
 3. All power distribution devices, conduit and wire as required in this Section and related Specification Sections listed herein.
 4. Provide all disconnects and power feeds as required for dimmer racks
 5. Provide continuous liaison with the Construction Manager(CM) and other trades during demolition, construction, and coordinate delivery schedules and installation of equipment.
 6. The EC shall provide coordination drawings for approval showing all elements of the items in this section in an AutoCAD® file Release 2012 or more recent due prior to the installation of any materials on site. This drawing shall be executed using a cross-reference of the appropriate areas of the building as a background supplied by the Architect. Minimum drawings shall include plan and section of pertinent areas noting panels, conduit size, elbows, bends and wiring devices. All elements of this drawing shall be on no more than three layers all prefixed with "-ELEC". All items shall be drawn full size with "color by layer". Hard (paper) and soft (digital) copies of this file shall be requested and used by the Architect and Theatre Consultant.
 7. Materials shall be as specified under Division 260000
 8. This specification shall be considered as an outline form and other appurtenances that may be required for the efficient and safe operation of the dimming and control systems specified in this section shall be furnished by the EC, the same as if specified herein.
 9. All work shall be manufactured and installed in accordance with the latest editions of applicable publications and standards of the following organizations:
 - a. National Electric Code (NEC) and all prevailing local regulations
 - b. Underwriter's Laboratories, Inc. (UL)
 - c. National Electrical MFRS. Association (NEMA)
 - d. Federal Communication Commission (FCC)
 - e. United States Institute of Theater Technology (USITT)
 10. The EC shall provide all mounting and mechanical installations and shall verify all mounting conditions.
 11. Any materials installed which shall not present an orderly and reasonably neat or workmanlike appearance shall be removed and replaced when so directed by the CM at the EC's expense
 12. Any quantities, measurements or dimensions listed or shown are for the convenience of the EC in the preparation of his estimate, but will not relieve the EC of his responsibility for the determination of the exact measurements required for a complete job.
- C. SYSTEM OUTLINE
1. The theatrical dimming system consists of wiring devices, both low and line voltage, theatrical dimmer rack, lighting control rack and remote consoles.
 2. The DMX 512 control signal shall be generated by various consoles and devices, and shall be connected to the dimmer racks via conduit runs and appropriate low voltage cables specified herein. Access to the DMX network shall be provided via the Lighting Control Rack (LCR).
 3. All equipment shall be the coordinated system integrated by the SI in coordination with the EC.
 4. The specified dimming and control components are called out in terms of products as manufactured by Electronic Theater Controls, Electronics Diversified, Union Connector and others. This equipment is fully described in the Contract Documents. Complete technical data is also available from the manufacturers. All catalog numbers are those shown on Manufacturer's data sheets and drawings unless otherwise noted.

5. The dimming equipment, wiring devices and control devices shall be set into place and installed by the EC. It shall be the EC's responsibility to run all conduit and wiring for line and low voltage circuits, and make only line voltage terminations at the wiring devices.
6. When the EC is finished, a fully working and tested system will be turned over to the Owner. If mention has been omitted of any items of the work or materials usually furnished for, or necessary to the completion of the electrical work or if there are conflicting points in the specifications and/or drawings, the Architect's attention should be called to such items in sufficient time for a formal addendum to be issued.

D. SYSTEM COMMISSIONING

1. At no time shall the equipment furnished be energized prior to the SI authorized commissioning
2. The EC shall notify the SI within at least two weeks time for system commissioning.
3. The EC shall confirm in writing that the following conditions have been met prior to scheduling system commissioning.
 - a. Arrangements shall be made for access to all equipment. Scaffolding, lifts or any other OSHA approved method shall be acceptable.
 - b. All dimmer racks shall be installed and wired.
 - c. All control wire shall be installed.
 - d. All distribution equipment shall be completely installed.
 - e. Continuity checks for the entire system shall have been performed and failures remedied.

E. INSPECTION AND TESTING

1. Field Check-out & Final Approvals
 - a. Furnish all equipment and instruments necessary for testing the complete wiring system during the progress of the work as well as after installation. Tests shall be demonstrated to the satisfaction of the Owner. Test the following:
 - 1) All circuits are continuous and free from short circuits
 - 2) All circuits are free from unspecified grounds
 - 3) All circuits are properly connected in accordance with the applicable wiring diagram
 - 4) Voltage drop at each end of the circuit with a 2000 watt load
 - 5) All low voltage circuits complying to industry standards
2. Final check of control systems.
 - a. All work under this contract, upon completion of installation, shall be demonstrated, tested and adjusted in coordination with the SI and the EC. No part of the system shall be energized before being so checked and the installation approved.
 - b. Make all necessary arrangements for all parties concerned to be present, by scheduling such inspection in a manner acceptable to the Theatre Consultant and give a minimum of 14 days notice.
 - c. Furnish all labor, materials and instruments necessary for this inspection and testing.
3. Final site visitation by the Theatre Consultant
 - a. When the work on the entire structure has been completed and is ready for final review, a visit will be made by the Theatre Consultant or his duly authorized representative, at which time the SI shall demonstrate that the requirements of the contract as it applies to his work have been carried out and that the system has been adjusted and operates in accordance therewith.
 - b. Any defects shall be repaired at once and the tests re-conducted.

2.27 PUBLIC SAFETY RADIO DISTRIBUTED ANTENNAE SYSTEM (DAS)

A. SUMMARY

1. This specification describes the criteria for deploying an Public Safety Radio Distributed Antenna System (DAS). The DAS components specified in this document include: Bi-Directional Amplifiers (BDA), Donor Antennas, Coverage Antennas, Coax Cable, Coax Connectors, Splitters, Combiners and Couplers. These devices shall be used as part of a system, by the DAS integrator, experienced with designing projects for in-building, public safety, 2-way radio systems.
2. The system specified is based upon TX/RX Systems Bird Technologies Group RescueLine Signal Booster and represents the performance standard upon which any equivalent solution shall be based. It shall be the integrator's responsibility to base the design on the frequency ranges used by both Police and Fire departments. The system provided shall meet IFC 2009 and NFPA 1 2009 codes and shall be designed as such. It shall include a true, integrated battery backup unit which is serially connected to the main BDA system.
3. Related Sections include the following:
 - a. Division 27, Section 270000 COMMUNICATIONS CABLING.

B. ABBREVIATIONS AND ACRONYMS

1. ACG: Automatic Gain Control
2. AHJ: Authority Having Jurisdiction
3. ATP: Acceptance Test Plan
4. BDA: Bi-Direction Amplifier
5. BOM: Bill-of-Material
6. DAS: Distributed Antenna System
7. EBS: Educational Broadband Service
8. ESMR: Enhanced Specialized Mobile Radio
9. FCC: Federal Communications Commission
10. GUI: Graphical User Interface
11. LMR: Land Mobile Radio
12. MTBF: Mean Time Between Failure
13. NFPA: National Fire Protection Association
14. NMS: Network Management System
15. PSN: Public Safety Network
16. RoF: Radio-over-Fiber
17. RSL: Received Signal Level
18. SMR: Specialized Mobile Radio
19. SMS: Short Message Service
20. SNIR: Signal-to-Noise Interference Ratio
21. SOW: Statement of Work
22. VSWR: Voltage Standing Wave Ratio

C. DEFINITIONS

1. Acceptance: Expressed approval by the AHJ and owners representative

D. GENERAL DESCRIPTION

1. The building shall be both pre and post tested for fire and police department radio signal strength. A test shall be scheduled with the Fire Department and Police Department. Any expense incurred by the test shall be the responsibility of this trade contractor.
2. A site survey to determine the RF signal strength on or near the building grounds to determine the level of amplification necessary to provide clear and reliable radio communications over 95% of the overall area inside the building will be required.

3. The Fire/Police/School Department radio test shall check the signal reception in several locations on the floor area. Signal strength shall be for clear reception throughout the building utilizing the type of hand held radio unit that is used by the Fire and Police Department. Quantity of test locations shall be determined and conducted by the local department representative. Each floor of the building shall be divided into a grid of approximately twenty (20) equal areas. A maximum of one (1) area will be allowed to fail the test per floor. A spot located approximately in the center of a grid area will be selected for the test. Once the spot has been selected, prospecting for a better spot within the grid area will not be permitted. Field strength testing instruments are to be recently calibrated (1 year) and of the frequency selective type incorporating a flexible antenna similar to the ones used on the hand held transceivers.
4. Required Signal Levels:
 - a. Signal strength shall be for clear reception throughout the building utilizing hand held radio units of the type(s), which are used by the Fire/Police Department. Signal strength testing shall follow TSB-88 standards using delivered audio quality measurements (DAQ).
 - b. A minimum signal strength of -95 dBm (DAQ4) shall be available on over 95% of the floor area required to be covered when transmitted from the fire department.
 - c. A minimum signal strength of -95 dBm (DAQ4) shall be received at the fire department system from over 95% of the floor area required to be covered.
5. Required Broadcasting Frequency:
 - a. Frequency to be compatible with Fire and Police Department equipment.
 - b. The building owner will be responsible for keeping the operational frequencies of the BDA compatible with the Fire and Police Department radio system.
6. The bi-directional antenna type system shall consist of the following components:
 - a. Bi-directional radio amplifier
 - b. Plenum rated coaxial cable
 - c. Antennas (internal and external)
 - d. Terminators
 - e. T-taps (if required)
 - f. Other components and interconnecting circuitry
 - g. Battery Backup NFPA Compliant unit (not UPS system)
 - h. Connect power supply to emergency circuit
7. It is the intent of these specifications that where a BDA system is required, a complete fully functioning system shall be installed, approved and tested before an Occupancy Permit is issued.
8. Areas requiring coverage include stairwells corridors, hallways, and other areas designated by the Fire Marshalls and/or the Authority Having Jurisdiction (AHJ).
9. The contractor shall coordinate with the Fire Department, Police Department and School Department Communications Division to obtain the correct frequencies and other similar information necessary to deploy a complete and fully operational system at this location.
10. Expansion: Without replacing or adding to the Infrastructure, the system shall have expansion capabilities to support the addition or changes of radio frequencies and future building renovations. Any additional Components required for system expansion shall comply with all specifications of this Section.
11. Alarming: The BDA shall include the following outputs which shall interface to the fire alarm system:
 - a. Signal booster malfunction alarm
 - b. Loss of AC Power Alarm
 - c. Low Battery Alarm
 - d. Antenna Circuit Malfunction
 - e. Charge Failure Alarm
12. Coordinate the installation of these alarms with the fire alarm contractor.

13. Antenna locations as shown on the drawings are approximations. The system provider is responsible for locating the in-building antennas and the donor antenna required by the equipment selected, proposed design and the design criteria.

E. DESIGN SUBMISSIONS

1. This trade contractor will complete a Fire Alarm Permit Application acquired from the Fire Prevention Division stating a "BDA" installation.
2. Plan Review: Provide one line, schematic and detail drawings of the proposed system architecture. Indicate proposed locations for system components. Provide specifications for procurement and installation of a complete system for review by the Fire Department and all other agencies and authorities having jurisdiction (included will be operational frequencies).
3. Testing and Commissioning: Coordinate the completion date of the Fire Department radio signal repeater system so as to permit a Certificate of Occupancy to be obtained in a timely manner, in accordance with a schedule established by the owner's project manager.
4. The entire system shall meet with the approval of the Fire Department and all other agencies and authorities having jurisdiction before a Certificate of Occupancy will be issued.

F. QUALITY ASSURANCE

1. Qualifications: The Installer shall employ NICET certified technicians.

G. CODES, STANDARDS AND CERTIFICATIONS

1. All work, including but not limited to: cabling, pathways, support structures, wiring, equipment, installation, workmanship, maintenance and testing shall comply with the latest editions of the National Fire Protection Association (NFPA), National Electrical Code, National Electrical Safety Code, all applicable local rules and regulations, equipment manufacturer's instructions, and the National Electrical Contractor's Association (NECA) Standard of Installation. In case of discrepancy or disagreement between the documents noted above, the contractor shall satisfy the most stringent requirements.
2. Requirements set forth by first-responder code, ordinance, or the AHJ shall supersede the requirements described herein and shall be met in their entirety. It is the Contractor's responsibility to ensure that the system complies with local code, ordinances or requirements established by the PSN AHJ.

H. REQUIREMENTS

1. WSP DAS:
 - a. On a per channel basis, the downlink RSL for each frequency band shall meet or exceed Design Audio Quality (DAQ) testing criteria.
 - b. Prior to installation, contractors shall confirm the channel count, loading and frequencies use in the serving area, and shall guarantee coverage for these channels per DAQ 3.4t criteria. The complete list shall be included as part of the contractors submittal
 - c. The DAS shall deliver coverage throughout 95% of the building, and 100% of areas designated as critical. Coverage areas shall include stairwells, elevators, and underground spaces.
 - d. The system shall be housed in a NEMA 4 cabinet and shall include 24 hour battery backup.
 - e. The system shall maintain maximum required output power while preventing excessive emissions per FCC requirements.

I. SUBMITTALS

1. The contractor, prior to beginning the on-site installation, is required to submit , for approval by the owner, a complete list of the proposed equipment with a system diagram showing how the various components are interconnected and their function. Included in the submittal shall be:
 - a. Product Data: Submit manufacturer datasheets for the following components:
 - 1) Bi-Directional Amplifiers (BDA)
 - 2) Donor and Coverage Antennas
 - 3) Coaxial Cable and Connectors
 - 4) Splitters, Combiners and Couplers
 - b. Shop Drawings: Submit the following items:
 - 1) RF site survey results
 - 2) System overview and riser diagram.
 - 3) Overlay of system components on floor plans.
 - 4) Donor Antenna lightning suppression and grounding details
 - c. Statement of Work (SOW): Submit a brief description of the DAS integrator role and responsibilities on this project. At a minimum, the services included shall be to perform the RF survey, systems design, test, optimization and commissioning of the DAS system
 - d. Acceptance Test Plan (ATP): Submit a proposed ATP including cable testing reports. At a minimum, testing requirements shall be design to satisfy requirements of section 3.02
 - e. Warranty Documents:
 - 1) Submit for all manufactured Components specified in this Section.
 - 2) Submit Contractor's System Warranty.
2. Submittal Requirements at Close Out
 - a. Drawings: Submit as-built drawings indicating:
 - 1) A final, signed copy of all previously submitted documents reflecting the final, as-built representation, equipment used and details
 - 2) Cable routing, splitters, couplers and coverage antenna final locations
 - 3) Active component locations, layout, configuration and programmed parameters
 - b. Test Reports
 - 1) Submit Accepted ATP reports confirming the requirements of Section 1.07 have been met.
 - c. Field Reports: Submit sweep-testing results for all cable runs.
 - d. Field Reports: Submit OTDR test results for all fiber runs.
 - e. Operation and Maintenance Data: Submit hardware and software manuals for all Active Components.
 - f. Warranty Documents:
 - 1) Submit for all manufactured components specified in this Section.
 - 2) Submit Contractor's System Warranty.

J. WARRANTY

1. Contractor shall warranty that the BDA equipment furnished shall be free from defects of material for a period of 5 years, beginning on the date of substantial completion, excluding specific items of work that require a warranty of a greater period that may be set forth in this Specification. The battery backup unit may carry a standard 1 year warranty. Include any costs necessary to extend the BDA warranty to 5 years.

2. Contractor shall warranty that all other materials furnished shall be free from defects of material for a period of 1 year, from the date of Substantial Completion, excluding specific items of work that require a warranty of a greater period that may be set forth in this Specification. Contractor shall warranty the workmanship for a period of 1 year, from the date of Substantial Completion, excluding specific items of work that require a warranty of a greater period that may be set forth in this Specification. Contractor shall warranty the system's performance for a period of 1 year, from the date of Substantial Completion, excluding specific items of work that require a warranty of a greater period that may be set forth in this Specification. Immediately upon receipt of written notice from the Owner, the Contractor shall repair or replace at no expense to the Owner, any defective material or work that may be discovered before final acceptance of work or within the warranty period; any material or work damaged thereby; and adjacent material or work that may be displaced in repair or replacement. Examination of or failure to examine work by the Owner will not relieve Contractor from these obligations.
 3. Manufacturer Warranty:
 - a. Splitters, Couplers and Coverage Antennas: standard manufacturer's warranty
 - b. Coaxial Cable and Connectors: standard manufacturer's warranty
 - c. Fiber-Optic Cable: standard.
 - d. Active Components: standard
- K. DAS SYSTEM INTEGRATORS
1. Allcom
 2. Worad, Inc.
 3. Comtronics
 4. Or approved equal.
- L. MANUFACTURERS
1. Specified BDA Manufacturers:
 - a. TX/RX- Bird Electronics
 - b. CommScope/Andrew
 - c. Cellwave Inc.
 - d. Or approved equal.
- M. The system shall be completed with all components and wiring required for compliance with all applicable codes and regulations, and for its operation as described hereinafter. No exclusion from or limitation in the symbolism used on the drawings or the language used in these specifications shall be interpreted as a reason for omitting any appurtenances or accessories required to enable the system to perform the specified functions.
- N. Upon completion of the installation , the work shall include making all arrangements with the owner's project manager and providing any assistance necessary for inspection and test required for approval by the Fire Department. Modifications, adjustments and/or corrective work necessary to obtain approval along with subsequent inspection and test resulting from the issuance of a "Notice of Defect" shall precede any consideration of formal acceptance by the building owner. In conjunction with the above, training as deemed necessary to instruct authorized building personnel in the proper operation of the system shall also form a part of the required work. Provide four hours of training.

O. POWER SUPPLY

1. The central equipment shall be supplied with an emergency power unit including batteries and battery charging equipment that maintains this cabinet and all outlying equipment that requires power operation without any change in status for a minimum period of twenty-four (24) hours. The emergency power units(s) shall be sized to meet the following minimum requirements: operating in normal (supervisory) mode, twenty-four (24) hours, followed by twelve (12) hours of emergency operation. Batteries shall be of the sealed maintenance free type.
2. System design shall be such that neither the failure of the normal power source, the transfer to an emergency source, nor the retransfer to the normal source shall cause a change in system status.
3. Serially connected battery backup.

P. EQUIPMENT LOCATION AND PROTECTION

1. Secured Space: The bi-directional radio amplifiers shall not be located in electric closets. They shall be located in a suitable non-finished space as approved by the engineer and/or where specifically shown on the drawings. The entrance to the secured space shall clearly identify the space as having the " Fire Department" radio signal repeater equipment, by the use of an attached engraved nameplate.
2. Unsecured Space: The bi-directional amplifiers shall be provided with NEMA 4 enclosures, hinged lockable doors, electric supervision against unauthorized access and the removal of any components, and shall each have an attached engraved nameplate identifying the unit.
3. The bi-directional amplifier shall be supplied with cavity style filtering in order to minimize unwanted frequencies from entering the amplifier. Cavities shall be tuned to the frequencies provided by the Fire Department. Cavity filters will be housed to allow access by technicians, but will be protected from tampering, or accidental damage.
4. The bi-directional amplifier shall contain automatic limiting control circuitry to avoid producing overdriven outputs from the amplifier.

Q. MAINTENANCE

1. Inspection and Test: Provide all material and labor to test system by verifying operation of the system throughout the building. Adjust to provide optimum system performance. Parts and labor for repairs and/or replacements is excluded.

R. COMPONENTS

1. Yagi Donor (Outdoor) Antennas:
 - a. Electrical:
 - 1) Frequency band: In accordance with Police/Fire Department requirements
 - 2) Bandwidth > 1.5 VSWR: 20
 - 3) Gain: ≥ 10 dB
 - 4) Maximum input power: 250 watts
 - 5) Vertical Beamwidth: 44 Deg.
 - 6) Front-to-back ratio: ≥ 16 dB
 - 7) Impedance: 50Ω
 - 8) Beamwidth, Horizontal, degrees: 60
 - 9) Azimuth Pattern: As proposed by the manufacturer to meet the specifications in this Section.
 - b. Mechanical:
 - 1) Connector: 50Ω N Type Female
 - 2) Mounting: Pole

- c. Environmental:
 - 1) Temperature: -40 °C to +60 °C
 - 2) Lighting protection: Direct ground
 - 3) Waterproof level: IP 66
 - 4) Wind Speed, maximum: 125 mph
 - 5) Wind Load: 0.45 sq. ft.
- 2. Bi-Directional Amplifier (BDA):
 - a. Characteristics
 - 1) Frequency: As determined by Police, Fire Department and School requirements.
 - 2) Gain: +80dB maximum
 - 3) Programmable Gain adjustment attenuation, 0-30dB, 0.5 dB steps
 - 4) Maximum Output Power: + 32 dBm
 - 5) Noise Figure: 8 dB maximum
 - 6) Operating Temperature Range: -30 °C to +50 °C
 - 7) Chassis: Shall be capable of rack or wall mounting by the DAS integrators design.
 - 8) Filtering: Digital
 - 9) Separate Control: Each RF amplifier shall be capable of adjusting and controlling power levels for each WSP when multiple WSPs share a single amplifier.
 - 10) FCC Part 90.219 Type Classification: Class A
 - 11) Alarming: Dry contacts for remote alarms
 - 12) Mounting Options: shall support rack, wall and pole mounting
 - 13) Power Consumption: less than 100VA
 - b. Compliance:
 - 1) NFPA: The BDA shall comply with NFPA-1 2009 edition Annex O In-Building Public Safety Radio Enhancement Systems.
 - 2) FCC: Shall be FCC type certified.
- 3. Air Dielectric, Plenum Rated Cable:
 - a. Material Characteristics:
 - 1) Jacket: Halogenated, Fire-Retardant, Plenum rated
 - 2) Outer Conductor Material: Corrugated Aluminum or Corrugated Copper
 - 3) Inner Conductor Material: Copper-Clad Aluminum Wire
 - b. Electrical Characteristics:
 - 1) Impedance: $50 \pm 2.0 \Omega$
 - 2) Frequency Band: 1 - 8800 MHz
 - 3) Peak Power Rating: $\geq 40.0 \text{ kW}$
 - c. Mechanical Characteristics:
 - 1) Diameter Over Jacket: $\leq .627 \text{ in}$
 - 2) Minimum Bending Radius: $\leq 5 \text{ in}$
 - 3) One Time Minimum Bending Radius: $\leq 3 \text{ in}$
 - 4) Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)
- 4. Foam Dielectric Cable: To be used for donor antenna and outdoors.
 - a. Material Characteristics:
 - 1) Jacket: Non-halogenated, Fire-Retardant Ployolefin
 - 2) Outer Conductor Material: Corrugated Copper
 - 3) Inner Conductor Material: Copper-Clad Aluminum Wire or Copper Tube
 - b. Electrical Characteristics:
 - Impedance: $50 \pm 1.0 \Omega$
 - Frequency Band: 1/2" Nominal: 1 - 8800 MHz, 7/8" Nominal: 1 - 5000 MHz
 - Peak Power Rating: $\geq 40.0 \text{ kW}$

c. Mechanical Characteristics:

Diameter Over Jacket: 1/2" Nominal: $\leq .630$ in, 7/8" Nominal: ≤ 1.1 in
Minimum Bending Radius: 1/2" Nominal: ≤ 5 in, 7/8" Nominal: ≤ 10 in
One Time Minimum Bending Radius: 1/2" Nominal: ≤ 2 in, 7/8" Nominal: ≤ 5 in

d. Attenuation Characteristics: 1/2" Nominal

Frequency (MHz) Attenuation (dB/100ft)
 $450 \leq 1.447$
Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)

e. Attenuation Characteristics: 7/8" Nominal:

Frequency (MHz) Attenuation (dB/100ft)
 $450 \leq .744$
Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)

5. Fiber-Optic Master Unit: Active fiber system, the Fiber- Optic Master Unit shall convert radio over coax to Radio-Over-Fiber (RoF) for distribution to Fiber-Optic Remote Units.

a. Characteristics

- 1) Transmission Media: Single-mode fiber at 1310 nm
- 2) Operating Temperature Range: +5 °C to +40 °C
- 3) Impedence: 50 Ω
- 4) Chassis:
 - a) Shall be of modular design capable of supporting ≥ 32 Remote Units per 19", 4 RU chassis
 - b) Shall support redundant power supplies
 - c) Shall have the capability to remotely power the Remote Units via composite fiber-optic cable
- 5) Automatic Gain Control (AGC): Shall provide AGC for optical loss compensation
- 6) Optical Budget: Shall support ≤ 3 dB optical budget (~3 km or 2 miles)
- 7) Auxiliary Channel: Shall provide an input to support 400 to 2700 MHz for future expandability
- 8) Interlink: Shall support one fiber or two fibers bi-directional optical link for distances up to 20 km with a 10 dB optical budget
- 9) Remote Supervision:
 - a) Shall support the TCP/IP protocol, SNMPv2, FTP, HTTP, Telnet, and be fully compatible with general purpose SNMP managers
 - b) Remote access shall be available via Point-to-Point Protocol (PPP), over circuit switched/packet data and wired/wireless modems
 - c) Each Active device shall be manageable via a Web GUI
 - d) Auto Mapping: Each board position shall be automatically mapped during system turn-up

b. Frequency Bands Supported: 800 MHz PSR

S. INSTALLATION

1. The contractor shall install the DAS in accordance with the integrator's instructions and recommendations.
2. Cable and Equipment:
3. Installation shall include the delivery, unloading, setting in place, fastening to walls, floors, ceiling, or other structures and where required, penetration fire-stop, interconnecting wiring of the system components, equipment alignment and adjustments, and all other work whether or not expressly required herein which is necessary to result in complete operational system.

4. All installation practices shall be in accordance with, but not limited to, these specifications and drawings. Installation shall be performed in accordance with the applicable standards, requirements and recommendations of National, State, and Local Authorities having jurisdiction. All distributed antenna cables shall be installed such that the cables are straight as possible.
5. During the installation, and up to the date of final acceptance, the integrator shall be under obligation to protect his finished and unfinished work against damage and loss. In the event of such damage or loss, he shall replace or repair such work at no cost to the owner.
6. All equipment shall be properly mounted on equipment racks or walls and secured in place. Wall mounted equipment shall be mounted over a ½" plywood securely attached to the wall.
7. Cables shall be properly supported with dedicated hangers or brackets. Cable trays shall be used only if they are dedicated low voltage trays and only with approval from the owner.
8. Fastenings and supports shall be adequate to support their loads with a safety factor of at least three.
9. All boxes, equipment, etc. shall be secured plumb, level and square.
10. In the installation of equipment and cable, consideration shall be given to operational efficiency and overall aesthetic factors. Antennas shall be centered and in-line with other ceiling mounted devices
11. All cables, regardless of length, shall be marked with cable markers reading "Public Safety Radio", at regular intervals but not less than every 30 ft. There shall be no unmarked cables at any place in the system. In addition, markings codes at each end of the cables and patch panels shall correspond to codes shown on drawings and/or run sheets.
12. All cables the integrator installs must be handled in accordance with the manufacturers guidelines. Transmission line cables have minimum bending radius specifications that shall be followed. In the event a cable is kinked or bent excessively during installation that section of cable cannot be used, even if subsequently straightened. The damaged area of the cable shall be removed and a new section installed using correct splice methods. Ultimately the cable must pass the testing and meet the manufacturers requirements
13. Radio communications cabling shall not be grouped with electrical cabling. It can only share sleeves and raceways with other low voltage data and communications cables.
14. Connection between cables and other antenna components shall use N-Type premium connectors. No splicing is permitted.
15. All power dividers shall be securely mounted in place by bolting the mount to a solid surface or securing each by suspension on the cables within 4 inches of each connector termination at the power divider. The transmission lines connecting to the device shall be routed in the shortest possible path.

T. GROUNDING PROCEDURE

1. In order to minimize problems resulting from improper grounding, and to achieve maximum signal-to-noise ratios, the following grounding procedures shall be adhered to:
2. System Ground: A signal primary "system ground" shall be established for the system. All grounding conductors in that area shall connect to this primary system ground. The system ground shall consist of a copper bar of sufficient size to accommodate all secondary ground conductors. An extension of the ground shall connect to the buildings lightning protection system per the direction of the on-site electrical engineer.
3. A copper conductor, having a maximum of 0.1 Ohms total resistance, shall connect the primary system ground bar to the primary system ground ring.

4. Secondary system grounding conductors shall be provided from all racks, radio consoles, and undergrounded radio equipment in each area, to the primary system grounding point for the area. Each of these grounding conductors shall have a maximum of 0.1 Ohms total resistance.
5. Under no conditions shall the AC neutral conductor, either in the power panel or in receptacle outlets, be used for a BDA system ground.
6. Radio cable Shields: All radio cable shields shall be grounded at both ends.
7. General: Because of the great number of possible variations in grounding systems, it shall be the responsibility of the installer to follow good engineering practice, as outlined above, and to deviate from these practices only when necessary to minimize crosstalk and to maximize signal to- noise ratios and reduce interference in the radio systems.

U. CABLE AND CONDUIT

1. Note the following circuitry requirements:
 - a. Conduit intended for use with the firefighter's communication bi-directional radio amplifier system shall be steel electric metallic tubing (EMT), except as follows:
 - 1) It shall be galvanized steel intermediate conduit where mounted within 8'-0" of the floor in mechanical spaces or otherwise exposed to mechanical damage, or where intended for embedment in concrete.
 - 2) It shall be galvanized steel intermediate conduit if local authorities prohibit use of EMT.
 - 3) It shall be rigid galvanized steel conduit for the power supply to the central equipment and to all outlying equipment cabinets requiring a 120-volt or 120/208- volt supply.
 - b. Where wires and cables are permitted to be run without conduit, they shall be independently supported from the building structure or ceiling suspension systems at intervals not exceeding four feet on center, utilizing cable supports specifically approved for the purpose. Wires and cables shall not rest on or depend on support from suspended ceiling media (tiles, lath, plaster, as well as splines, runners or bars in the plane of the ceiling), nor shall they be supported from pipes, ducts or conduits. Bundling and/or supporting ties shall be of a type suitable for sue in a ceiling air handling plenum regardless of whether or not installed in a plenum.
 - c. Cables shall be tagged or labeled at each termination point and in each intermediate junction box, pull box or cabinet through which they pass, as well as intervals not exceeding 50 feet on centers where cables are run without conduit.
 - d. Comply with applicable building and electrical code requirements for locating and routing circuitry, for installing circuitry, and for fire stopping.
 - e. The covers of all dedicated junction, pull boxes shall be painted red and labeled "Fire Dept. Radio System". Junction and pull boxes will not be shared with other systems.
 - f. Cables other than radiating coaxial cables shall be run in conduit where indicated by the Engineer. Where not indicated, cable shall be installed per manufacturer's recommendation. Conduit shall be electric metallic or threaded conduit subject to the restrictions specified elsewhere for light and power circuitry.
 - g. Radiating coaxial cables shall be run without conduit. Where installed in a plenum type ceiling cable insulation shall be of a fire-resistant low-smoke producing type, with a minimum rating of CATVR. This classification shall be clearly marked on the outer surface of the cable at regular intervals.

V. ACCEPTANCE TESTING

1. Submit certification that system is compatible with Fire Department radio systems prior to installation.
2. Verify proper operation of system by means of field test with:
3. Fire Department requirements, and include all adjustments and modifications to the system required for proper operation. Coverage of each floor of the building to a minimum of 95% is required for acceptance.
4. No activation, or power up of any RF equipment is permitted without first obtaining permission of the Fire Department. This includes any testing or calibration.
5. The contractor shall complete the acceptance testing as prescribed in the approved Acceptance Test Plan (ATP) submittal.
6. Acceptance Test Procedure: Upon completion of installation, the building Owner will have the option to participate in the radio system tested to ensure that two-way radio coverage on each floor of the building is a minimum of 90 percent. and be tested as follows:
7. Each floor of the building shall be divided into a grid of 20 or more, approximately equal areas. No two test locations shall be greater than 50 ft apart
8. The test shall be conducted using a calibrated portable radio of the latest brand and model used by the agency talking through the agency's radio communications system.
9. No area designated as critical and no two adjacent areas shall be allowed to fail the test.
10. In the event that any three non-adjacent, non-critical areas fail the test, in order to be more statistically accurate, the floor may be divided into smaller areas. In the event that three noncritical, non-adjacent areas still fail the test, the contractor shall reconfigure the system to meet the 90-percent coverage requirement with no three adjacent areas failing.
11. A installation a spectrum analyzer or other suitable test equipment shall be utilized to insure spurious oscillations are not being generated by the subject signal booster. This test shall be conducted at time of system acceptance.

2.28 MANUAL PMH PAD-MOUNTED GEAR

A. General

1. The pad-mounted gear shall be in accordance with the one-line diagram, and shall conform to the following specification.
- B. The pad-mounted gear shall consist of a single self-supporting enclosure, containing interrupter switches and power fuses with the necessary accessory components, all completely factory-assembled and operationally checked.

C. Ratings:

The ratings for the integrated pad-mounted gear assembly shall be as designated below.

Kv, Nominal.....	14.4
Kv, Maximum.....	17.0
Kv, BIL.....	95
Main bus Continuous, Amperes.....	600
Three-Pole Interrupter Switches	
Continuous, Amperes.....	600
Load Dropping, Amperes.....	600
Two-Time Duty-Cycle Fault-Closing,	
Amperes Rms Asymmetrical.....	25,000
Fuses with Integral Load Interrupter	
Maximum, Amperes.....	200E
Load Dropping, Amperes.....	600
Two-Time Duty-Cycle Fault-Closing	
Capability, Amperes Rms Asymmetrical.....	13,000
Short-Circuit Ratings	
Amperes Rms Symmetrical.....	14,000
Mva Three-Phase Symmetrical	
At Rated Nominal Voltage.....	350

The momentary and two-time duty-cycle fault-closing ratings of switches, momentary rating of bus, interrupting ratings of fuses, and one-time duty-cycle fault-closing capabilities of fuses with integral load interrupters shall equal or exceed the short-circuit ratings of the pad-mounted gear.

D. Compliance with Standards and Codes

The pad-mounted gear shall conform to or exceed the applicable requirements of the following standards and codes:

1. All portions of ANSI C57.12.28, covering enclosure integrity for pad-mounted equipment.
2. Article 490-21(e) in the National Electrical code, which specified that the interrupter switches in combination with power fuses shall safely withstand the effects of closing, carrying, and interrupting all possible currents up to the assigned maximum short-circuit rating.
3. All portions of ANSI, IEEE, and NEMA standards applicable to the basic switch and fuse components.

E. Enclosure Design

1. To ensure a completely coordinated design, the pad-mounted gear shall be constructed in accordance with the minimum construction specifications of the fuse and/or switch manufacturer to provide adequate electrical clearances and adequate space for fuse handling.
2. In establishing the requirements for the enclosure design, consideration shall be given to all relevant factors such as controlled access, tamper resistance, and corrosion resistance.

F. High-Voltage Bus

1. Bus and interconnections shall consist of aluminum bar of 56% IACS conductivity.
2. Bus and interconnections shall withstand the stresses associated with short-circuit currents up through the maximum rating of the pad-mounted gear.
3. Bolted aluminum-to-aluminum connections shall be made with a suitable number of ½" – 13 galvanized steel bolts and with two Belleville spring washers per bolt, one under the bolt head and one under the nut. Bolts shall be tightened to 50 foot-pounds torque.
4. Before installation of the bus, all electrical contact surfaces shall first be prepared by machine abrading to remove any aluminum-oxide film. Immediately after this operation, the electrical contact surfaces shall be coated with a uniform coating of an oxide inhibitor and sealant.

G. Ground-Connection Pads

1. A ground-connection pad shall be provided in each compartment of the pad-mounted gear.
2. The ground-connection pad shall be constructed of 3/8" thick steel, which shall be nickel plated and welded to the enclosure, and shall have a short-circuit rating equal to that of the pad-mounted gear.
3. Ground-connection pads shall be coated with a uniform coating of an oxide inhibitor and sealant prior to shipment.

H. Enclosure Including Outdoor Finish

1. Enclosure
 - a. The pad-mounted gear enclosure shall be of unitized monocoque (not structural-frame-and-bolted-sheet) construction to maximize strength, minimize weight, and inhibit corrosion.
 - b. The basic material shall be 11-gauge hot-rolled, pickled and oiled steel sheet.
 - c. All structural joints and butt joints shall be welded, and the external seams shall be ground flush and smooth. The gas-metal-arc welding process shall be employed to eliminate alkaline residue and to minimize distortion and spatter.
 - d. To guard against unauthorized or inadvertent entry, enclosure construction shall not utilize any externally accessible hardware.
 - e. The base shall consist of continuous 90-degree flanges, turned inward and welded at the corners, for bolting to the concrete pad.
 - f. The door openings shall have 90-degree flanges, facing outward, that shall provide strength and rigidity as well as deep overlapping between doors and door openings to guard against water entry.
 - g. Enclosure top side edges shall overlap with roof side edges to create a mechanical maze which shall allow ventilation to help keep the enclosure interior dry while discouraging tampering or insertion of foreign objects.

- h. A heavy coat of insulating “no-drip” compound shall be applied to the inside surface of the roof to minimize condensation thereon.
- i. Insulating interphase and end barriers of NEMA GPO3-grade fiberglass-reinforced polyester shall be provided for each interrupter switch and each set of fuses where required to achieve BIL ratings. Additional insulating barriers of the same material shall separate the front compartments from the rear compartments and isolate the tie bus (where furnished).
- j. Full-length steel barriers shall separate side-by-side compartments.
- k. Interrupter switches shall be provided with dual-purpose front barriers. These barriers, in their normal hanging positions, shall guard against inadvertent contact with live parts. It shall also be possible to lift these barriers out and insert them into the open gap when the switch is open. These barriers shall meet the requirements of Section 381G of the National Electrical Safety Code (ANSI Standard C2).
- l. Interrupter switches shall be provided with window panels to allow viewing of the switch position without removing the dual-purpose front barriers. Window panels shall be removable to facilitate phasing and shall be secured to the enclosure with stainless-steel or zinc-nickel-plated hardware.
- m. Each fuse shall be provided with a dual-purpose front barrier. These barriers, in their normal hanging positions, shall guard against inadvertent contact with live parts. It shall also be possible to lift these barriers out and inset them into the open gaps when the fuses are in the disconnect position. These barriers shall meet the requirements of Section 381G of the National Electrical Safety Code (ANSI Standard C2).
- n. The enclosure shall be provided with an instruction manual holder.
- o. Lifting tabs shall be removable. Sockets for the lifting-tab bolts shall be blind-tapped. A resilient material shall be placed between the lifting tabs and the enclosure to help prevent corrosion by protecting the finish against scratching by the tabs. To further prevent corrosion, this material shall be closed-cell to prevent moisture from being absorbed and held between the tabs and the enclosure in the event that lifting tabs are not removed.
The following features shall be provided:
- p. To guard against corrosion due to extremely harsh environmental conditions, the entire exterior of the enclosure shall be fabricated from 11-gauge Type 304 stainless steel.
- q. Inner barrier panels that meet the Rural Electrification Association’s requirements for “dead-front” and the requirements of Section 381G of the National Electrical Safety Code (ANSI Standard C2) shall be provided – one for each door opening providing access to high voltage. These panels shall be secured in place with recessed pentahead bolts. When so secured, they shall guard against inadvertent contact with live parts.
- r. A steel-compartmented base spacer shall be provided to increase the elevation of live parts in the pad-mounted gear above the mounting pad by 6 inches.
- s. Manufacturers S & C PME or approved equal.

2.29 MEDIUM VOLTAGE CABLE

A. EPR Power Cable, 15 kv, 133% insulation level:

- 1. Scope: This specification describes single conductor General Cable-EPR (ethylene-propylene-rubber) insulated, polyvinyl chloride jacketed shielded power cables for use in circuits not exceeding 15,000 volts 133% insulation level at conductor temperatures of 105°C continuous normal operation, 140°C for emergency overload conditions, and 250°C for short circuit conditions. Cables are intended for use as Type MV-105 in wet or dry locations, including conduit, cable tray, duct, direct burial and aerial installation.

2. Standards: The following standards shall form a part of this specification to the extent specified herein:
 - a. AEIC CS8 for Extruded Dielectric, Shielded Power Cables.
 - b. ICEA Pub. No. S-93-639 and S-97-682 and NEMA Pub. No. WC74 for 5-46Kv Shielded Power Cable For Use in the Transmission and distribution of Electric Energy.
 - c. UL Standard 1072 for Type MV-105.
 3. Conductors: (AWG as pre Drawings) copper, Class B compact stranded annealed, uncoated copper per Part 2 of ICEA.
 4. Conducting Shielding: The conductor shall be covered with a layer of extruded semi-conducting polymer compound with an average thickness in accordance with ICEA S-93-639 Section 3. The extruded layer shall be firmly bonded to the cable insulation and shall be in accordance with Section 3 and meet the Electrical Requirements of Section 3
 5. Insulation: Directly over the conductor shielding shall be applied a homogeneous wall of General Cable-EPR insulation. The average thickness of insulation shall be 220 mils. Minimum thickness at any point shall be not less than 90% of the specified thickness. Physical and electrical properties of the insulation shall be in accordance with Table 4.4 of ICEA.
 6. Shielding: Over the insulation shall be applied an extruded semi-conducting polymer shield. It shall be in intimate contact with the outer surface of the insulation and shall be free-stripping, leaving no conducting particles or other residue on the insulation surface. This layer shall be legibly identified as being conducting. The thickness of this layer shall be in accordance with ICEA S-93-639 Section 5. The insulation shield shall meet the resistivity requirements of ICEA S-93-639 Section 5.
 - a. An uncoated copper tape shall be a helically applied 5 mil uncoated copper shielding tape with a minimum lap of 12.5%. This tape shall meet the requirements of Section 6 of ICEA S-93-639.
 7. Circuit Identification: A color coded tape (black, red, blue) applied under the metallic shielding tape shall provide circuit identification on each power conductor.
 8. Assembly: Three insulated and shielded phase conductors shall be cabled together with a Class B stranded, uncoated copper grounding conductor and suitable fillers to make round. Length of lay shall not exceed 35 times the phase conductor diameter. The grounding conductor shall comply with the requirements of Table 250.66 of the National Electrical Code and UL Standard 1072.
 9. Cable Tape: The cable assembly shall be covered with a suitable tape having a minimum 10% lap,
 10. Overall Jacket: A polyvinyl chloride jacket shall be applied overall. The jacket shall meet the requirements of Section 7 of ICEA S-93-639 and the Sunlight Resistant requirements of UL Standard 1072. The average thickness of the jacket shall be as specified in Section 7 of ICEA. The minimum thickness at any point shall be not less than 80% of that specified.
 11. Identification: All cable shall be identified by means of surface ink printing indicating manufacturer, number of conductors, size, insulation type, voltage rating and UL designations.
 12. Tests: Cable shall be tested in accordance with AEIC CS8, ICEA S-93-639 and UL Standard 1072.
 13. All splices shall be made using Elastimold splice kits.
- B. Acceptable manufacturers:
General Cable
Okonite

PART 3 - EXECUTION

3.1 INSPECTION AND ACCEPTANCE

- A. Examine all surfaces and contiguous elements to receive work of this section and correct, as part of the Work of this Contract, any defects affecting installation. Commencement of work will be construed as complete acceptability of surfaces and contiguous elements.

3.2 WORK COORDINATION AND JOB OPERATIONS

- A. Equipment shall not be installed in congested and possible problem areas without first coordinating installation of same with other trades. Relocate electrical equipment installed in congested or problem areas should it interfere with the proper installation of equipment to be installed by other trades.
- B. Particular attention shall be directed to coordination of lighting fixtures and other electrically operated equipment requiring access which is to be installed in ceiling areas. Coordinate with other trades, the elevations of equipment in hung ceiling areas to insure adequate space for installation of recessed fixtures before said equipment is installed. Conflicts in mounting heights and clearances above hung ceilings for installation of recessed lighting fixtures or other electrically operated equipment requiring access shall be brought to the attention of Architect for a decision prior to equipment installation.
- C. Furnish to General Contractor and other subcontractors information relative to portions of electrical installation that will affect other trades sufficiently in advance so that they may plan their work and installation.
- D. Obtain from other trades information relative to electrical work which he, the Electrical Subcontractor, is to execute in conjunction with installation of other trades' equipment.
- E. Lighting fixtures in mechanical spaces or utility/ storage rooms shall only be installed after all mechanical equipment is in place.

3.3 PLANS AND SPECIFICATIONS

- A. Plans:
 - 1. Drawings showing layout of electrical systems indicate approximate location of raceways, outlets, and apparatus. Runs of feeders and branch circuits are schematic and are not intended to show exact routing. Final determination as to routing shall be governed by structural conditions and as indicated on the approved coordination drawings.
- B. Specifications:
 - 1. Specifications supplement drawings and provide specifics pertaining to methods and material to be used.

3.4 IDENTIFICATION

- A. Equipment shall be marked for ease of identification as follows:
1. Provide screw-on nameplates on switchboards, panelboards, F.A. terminal cabinets, starters, and disconnect switches. Nameplates to be of black phenolic with white engraving. For starters and disconnect switches lettering shall be minimum of ¼ in. high. Nameplates on panelboards shall have the following information.
 - a. Line 1 - Panel designation in ½ in. high letters.
 - b. Line 2 - Utilization voltage in 3/8 in. high letters.
 - c. Line 3 - Distribution source "Fed from ¼ in. high letters.
 2. Neatly typed directory cards listing circuit designations shall be fastened inside the cover of panelboards. Spare circuits shall be penciled.
 3. Color coding schedules. If there is more than a single system voltage, different voltages shall have separate color codes, as previously specified. A copy of the color code schedule shall be affixed to each secondary switchboard and distribution panel and shall be of the phenolic nameplate type as previously specified. A typewritten color code schedule shall also be affixed, under plastic, inside each panelboard door.
 4. Outlet boxes both concealed and exposed shall be identified as to panel origination and circuit number by means of fibre pen on the inside of coverplate.
 5. Special system outlet boxes concealed above hung ceilings shall be identified as to system by spray painting during roughing. The following systems shall be identified.
 - a. Fire Alarm - red.
 - b. Normal/Emergency - yellow.
 - c. Security - blue.
 - d. Sound - green.
 6. Wiring device plates on devices connected to normal-emergency circuits shall be red in color.
 7. All conductors in boxes larger than standard outlet boxes, in all wireways, and trench headers. shall be grouped logically and be identified.
 8. Grounding conductors and neutrals shall be labeled in panels, and wireways. as to circuits associated with.

3.5 PROTECTION AND CLEANUP

- A. Protection:
1. Materials and equipment shall be suitably stored and protected from weather.
 2. During progress of work, pipe and equipment openings shall be temporarily closed so as to prevent obstruction and damage.
 3. Be responsible for maintenance and protection of material and equipment until final acceptance.
- B. Cleanup:
1. Keep job site free from accumulation of waste material and rubbish. Remove all rubbish, construction equipment, and surplus materials from site and leave premises in a clean condition.
 2. At completion, equipment with factory finished surfaces shall be cleaned and damaged spots touched up with the same type paint applied at factory.
 3. Particular attention is called to Section 110-12(c) of the NEC, which requires that internal parts of electrical equipment not be contaminated by construction operations.

3.6 PORTABLE OR DETACHABLE PARTS

- A. Retain possession of and be responsible for spare parts, portable and detachable parts, and other removable portions of installation including fuses, keys, locks, blocking clips, inserts, lamps, instructions, drawings, and other devices or materials that are relative to and necessary for proper operation and maintenance of the system until final acceptance, at which time such parts shall be installed or turned over to the Owner, as the case may be.
- B. SAFETY PRECAUTIONS
 - 1. Provide proper guards, signage, and other necessary construction required for prevention of accidents and to insure safety of life and property. Remove any temporary safety precautions at completion.

3.7 MOUNTING HEIGHTS

- A. All electrical equipment shall be mounted at the following heights unless noted or detailed otherwise on drawings. Notes on architectural drawings shall supersede those noted below or detailed on the electrical drawings. If mounting height of an electrical component is questionable, obtain clarification from Architect before installation.
 - 1. Duplex convenience outlets, microphone outlets, and telephone outlets - 18 inches.
 - 2. Light switches, pushbutton stations, HOA switches, and all other toggle or control switches for the operation of heating, ventilating, and air conditioning, plumbing, and general service - 48 inches.
 - 3. Clock outlets - 84 inches.
 - 4. Fire alarm pull stations - 48 inches.
 - 5. Fire alarm audio visual signals - 80 inches or 6 inches below ceiling, whichever is lower.
 - 6. Panelboards for lighting, power, telephone, and other auxiliary systems – 78 in. to top.
 - 7. Equipment located in lobbies shall be located as detailed on architectural drawings.
 - 8. All receptacles, light switches, fire alarm signals, and clocks sharing a common location shall be symmetrically arranged.
 - 9. Exterior and interior wall brackets shall be as detailed on architectural drawings.
- B. Mounting heights given are from finished floor to centerline. In the case of a raised floor, surface of raised floor is the finished floor.

3.8 WORKMANSHIP AND INSTALLATION METHODS

- A. Work shall be installed in first-class manner consistent with best current trade practices. Equipment shall be securely installed plumb and/or level. Flush-mounted outlet boxes shall have front edge flush with finished wall surface. No electrical equipment shall be supported by work of other trades. Cable systems shall be supported and not draped over ducts and piping or laid on ceiling suspension members. Lighting fixtures shall be installed to agree with Architects reflected ceiling plans.
- B. Supports:
 - 1. Support work in accordance with best industry practice and by use of standard fittings.
 - 2. In general, walls and partitions will not be suitable for supporting weight of panelboards, dry type transformers and the like. Provide supporting frames or racks extending from floor slab to structure above.

3. Provide supporting frames or racks for equipment, intended for vertical surface mounting in free standing position where no walls exist.
 4. Supporting frames or racks shall be of standard angle, standard channel or specialty support system steel members, rigidly bolted or welded together and adequately braced to form a substantial structure. Racks shall be of ample size to assure a workmanlike arrangement of equipment.
 5. Provide $\frac{3}{4}$ in. thick painted plywood mounting surfaces in all electric and telephone areas and for all equipment on free standing racks. All plywood shall be fire retardant and painted both sides and edges with 2 coats of white paint.
 6. No work for exposed installations in damp locations shall be mounted directly on any building surface. In such locations, flat bar members or spacers shall be used to create a minimum of $\frac{1}{4}$ in. air space between building surfaces and work.
 7. Nothing (including outlet, pull and junction boxes and fittings) shall depend on electric raceways or cables for support. All outlet, pull, and junction boxes shall be independently supported.
 8. Nothing shall rest on, or depend for support on, suspended ceiling or its mounting members.
 9. Support surface or pendant mounted lighting fixtures:
 - a. From outlet box by means of an interposed metal strap, where weight is less than five pounds.
 - b. From outlet box by means of a hickey or other direct threaded connection, where weight is from five to fifty pounds.
 - c. Directly from structural slab, deck or framing member, where weight exceeds fifty pounds.
 - d. Pendant lighting fixtures shall be supported by threaded rods in non-public areas and by manufacturers standard tube hangers with swivel aligner and canopy in public areas. Provide non-standard pendant lengths where required to mount fixtures at elevations either called for on drawings or as shown in architectural elevations.
 10. Support recessed lighting fixtures directly from structural slabs, decks or framing members, by means of jack chain or air craft cable, one at each end of fixture at opposite corners.
 11. Where support members must of necessity penetrate air ducts, provide airtight sealing provisions which allow for a relative movement between the support members and the duct walls.
 12. Provide channel sills or skids for leveling and support of all floor mounted electrical equipment.
 13. Where permitted loading is exceeded by direct application of electrical equipment to a slab or deck, provide proper dunnage to distribute the weight in a safe manner.
 14. Support metallic raceways by either running within steel frame or hung from the building frame. Anything hung from building frame shall be attached with metallic fasteners.
- C. Fastenings:
1. Fasten electric work to building structure in accordance with the best industry practice.
 2. Where weight applied to attachment points is 100 pounds or less, fasten to building elements of:
 - a. Wood -- with wood screws.
 - b. Concrete and solid masonry -- with bolts and expansion shields.
 - c. Hollow construction -- with toggle bolts.
 - d. Solid metal -- with machine screws in tapped holes or with welded studs.

3. Where weight applied to attachment points exceeds 100 pounds, fasten as follows:
 - a. At field poured concrete slabs, provide inserts with 18 in. minimum length slip-through steel rods, set transverse to reinforcing steel.
 - b. Where building is steel framed, utilize suitable auxiliary channel or angle iron bridging between structural steel elements to establish fastening points. Bridging members shall be suitably welded or clamped to building steel. Provide threaded rods or bolts to attach to bridging members.
 4. Floor mounted equipment shall not be held in place solely by its own dead weight. Provide floor anchor fastenings. Floor mounted equipment over 72 inches in height shall also be braced to nearest wall or overhead structural elements.
 5. For items which are shown as being mounted at locations where fastenings to the building construction element above is not possible, provide suitable auxiliary channel or angle iron bridging to building structural elements.
 6. Fastenings for metallic raceways using the fastening as support shall be of the metallic type. Fastenings to hold raceways or cables in place may be via traps.
- D. General Raceway Installation:
1. Install the various types of raceways in permitted locations as previously specified. All raceways shall be run concealed. Consult Architect for instruction for raceways which must be exposed in public spaces.
 2. Raceways for normal emergency or emergency only wiring cannot contain other conductors.
 3. Raceways shall be properly aligned, grouped, and supported in accordance with code. Exposed raceways shall be installed at right angles to or parallel with structural members. Concealed raceways may take most direct route between outlets.
 4. Raceways run on trapeze hangers shall be secured to the trapeze.
 5. Raceways shall be continuous and shall enter and be secured to all boxes in such a manner that each system shall be electrically continuous from service to all outlets. Provide grounding bushings and bonding jumpers where raceways attach to painted enclosures or terminate below equipment.
 6. Where raceways enter boxes, cabinets, tap boxes, other than those having threaded hubs, a standard locknut shall be used on the outside and locknut and bushing on the inside.
 7. Where raceways terminate below equipment and there is no direct metal to metal continuity, provide grounding bushings on raceways and interconnect with equipment grounding conductor.
 8. All empty raceways shall be provided with a pull wire.
 9. All raceway sleeves, stub-ups, or stub-outs, where not connected to a box or cabinet, shall be terminated with a bushing.
 10. All raceway joints shall be made up tight and no running threads will be permitted.
 11. Where raceways are cut, the inside edge shall be reamed smooth to prevent injury to conductors.
 12. All vertical raceways passing through floor slabs shall be supported.
 13. Raceways shall not be installed in concrete slabs above grade or below waterproofed slabs.
 14. Electric raceways and/or sleeves passing through floors or walls shall be of such size and in such location as not to impair strength of construction. Where raceways alter structural strength or the installation is questionable, the structural engineer shall be contacted for approval.
 15. Raceways shall not run directly above or below heat producing apparatus such as boilers, nor shall raceways run parallel within 6 inches of heated pipes. Raceways crossing heated pipes shall maintain at least a 1 inch space from them.
 16. Raceways shall be installed in such a manner as to prevent collection of trapped condensates, and all runs shall be arranged to drain.

17. Raceways passing between refrigerated and non-refrigerated spaces and those penetrating enclosures with air movement shall be provided with seals.
 18. Raceways feeding fire and jockey pumps shall be rigid metal conduit either run below slab or inside 2 hour rated enclosure. Final connections to motors shall be liquidtight flexible conduit.
 19. Where two alternate wiring methods interconnect such as EMT to flexible metal conduit, an outlet box shall be provided.
 20. All empty raceways entering building and all sleeves or core drilled openings through floors shall be sealed.
 21. Each exterior raceway or assembly in a ductbank shall be provided with continuous warning tape installed 12 inches above raceway or ductbank.
 22. Underground rigid non-metallic raceways where allowed and run as a ductbank encased in concrete shall be installed with plastic spacers to ensure a separation of 3 inches between raceways. Top of ductbanks shall be 30 inches below grade, unless otherwise detailed.
 23. Elbows and extensions of rigid non-metallic raceway systems which penetrate slabs shall be rigid or intermediate metal conduit.
 24. Raceways used for transformer connections shall be flexible type and shall contain a grounding conductor.
 25. Raceways entering building through foundation wall into a basement area shall be provided with wall entrance seals or with other acceptable waterproofing method.
- E. General Outlet Box Installation:
1. Boxes shall be set flush with finish surface and provided with proper type extension rings or plaster covers. Thru the wall boxes are not permitted. Check device or fixture to be mounted to box to ensure box orientation is proper.
 2. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling-in operation.
 3. Plug unused openings on all remove knockouts.
 4. Where required for horizontal and vertical alignment of boxes in stud partitions, bar hangers spanning two studs shall be used. Device boxes for insertion type receptacles shall be provided with far side box supports where there are less than two entering nonflexible raceways, and where bar rangers are not provided.
 5. Boxes flush mounted in fire rated partitions and on opposite sides of the partition shall be separated by a distance of 24 inches in accordance with UL listing for the box.
 6. Locations of outlets indicated on drawings are approximate. For items exposed to view, refer to architectural drawings and coordinate locations with masonry joints, panel joints, ceiling grids, and structural members.
 7. In case of conflict with standard mounting heights and device alignment, consult Architect prior to roughing.
 8. Check all door swings on architectural drawings to ensure lighting switches are installed on strike side of door.
 9. The right to make any reasonable change in location of outlets prior to roughing is reserved by Architect. "Reasonable change" shall be interpreted as movement within 10 feet of location shown.
 10. Obtain dimensioned plan from Architect for floor outlets.
 11. Outlet boxes for use where surface metal raceways are allowed shall be of a type specifically designed to be used with such surface metal raceway systems.
- F. Conductor Installation:
1. No conductors shall be pulled into individual raceways until such raceway system is complete and free of debris. No harmful lubricants shall be used to ease pulling.
 2. All conductors shall be wired so that grounded conductor is unbroken; switches in all cases being connected in ungrounded conductor.
 3. Connections throughout the entire job shall be made with solderless type devices of approved design satisfactory to Inspector of Wires.

4. All taps and splices shall be insulated equal to that of conductor insulation.
 5. All conductors of each feeder in pull boxes and wireways shall be grouped, tied together, supported, and identified.
 6. All conductors in panelboards and other wiring enclosures shall be neatly formed and grouped.
 7. All conductors of emergency only and/or normal/emergency shall be run in separate raceway systems to final outlet box.
 8. Provide support for conductors in vertical raceways in accordance with Article 300-19.
 9. Strip insulation from conductors with approved tools and only of sufficient length for proper termination. Cutting of conductor stranding is unacceptable.
 10. Taps from paralleled conductors shall be of a type which tap each conductor, such as ILSCO "PTA" series.
 11. Grounding conductors are to be identified as to associated power circuits.
- G. Type MC Cable Installation:
1. Where cable is permitted under the products section, the installation of same shall be done in accordance with code and the following:
 - a. Cable shall be supported in accordance with code. Tie wire is not an acceptable means of support. Horizontally run cable supports such as Caddy WMX-6, and clamps on vertical runs such as Caddy CJ6 shall be used. Where cables are supported by the structure and only need securing in place, then ty-raps will also be acceptable. Ty-raps are not acceptable as a means of support. All fittings, hangers, and clamps for support and termination of cables shall be of types specifically designed for use with cable, i.e., romex connectors not acceptable.
 - b. Armor of cable shall be removed with rotary cutter device equal to roto-split by Seatek Co., not with hacksaw.
 - c. Use split "insuliner" sleeves at terminations.
 - d. Any cable system used in conjunction with isolated ground circuits shall have both an isolated ground conductor and an equipment ground conductor.
- H. Stranded Conductor Installation:
1. If Contractor selects stranded conductors for # 10 AWG and smaller, terminate such conductors as follows:
 - a. No stranded conductor may be terminated under a screwhead. Provide insulated terminal lugs for all screw connections equal to Thomas & Betts "STA-KON" type RC with forked tongue and turned up toes. Installation of lugs shall be done with compression tool such as T&B WT-145C which prevents opening of tool until full compression action is completed.
 - b. Backwired wiring devices shall be of clamp type; screw tightened. Force fit connections not allowed.
 2. Stranded conductors will not be allowed for fire alarm work.
- I. Accessibility:
1. Electrical equipment requiring service or manual operation shall be accessible.
 2. Work switches for equipment within accessible hung ceiling spaces, such as fan powered terminal boxes, shall be located at terminal box, and so located so as to be accessible.
- J. Vibration Elimination: All equipment connections to rotating equipment or equipment capable of vibration shall be made up by flexible raceways.
- K. Wiring Device Gaskets: Provide wiring device gaskets at coverplates where device is mounted in wall separating conditioned and non-conditioned spaces.

3.9 FEEDER CIRCUITS

- A. Provide feeders as called for on the drawings.
- B. Feeders shall be defined as any circuit originating from the main building switchboard and/or distribution panels.
- C. All feeder conductors shall be continuous from origin to panel or equipment termination without splicing.
- D. All feeders shall be conductors pulled into raceways. Cable systems are not allowed for feeders unless specifically indicated.

3.10 BRANCH CIRCUITS

- A. Provide all branch circuit wiring and outlets for a complete and operating system. The system shall consist of insulated conductors connected to the panelboards and run in raceways or as cable systems if permitted under products section, to the final outlet and shall include outlet boxes, supports, fittings, receptacles, plates, fuses, for a fully functional system.
- B. Provide dedicated neutrals for all lighting circuits and all circuits originating from panelboards fed from K-rated transformers.
- C. Physical arrangement of branch circuit wiring shall correspond to circuit numbering on drawings. Combining of circuits and raceways will be allowed up to a 3 phase, 4 wire circuit or 3 phase 6 wire (dedicated neutrals) in a single raceway. Any combination of homeruns such as this, however, shall be indicated on record drawings. When a common grounded conductor is used for more than one circuit, the arrangement shall be such that a receptacle, fixture, or other device may be removed or disconnected without disconnecting the grounded conductor for other circuits. Ground fault circuit breakers and isolated ground outlets shall be wired with separate neutrals and separate grounding conductors per circuit. A consistent phase orientation shall be adhered to throughout project at terminations.
- D. Circuits feeding three phase equipment shall not be combined into common raceways, unless specifically indicated.
- E. All wiring in panelboards and cabinets shall be neatly formed and grouped.

3.11 FIRESTOP SYSTEMS:

- A. General: Install firestop systems at all new and existing fire-rated construction where penetrated by the Work of this Section.
- B. Refer to Section 078400 - Firestopping, for all installation requirements for maintaining integrity of fire-rated construction at penetrations.

3.12 WATERPROOFING

- A. Waterproof all openings in slabs and walls.

3.13 CUTTING AND PATCHING

- A. Penetrations through new and existing construction as required for the Work of this Section:
1. Coring: Perform all coring for required work.
 2. Notify Masonry Sub-Contractor of exact locations and sizes for openings required in masonry, to be executed under Section 042000 – Unit Masonry, utilizing lintels furnished per Section 055000 – Metal Fabrications. Cut openings in new and existing non-masonry construction where required for penetrations. All cutting shall conform to the requirements of Section 017329 – Cutting and Patching, and 024119 – Demolition.
 3. Refer to Section 024119 – Demolition for restrictions on all alterations to structural elements.

3.14 ELEVATOR COORDINATION

- A. Elevator Electrical Work:
1. Several items pertaining to elevator electrical system shall be provided by Electrical Subcontractor as follows:
 - a. Power source to elevator machine room including fused disconnect switch and wiring between disconnect switch and controller for each elevator.
 - b. Power source to elevator machine room including fused disconnect switch (120 volt) for elevator signal system and cab light for each cab.
 - c. Light, switch, and GFCI receptacle in each pit.
 - d. Light, switch, and GFCI receptacle in machine room.
 - e. Junction box in machine room with five control modules from fire alarm system for elevator recall to prevent cab opening on a fire floor.
 - f. Junction box in machine room for cab telephone with one 1 in. conduit with (2) CAT 6 telephone cables to main telephone demarcation backboard.

3.15 MECHANICAL SYSTEM COORDINATION

- A. The Mechanical System Subcontractor will be providing various items of mechanical services equipment and control apparatus. Electrical Subcontractor shall furnish disconnect switches and starters and connect up power wiring to this equipment.
- B. The Mechanical and Electrical Subcontractor shall closely coordinate their respective portions of work.
- C. If, due to local regulations, electric heating equipment furnished by the mechanical systems subcontractor is required to be installed by licensed electricians in order to allow connection by Electrical Subcontractor's licensed electricians, it will then be Mechanical Subcontractor's responsibility to engage and pay for services of such licensed electricians.
- D. Power wiring to be provided by Electrical Subcontractor is the line voltage power supply wiring. Control wiring is responsibility of Mechanical System Subcontractor unless specifically indicated on electrical drawings, or in this Division of the specifications. Temperature Control Subcontractor shall refer to electrical drawings for location of all magnetic starters.
- E. 120 volt control wiring source to the temperature control panel is the responsibility of Electrical Subcontractor.

3.16 DISTRIBUTION EQUIPMENT TESTING

- A. All dry-type transformers, individual motor starters, switchboard and main distribution panels, motor controls, motor control centers, feeder conductors, and emergency systems shall be tested in accordance with the following. In general, all tests shall be done in accordance with the 1995 Acceptance Testing Specifications of the International Electrical Testing Association.
- B. The Testing Subcontractor may be an independent contractor or a manufacturer of the equipment, which is to be tested.
- C. Test report forms, delineating tests to be made, and method of recording same shall be submitted prior to commencing work. Test reports when submitted shall include interpretation of results and recommendation for any corrective work required.
- D. Switchboard and Main Distribution Panels:
 - 1. Visual Inspection:
 - a. Check for foreign material within bus enclosure.
 - b. Check for missing hardware.
 - c. Inspect entire assemblies for transit damage or factory defects.
 - d. Check for all bus dimensions and bracing per specifications.
 - e. Check ratings of current transformers and potential transformers.
 - f. Check ratings of all protective relays per drawings.
 - 2. Physical Inspection:
 - a. Torque all bus hardware to proper tension.
 - b. Circuit breaker interlocks all work properly.
 - c. All doors and hinged panels open and close properly.
 - d. Relay blocking removed from all control and protective relays.
 - e. All circuit breakers operate, close and trip mechanically.
 - f. Torque all feeder conductors to terminal manufacturers' recommendations.
 - 3. Electrical Testing:
 - a. Breakers operated electrically trip and close from local and remote positions.
 - b. All circuit breakers calibrated to manufacturer's respective time current curves as specified.
 - 1) Long time pick-up amps.
 - 2) Long time delay tripping at 300 percent of current setting.
 - 3) Resets okay at 80 percent of pick-up value.
 - 4) Short time pick-up current.
 - 5) Short time delay trip time at 105 percent of setting.
 - 6) Instantaneous minimum pick-up current.
 - c. All protective relays calibrated to manufacturer's characteristic time curves for pick-up, drop-out, instantaneous and time delay.
 - d. All instruments calibrated for accuracy.
 - e. Protective relay schemes to be electrically tested by primary injection of current through current transformers and the tripping of associated circuit breakers.
 - f. Insulation resistance tests made on all circuit breakers, line to load breaker open, line to ground breaker closed, 3 poses tested individually. Switchgear bus to be tested phase to phase and phase to ground with Megohmmeter type instrument. Relays also to be insulation resistance tested.

- E. Transformers:
1. Visual inspection for transit damage such as broken porcelain, brazed connections broken off, core shifted on frame, winding damage, and loose parts.
 2. Insulation resistance tests in accordance with U.S.A.S.I. Standard C571222 and NEMA TRI-2.055.
 3. D.C. over-potential test procedures and A.C. voltage values for factory proof testing of C57.12968 and NEMA TRI-2.055. The ratio applied for converting A.C. test potential to equivalent D.C. value is 1.6.
 4. Acceptance test voltage for new transformers at D.C. value will be 75 percent of equivalent A.C. voltage used for factor proof testing the value will be 65 percent.
 5. Transformers shall be subjected to a ratio and polarity test to prove the polarity and winding ratio as in accordance with nameplate specifications.
 6. Torque all connections to terminal manufacturers' recommendations.
- F. Starters:
1. Visual inspection to determine:
 - a. Shipping damage.
 - b. Proper bussing and contactor sizes.
 - c. Correct overload relay heater ratings. Any incorrectly sized overloads shall be replaced by the contractor who originally provided same.
 2. Electrical Testing:
 - a. Electrical operation of control relays, timing relay, and contactor coils.
 - b. Insulation resistance test on all current carrying bus to ground and between phases.
 - c. Calibration check of overload heater to ascertain tripping point and time delay at 300 percent of heater rating.
- G. Conductors: All secondary service conductors and all feeder conductors from switchboards and distribution panels shall be tested.
1. Visual and mechanical inspection: Conductors to be inspected for physical damage and proper connection and sizing in accordance with single line diagram.
 2. Conductor connections shall be torque tested to manufacturer's recommended values.
 3. Electrical Tests: Perform insulation resistance test on each conductor with respect to ground and adjacent conductor.
 4. Perform continuity test to insure proper conductor connection.
- H. Emergency Systems:
1. Engine Generator - Prior to the emergency generator test specified under the emergency generator specification, the testing contractor shall perform the following:
 - a. Visual and Mechanical Inspection:
 - 1) Inspect for physical damage.
 - 2) Compare nameplate rating and connection with specifications and single line diagram.
 - 3) Inspect for proper anchorage and grounding. Verify engine cooling and fuel system integrity.
 - b. Electrical and Mechanical Tests:
 - 1) Perform a dielectric absorption test on generator winding with respect to ground. Determine polarization index.
 - 2) Perform phase rotation test to determine compatibility with load requirements.
 - 3) Test protective relay devices in accordance with applicable sections of these specifications.
 - 4) Perform dc over potential test between winding and ground.

2. Automatic Transfer Switches:
 - a. Visual and Mechanical Inspection:
 - 1) Inspect for physical damage.
 - 2) Verify that the short circuit withstand rating exceeds the available short circuit duty.
 - 3) Compare equipment nameplate information and connections with single line diagram and report any discrepancies.
 - 4) Check switch to ensure positive interlock between normal and alternate sources. (Mechanical and Electrical).
 - 5) Check tightness of all control and power connections.
 - 6) Perform manual transfer operation.
 - 7) Ensure manual transfer warnings are attached and visible to operator.
 - b. Electrical Tests:
 - 1) Perform insulation resistance tests phase-to-phase and phase-to-ground with switch in both source positions.
 - 2) Measure contact resistance in normal and alternate source position.
 - 3) Set and calibrate in accordance with the project electrical engineer's specifications.
 - a) Voltage and frequency sensing relays.
 - b) All time delay relays.
 - c) Engine start and shutdown relay.
 - 4) Perform automatic transfer by tests.
 - a) Simulating loss of normal power.
 - b) Return to normal power.
 - c) Simulating loss of emergency power on return to normal.
 - d) Simulate all forms of single phase conditions.
 - 5) Monitor and verify correct operation and timing.
 - a) Normal voltage sensing relays.
 - b) Engine start sequence.
 - c) Time delay upon transfer.
 - d) Alternate voltage sensing relays.
 - e) Automatic transfer operation.
 - f) Interlocks and limit switch function.
 - g) Timing delay and retransfer upon normal power restoration.
 - h) Engine cool down and shutdown feature.
- I. Grounding Grids or Electrodes: Measurement of resistance from ground grids or electrodes to earth to determine adequacy of grounding system in building and compliance with specifications and/or electrical code.
- J. Settings of Adjustable Devices: Using the result of the fault current and coordination study specified hereinafter, the Testing Contractor shall set all adjustable devices.
- K. In addition to the testing requirements of this Section refer to Section 019100 – COMMISSIONING REQUIREMENTS and Section 260800 – COMMISSIONING OF ELECTRICAL SYSTEMS, for additional requirements.

3.17 ARC FLASH HAZARD ANALYSIS / SHORT CIRCUIT COORDINATION STUDY

A. Contract

1. Work of this Section is part of the Electrical trade contract. Refer to Section 26 00 00 for additional information about this work.

B. Related Documents

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

C. Scope

1. The contractor shall furnish short-circuit and protective device coordination studies as prepared by the manufacturer of the switchgear provided for the project.
2. The contractor shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in the current version of NFPA 70E -Standard for Electrical Safety in the Workplace. The arc flash hazard analysis shall be performed according to the IEEE Standard 1584 – 2002, the IEEE Guide for Performing Arc-Flash Calculations.
3. The scope of the studies shall include new distribution equipment supplied by switchgear manufacturer furnishing the electrical distribution equipment for this project.

D. References

1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - a. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
 - b. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
 - c. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
 - d. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
 - e. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
 - f. IEEE 1584 -Guide for Performing Arc-Flash Hazard Calculations
2. American National Standards Institute (ANSI):
 - a. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
 - b. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
 - c. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
 - d. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single- Pole Air Switches, Fuse Disconnecting Switches and Accessories.
3. The National Fire Protection Association (NFPA)
 - a. NFPA 70 -National Electrical Code, latest edition
 - b. NFPA 70E – Standard for Electrical Safety in the Workplace

- E. Submittals For Review/Approval
 - 1. The studies shall be submitted to the design engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the study may cause delays in equipment shipments, approval from the Engineer may be obtained for a preliminary submittal of data to ensure that the selection of device ratings and characteristics will be satisfactory to properly select the distribution equipment. The formal study will be provided to verify preliminary findings.

- F. Submittals For Construction
 - 1. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. A minimum of five (5) bound copies of the complete final report shall be submitted. For large system studies, submittals requiring more than five (5) copies of the report will be provided without the section containing the computer printout of the short-circuit input and output data. Electronic PDF copies of the report shall be provided upon request.
 - 2. The report shall include the following sections:
 - a. Executive Summary including Introduction, Scope of Work and Results/Recommendations.
 - b. Short-Circuit Methodology Analysis Results and Recommendations
 - c. Short-Circuit Device Evaluation Table
 - d. Protective Device Coordination Methodology Analysis Results and Recommendations
 - e. Protective Device Settings Table
 - f. Time-Current Coordination Graphs and Recommendations
 - g. Arc Flash Hazard Methodology Analysis Results and Recommendations including the details of the incident energy and flash protection boundary calculations, along with Arc Flash boundary distances, working distances, Incident Energy levels and Personal Protection Equipment levels.
 - h. Arc Flash Labeling section showing types of labels to be provided. Section will contain descriptive information as well as typical label images.
 - i. One-line system diagram that shall be computer generated and will clearly identify individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location, device numbers used in the time-current coordination analysis, and other information pertinent to the computer analysis.

- G. Qualifications
 - 1. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the responsible charge and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies.
 - 2. The Registered Professional Electrical Engineer shall be an employee of the equipment manufacturer.
 - 3. The approved engineering firm shall demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual arc flash hazard analyses it has performed in the past year.

- H. Computer Analysis Software
 - 1. The studies shall be performed using SKM Systems Analysis Power*Tools for Windows (PTW) software program.

- I. Studies
 - 1. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D. This study shall also include short-circuit and protective device coordination studies.

- J. Data
 - 1. Contractor shall furnish all data as required for the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.
 - 2. Source combination may include present and future motors and generators.
 - 3. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner, or Contractor.
 - 4. If applicable, include fault contribution of existing motors in the study. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.

- K. Short-Circuit Analysis
 - 1. Transformer design impedances shall be used when test impedances are not available.
 - 2. Provide the following:
 - a. Calculation methods and assumptions
 - b. Selected base per unit quantities
 - c. One-line diagram of the system being evaluated that clearly identifies individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location and other information pertinent to the computer analysis
 - d. The study shall include input circuit data including electric utility system characteristics, source impedance data, conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other circuit information as related to the short-circuit calculations.
 - e. Tabulations of calculated quantities including short-circuit currents, X/R ratios, equipment short-circuit interrupting or withstand current ratings and notes regarding adequacy or inadequacy of the equipment rating.
 - f. Results, conclusions, and recommendations. A comprehensive discussion section evaluating the adequacy or inadequacy of the equipment must be provided and include recommendations as appropriate for improvements to the system.
 - 3. For solidly-grounded systems, provide a bolted line-to-ground fault current study for applicable buses as determined by the engineer performing the study.
 - 4. Protective Device Evaluation:
 - a. Evaluate equipment and protective devices and compare to short circuit ratings
 - b. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short- circuit stresses
 - c. Switchgear Manufacturer shall notify Owner in writing, of any circuit protective devices improperly rated for the calculated available fault current.

- L. Protective Device Time-Current Coordination Analysis
1. Protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs.
 2. Include on each TCC graph, a complete title with descriptive device names.
 3. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
 4. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
 5. Plot the following characteristics on the TCC graphs, where applicable:
 - a. Electric utility's overcurrent protective device
 - b. Medium voltage equipment overcurrent relays
 - c. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
 - d. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
 - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves
 - f. Medium voltage conductor damage curves
 - g. Ground fault protective devices, as applicable
 - h. Pertinent motor starting characteristics and motor damage points, where applicable
 - i. Pertinent generator short-circuit decrement curve and generator damage point
 - j. The largest feeder circuit breaker in each motor control center and applicable panelboard.
 6. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.
 7. Provide the following:
 - a. A One-line diagram shall be provided which clearly identifies individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus when known.
 - b. A sufficient number of log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices and other pertinent system parameters.
 - c. Computer printouts shall accompany the log-log plots and will contain descriptions for each of the devices shown, settings of the adjustable devices, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.
 - d. The study shall include a separate, tabular printout containing the recommended settings of all
 - e. adjustable overcurrent protective devices, the equipment designation where the device is located, and the device number corresponding to the device on the system one-line diagram
 - f. A discussion section which evaluates the degree of system protection and service continuity with overcurrent devices, along with recommendations as required for addressing system protection or device coordination deficiencies.
 - g. Switchgear Manufacturer shall notify Owner in writing of any significant deficiencies in protection and/or coordination. Provide recommendations for improvements.
- M. Arc Flash Hazard Analysis
1. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2009, Annex D. The arc flash hazard analysis shall be performed in conjunction with the short-circuit analysis (Section 2.03) and the protective device time-current coordination analysis (Section 2.04)

2. The flash protection boundary and the incident energy shall be calculated at significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.
3. Circuits 240V or less fed by single transformer rated less than 125 kVA may be omitted from the computer model and will be assumed to have a hazard risk category 0 per NFPA 70E.
4. Working distances shall be based on IEEE 1584. The calculated arc flash protection boundary shall be determined using those working distances.
5. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations
6. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location in a single table. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum. Conversely, the maximum calculation will assume a maximum contribution from the utility. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable as well as any stand-by generator applications.

The Arc-Flash Hazard Analysis shall be performed utilizing mutually agreed upon facility operational conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.

7. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors should be decremented as follows:
 - a. Fault contribution from induction motors should not be considered beyond 5 cycles. For each piece of ANSI rated equipment with an enclosed main device, two calculations shall be made. A calculation shall be made for the main cubicle, sides, or rear; and shall be based on a device located upstream of the equipment to clear the arcing fault. A second calculation shall be made for the front cubicles and shall be based on the equipment's main device to clear the arcing fault. For all other non-ANSI rated equipment, only one calculation shall be required and it shall be based on a device located upstream of the equipment to clear the arcing fault.
8. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.
9. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.
10. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. A maximum clearing time of 2 seconds will be used based on IEEE 1584-2002 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

11. Provide the following:
 - a. Results of the Arc-Flash Hazard Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, working distances, personal-protective equipment classes and AFIE (Arc Flash Incident Energy) levels.
 - b. The Arc-Flash Hazard Analysis shall report incident energy values based on recommended device settings for equipment within the scope of the study.
 - c. The Arc-Flash Hazard Analysis may include recommendations to reduce AFIE levels and enhance worker safety.

N. FIELD ADJUSTMENT

1. Contractor shall adjust relay and protective device settings according to the recommended settings table provided by the coordination study.
2. Contractor shall make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
3. Switchgear manufacturer shall notify the design engineer in writing of any required major equipment modifications.

O. ARC FLASH LABELS

1. Contractor shall provide a 4.0 in. x 4.0 in. Brady thermal transfer type label of high adhesion polyester for each work location analyzed.
 - a. The labels shall be designed according to the following standards:
 - b. UL969 – Standard for Marking and Labeling Systems
 - c. ANSI Z535.4 – Product Safety Signs and Labels
 - d. NFPA 70 (National Electric Code) – Article 110.16
2. The label shall include the following information:
 - a. System Voltage
 - b. Flash protection boundary
 - c. Personal Protective Equipment category
 - d. Arc Flash Incident energy value (cal/cm²)
 - e. Limited, restricted, and prohibited Approach Boundaries
 - f. Study report number and issue date
3. Labels shall be printed by a thermal transfer type printer, with no field markings.
4. Arc flash labels shall be provided for equipment as identified in the study and the respective equipment access areas per the following:
 - a. Floor Standing Equipment - Labels shall be provided on the front of each individual section. Equipment requiring rear and/or side access shall have labels provided on each individual section access area. Equipment line-ups containing sections with multiple incident energy and flash protection boundaries shall be labeled as identified in the Arc Flash Analysis table.
 - b. Wall Mounted Equipment – Labels shall be provided on the front cover or a nearby adjacent surface, depending upon equipment configuration.
 - c. General Use Safety labels shall be installed on equipment in coordination with the Arc Flash labels. The General Use Safety labels shall warn of general electrical hazards associated with shock, arc flash, and explosions, and instruct workers to turn off power prior to work.

3.18 STORAGE AND INSTALLATION OF EQUIPMENT

- A. The electrical subcontractor shall store and install electrical equipment and wiring listed for dry locations only after the building is watertight.

3.19 WASTE MANAGEMENT

- A. Separate and recycle materials and material packaging in accordance with Waste Management Plan and to the maximum extent economically feasible and place in designated areas for recycling.
- B. Set aside and protect materials suitable for reuse and/or remanufacturing.
- C. Separate and fold up metal banding; flatten and place along with other metal scrap for recycling in designated area.
- D. Coordinate with Section 017400 – CLEANING AND WASTE MANAGEMENT.

3.20 TRAINING

- A. All training shall be scheduled with the user. Training shall be videotaped and a DVD delivered to the Owner. Refer to each specific system for amount of training required.

END OF SECTION

SECTION 260543

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Transformer Pad as required by local Electric Utility Company.
2. Electrical Service: As shown on drawings and as required by Electric Utility Company.
3. Telephone Service: As shown on drawings and as required by Telephone Utility Company.
4. Cable Service: As shown on drawings and as required by Cable Utility Company.
5. Fire Alarm Service: As shown on drawings and as required by City of Dover Fire Department.
6. Other site work conduits as shown on Contract Drawings.

1.2 QUALITY ASSURANCE

A. Applicable requirements of following standards and codes apply:

1. Building and Fire Codes.
2. National Electric Safety Code (NESC) and OSHA requirements.

B. City of Dover Construction Standards, latest edition.

1.3 JOB CONDITIONS

A. Inspection:

1. Examine areas for conditions under which work is to be performed. Report in writing to the OWNER's Representative all conditions contrary to those shown on Drawings or specified herein and all other conditions that will affect satisfactory execution of work such as improper constructed substrates or adjoining work. Do not proceed with work until unsatisfactory conditions have been corrected.
2. Starting work constitutes acceptance of conditions under which work is to be performed. After such acceptance this contractor shall at his expense, be responsible for correcting all unsatisfactory and defective work resulting from such unsatisfactory conditions.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Electrical Conduit: Material and size as specified by Electric Utility Company.

- B. Concrete and steel for blocking and transformer pad (if required) in accordance with Electric Utility Company standards.
- C. Telephone Conduit: Material and size as specified by utility companies providing service.
- D. Cable Conduit: Material and size as specified by utility companies providing service.
- E. Fire Conduit: Material and size as specified by utility companies providing service.

PART 3 - EXECUTION

3.1 TRENCHING, BACKFILLING AND COMPACTION

- A. Trenching, backfilling and compacting: In accordance with most stringent requirements of Division 31 Section "Earth Moving" or with utility companies providing service to site.

3.2 INSTALLATION

- A. Minimum depth of cover on all conduit will be 36", or in accordance with standard specifications of each utility company.
- B. Minimum vertical clearance will be 12" from other utilities.
- C. Provide concrete blocking at all bends in accordance with specifications of each utility company.

3.3 TESTING AND INSPECTION

- A. Contractor shall secure inspection and approval of all utility facilities by inspecting authority prior to connection of service.
- B. Representatives of utility companies providing to site shall inspect applicable conduit installation prior to backfilling. Conduit and equipment pad installation shall be inspected by representative of each utility company prior to laying concrete.

3.4 CONSTRUCTION

- A. All conduit will be installed as shown on Drawings and in accordance with utility company requirements.
- B. Install equipment pads 3" above finished grade.
- C. Install 1/8" nylon pulling cord in each conduit. Pull mandrel through each conduit to check and clear blockage. Conduit will be plugged with PVC cap at both ends.
- D. Transformer pads will be built by Contractor in accordance with design requirements and specifications of electric utility company. For verification of pad design, size, and location, contact local electric utility company.

END OF SECTION 260543

SECTION 26 08 00 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.

1.2 SUMMARY

- A. This section includes commissioning process requirements for Electrical systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
- C. Certificates of readiness
- D. Certificates of completion of installation, pre-start, and startup activities.
- E. O&M manuals
- F. Test reports

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired

resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the electrical contractor of Division 26 shall ultimately be responsible for all standard testing equipment for the electrical systems and controls systems in Division 26.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems
- B. Red-lined Drawings: The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. Operation and Maintenance Data: Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and

systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.

- D. Demonstration and Training: Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the Contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior to the training session

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Perform tests as required by Division 26.
- B. Attend construction phase controls coordination meetings.
- C. Participate in Electrical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CA.
- D. Provide information requested by the CxA for final commissioning documentation.
- E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- F. Prepare preliminary schedule for Electrical system orientations and inspections, operation and maintenance manual submissions, training sessions, equipment start-up and task completion for owner. Distribute preliminary schedule to commissioning team members.
- G. Update schedule as required throughout the construction period.
- H. Assist the CxA in all verification and functional performance tests.
- I. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the test period.
- J. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.
- K. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- L. Notify the CxA a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.
- M. Participate in, and schedule vendors and contractors to participate in the training sessions.
- N. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
- O. The equipment supplier shall document the performance of his equipment.
- P. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.

- Q. Equipment Suppliers
 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 2. Assist in equipment testing per agreements with contractors.
 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

- R. Refer to Division 01 Section “General Commissioning Requirements” for additional Contractor responsibilities.

3.3 CxA'S RESPONSIBILITIES

- A. Refer to Division 01 Section “General Commissioning Requirements” for CxA’s Responsibilities.

3.4 TESTING PREPARATION

- A. Certify in writing to the CxA that Electrical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that Electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify in writing that testing procedures have been completed and that testing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.5 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of Electrical testing shall include the entire Electrical installation, from the incoming power equipment throughout the distribution system. Testing shall include measuring, but not limited to resistance, voltage, and amperage of system(s) and devices.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA along with the Electrical contractor and other contracted subcontractors, including the fire alarm Subcontractor shall prepare detailed testing plans, procedures, and checklists for Electrical systems, subsystems, and equipment.

- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the Electrical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.6 ELECTRICAL SYSTEM TESTING PROCEDURES

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual Division 26 sections. Provide submittals, test data, inspector record, infrared camera and certifications to the CA.
- B. Electrical Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 26 Sections "Instrumentation and Control" and "Sequence of Operations" Assist the CxA with preparation of testing plans.
- C. Fire Detection and Alarm System Testing: Provide technicians, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- D. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
 - 1. Electrical Power Systems and all equipment forming a part of these systems including, but not limited to, electrical supply and distribution systems, emergency and standby power systems including automatic transfer switching systems, lighting and lighting control systems, low voltage systems, grounding and bonding systems, audio visual systems (See Division 27), photovoltaic systems, wind power systems and interfaces to automated temperature/building automation control systems.
 - 2. Life Safety Systems and all equipment forming a part of these systems including, but not limited to, security and surveillance systems (see Division 28) and fire alarm systems.

3.7 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.8 APPROVAL

- A. Refer to Division 01 Section “General Commissioning Requirements” for approval procedures.

3.9 DEFERRED TESTING

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to deferred testing.

3.10 OPERATION AND MAINTENANCE MANUALS

- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
- B. Refer to Division 01 Section “General Commissioning Requirements” for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.11 TRAINING OF OWNER PERSONNEL

- A. Refer to Division 01 Section “General Commissioning Requirements” for requirements pertaining to training.

END OF SECTION 26 08 00

SECTION 270000

TECHNOLOGY

PART 1 - GENERAL.....	1
1.1 GENERAL PROVISIONS.....	1
1.2 QUALITY ASSURANCE.....	1
1.3 COOPERATION AND COORDINATION WITH OTHER TRADES.....	1
1.4 SUBMITTALS.....	2
1.5 TELEPHONE/DATA SYSTEM.....	4
1.6 DEFINITIONS.....	6
1.7 SYSTEM DESCRIPTION.....	6
1.8 SCOPE OF WORK.....	6
1.9 PROTECTION OF WORK AND PROPERTY.....	7
1.10 SEQUENCING AND SCHEDULING.....	8
1.11 WARRANTY.....	8
1.12 MAINTENANCE.....	9
1.13 SEISMIC REQUIREMENTS.....	10
1.14 FUNCTION AND OPERATION.....	10
1.15 EXTRA MATERIALS.....	10
PART 2 - PRODUCTS.....	11
2.1 GENERAL.....	11
2.2 COMMUNICATION EQUIPMENT ROOM FITTINGS.....	11
2.3 FIBER OPTIC CABLE:.....	14
2.4 UTP CABLE (BACKBONE).....	16
2.5 FIBER INNERDUCT.....	17
2.6 FIBER DISTRIBUTION.....	17
2.7 WORK STATION CABLE.....	18
2.8 MAIN DISTRIBUTION FACILITY (MDF).....	24
2.9 INTERMEDIATE DISTRIBUTION FACILITIES.....	25
2.10 TESTING AND DOCUMENTATION.....	26
2.11 INTEGRATED SOUND, PUBLIC ADDRESS SYSTEM.....	27
2.12 WIRELESS MASTER CLOCK SYSTEM.....	40
2.13 AUDIO/VISUAL CABLING.....	43
2.14 MISCELLANEOUS CABLING SYSTEM.....	45
2.15 TWO WAY COMMUNICATIONS CALL BOXES.....	45
PART 3 - EXECUTION.....	48
3.1 GENERAL.....	48
3.2 EQUIPMENT RACKS, CABINETS AND BRACKETS.....	49
3.3 TERMINATIONS.....	50
3.4 CABLE PATHWAYS.....	50
3.5 SEALING OF PENETRATIONS AND OPENINGS.....	50
3.6 SEISMIC SUPPORTS, SUPPLEMENTARY STEEL AND CHANNELS.....	50
3.7 IDENTIFICATION.....	52
3.8 CABLE SUPPORTS.....	53
3.9 CABLE PROTECTION.....	53
3.10 INSTALLATION.....	54
3.11 TRAINING.....	55
3.12 ACCEPTANCE DEMONSTRATIONS.....	56
3.13 PROJECT OWNER COORDINATION.....	57

3.14	CLEANING UP	57
3.15	PROJECT CLOSEOUT	57

END OF INDEX

SECTION 270000

TECHNOLOGY

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this section of the Specifications.
- B. Examine all other sections of the specifications for requirements that affect work of this section whether or not such work is specifically mentioned in this section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 QUALITY ASSURANCE

- A. Sustainable Goals: The Architect has designed the project to meet the Owner's sustainable goals. Products and systems have been specified which meet certain third-party evaluations or have particular VOC and source requirements. Evaluation of products proposed for substitution will be evaluated based on the Owner's sustainable goals and other criteria included in Division 01. The Contractor is encouraged to use sustainable construction practices, means and methods. Unless specifically stated in a specification section, no sustainable design documentation is required of the Contractor.

1.3 COOPERATION AND COORDINATION WITH OTHER TRADES

- A. The work shall be so performed that the progress of the entire building construction, including all other trades, shall not be delayed and not interfered with. Materials and apparatus shall be installed as fast as conditions of the building will permit.
- B. This section shall be furnish/installed as follows by a firm/company that is a qualified systems contractor. The Electrical Subcontractor shall be responsible for properly preparing the project for installation by systems contractor, as specified.
 - 1. Electrical Subcontractor responsibilities shall include: The Electrical Subcontractor shall be responsible for furnishing and installing all related building preparation including, but not limited to: outlet boxes with plaster rings, floor boxes, poke through devices, pathways, power, cableways, cable tray, cable protection, wiremold, surface raceways, cable supports, conduits with bushings, conduit stubs with bushings, sleeves with bushings (all conduits, stubs, sleeves, J-Hooks, shall be brought to an accessible ceiling or accessible area below floor), pull strings, bonding, grounding, core drilling, cutting, patching, fireproofing of penetration & openings, environmental seals, smoke and fire stopping seals including all conduits, raceways, sleeves, slots, where cables pass from one location to another, seismic supports, supplementary steel and channels, for a completely operational system, as specified. The Electrical Contractor is responsible for installing all required sleeves for a complete installation whether they are shown or not on the floor plans the routing of cables is determined by the Architecture and no Ethernet cable can exceed 90m or max distance rating of CAT6 or CAT6A cable use. The Electrical Subcontractor shall also accept delivery

- and properly store & secure all equipment and materials required by the systems contractor. The Electrical Subcontractor shall install all specialized backboxes (microphone, amplifier,) and any exterior antennas furnished by Systems Contractor.
- a. The Electrical Subcontractor shall provide cable tray over each rack and cabinet to facilitate a neat and orderly installation of cables and to secure the top of the racks to the structure. Cables shall drop straight down to equipment racks. Cable trays shall be secured at both ends to the structure and connected together for a complete contiguous installation. Utilize proper supports to support the cable tray to the building structure as well as the equipment rack and cabinet. Submit mounting supports for approval before installation.
 - b. The Electrical Subcontractor shall provide 120VAC power as shown on drawings.
 - c. This entire section: The Electrical Subcontractor shall read this section in its entirety and shall provide all requirements of the Electrical Subcontractor as detailed in this section.
2. Systems Contractor responsibilities for this section shall be: Systems contractor shall be responsible for providing, installing, programming, troubleshooting, training and warranty service of all cabling, terminal equipment, headend equipment specified in this section for a completely operational system. The systems contractor shall furnish all specialized backboxes (speaker, microphone, amplifier) and all exterior antennas to the Electrical Subcontractor for their installation.
- a. Keep fully informed as to the shape, size and position of all openings required for all apparatus and give information in advance to build openings into the work. The electrical subcontractor shall furnish and set in place all sleeves, pockets, supports and incidentals.
 - b. All distribution systems which require pitch or slope such as plumbing drains, steam and condensate piping shall have the right of way over those which do not. Confer with other trades as to the location of pipes, ducts, lights and apparatus and install work to avoid interferences.
 - c. Coordinate exact locations and roughing in dimensions of all work before installation and make all final connections. Any changes required to avoid interferences or to provide adequate clearances for Code and maintenance requirements shall be made at no additional costs.
 - d. Structural elements of the project shall not be relocated, altered or changed to accommodate the work without written authorization from the Architect.
 - e. Work that is installed before coordination with other trades or that causes interference with the work of other trades shall be changed to correct condition.
 - f. Obtain a complete set of Project Drawings and Specifications for coordination and to determine the full scope of work.
 - g. Attend project coordination meetings to coordinate work of this section, work of other trades and project and phasing requirements.

1.4 SUBMITTALS

- A. Product Data for all materials specified and shown on drawings to be installed.
- B. Equipment List: Provide a detailed Equipment List showing quantities by manufacturer and model number of all major items of equipment and installation material to be used in the system as specified herein.
- C. Submit supporting hardware for this system as part of the work for approval prior to installation.

- D. Product Data: Include complete sets of indexed cut sheets, in quantity as dictated by the project, of all major pieces of equipment and materials being supplied. Arrange these sheets in the order the equipment appears in the Specification. Clearly highlight information showing compliance with this and/or all applicable Specifications. In the event that the manufacturer or representatives' cut sheet contains more than one item, clearly indicate which items of the cut sheet are intended for installation.
- E. Shop Drawings: Submit a set of complete Shop Drawings, by system, showing equipment to be installed. Include system configuration block diagrams of all equipment, indicating equipment type and model numbers. Show each and every component, system and subsystem, as well as all proposed connections between system components, and proposed layouts of equipment racks for the entire system.
1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 2. Cabling administration drawings and printouts.
 3. Wiring diagrams to show typical wiring schematics including the cross-connects.
 4. Cross-connects. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
 5. Cross-connects and patch panels. Detail mounting assemblies and show elevations and physical relationship between the installed components.
 6. Cable tray layout showing cable tray route to scale with relationship between the tray and adjacent structural, electrical and mechanical elements.
- F. Quality Assurance Submittals:
1. Provide manufacturer's certification that Installer is qualified to install systems specified. Include a written statement signed by the Installer attesting that they have been in business for at least five years in the installation and servicing of systems specified. Include the names of at least five clients for whom similar Work as specified has been performed in the past three years; list the individual responsible for the day-to-day operation of the system along with their current telephone number and address.
 2. Provide names, qualifications, and certifications of installation personnel including Communication Systems Installer's site Supervisor/Foreman who shall be in charge of, and responsible for, all activities at the job site for the duration of the Project. The job Supervisor/Foreman shall not be changed during the project without notification and approval from the Owner.
 3. Complete warranty information including sample Registration Certificate.
 4. Technical Diagrams and Drawings:
 - a. Simplified single line block diagrams showing the interconnection of all equipment and functional relationships. Show all equipment, patch panels, cables and jacks, whether connected or not. The intent of these diagrams is to provide sufficient clear and complete information that a technician of average skill may efficiently troubleshoot and service the system, even if unfamiliar with the installation.
 - b. Provide "As Built" architectural quality plan Drawings at 1/8 inch = 1 ft-0 in. scale. Provide an electronic copy of the "As Built" drawings on CD(s).
 - c. All technical diagrams and drawings shall be mounted on the wall behind a clear plastic cover for protection. There shall be 1 set of the above drawings and diagrams provided per equipment room, this includes both the MDF Room and all IDFs.

1.5 TELEPHONE/DATA SYSTEM

A. General:

1. All telecommunication and data system interconnecting wiring, terminal blocks, connections, terminations, shall be furnished and installed by a licensed and certified installer.
2. The Electrical Subcontractor (E.C.) shall furnish and install all raceways, and outlet boxes as indicated on the drawings, including pull wires for all empty raceways and all access panels. General contractor will furnish and install all backboards (3/4 inch thick by 78 in. high) which shall be mounted at the MDF room and each IDF room.
3. General Requirements:
 - a. Applicable Standards:
 - 1) Materials and equipment shall be installed in accordance with the most current versions of the National Electrical Code, local codes, safety codes, ANSI, ASTM, EIA, TIA, BISCI, IEEE, UL, NFPA.
 - a) The following industry standards are the basis for the structured cabling system described in this document.
 - ANSI/TIA/EIA
 - TIA/EIA-568-B Commercial Building Telecommunications Cabling Standard
 - TIA/EIA-568-B.1 General Requirements
 - TIA/EIA-568-B.2 Balanced Twisted Pair Cabling Components Standard
 - TIA/EIA-568-B.3 Optical Fiber Cabling Components Standard
 - TIA/EIA - 942 Telecommunications Infrastructure for Data Centers
 - TIA/EIA-569-A Commercial Building Standard for Telecommunications Pathway and Spaces
 - TIA/EIA-606-A Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
 - J-STD-607-A Commercial Building Grounding/Bonding Requirements NFPA
 - NFPA 70 National Electric Code (NEC) ISO/IEC
 - ISO 11801 Generic Cabling for Customer Premises
 - EIA/TIA-TSB 67. Telecommunications Systems Bulletin, Additional Transmission Specifications for Unshielded Twisted-Pair Cabling Systems"
 - EIA/TIA-455-61. "FOTP-61, Measurement of Fiber or Cable Attenuation Using An OTDR".
 - IEEE 802.3 "Carrier Sense Multiple Access With Collision Detection".

- ATM Forum Standard for 155 Mb/s ATM over Category 6 (AF-PHY-0015.000, 9/94)
 - BISC1: Telecommunications Distribution Methods and LAN Design Manual
 - IEEE-802: Standards for Local Area Networking
 - UL Performance Levels Certification Program
 - ANSI-IEEE-C2: National Electrical Safety Code (NEC)
 - ANSI/NFPA-101: Life Safety Code
 - National Electric Code CMR527
- b. Exposed wiring is not acceptable in any occupied space.
- c. Contractor is responsible for strict adherence to National electrical codes, and all other applicable codes.
- d. The contractor is responsible for obtaining municipal permits and inspections as mandated by law.
- e. All exposed cabling shall be run in raceway or conduit.
- f. All penetrations in station raceway shall have rubber or equivalent grommets to prevent cable cuts on trough edges.
- g. Raceway shall be of sufficient size to accommodate all wiring. Fill density not to exceed 40 percent, unless otherwise noted. It is the responsibility of the bidder to determine the size needed based upon the floor plans provided. A minimum size of ¾ in. conduit shall be adhered to.
- h. All raceways shall be attached to the building structure using screws and anchors.
- i. The I.T. sub contractor is responsible for all aspects of MDF & IDF construction. Refer to drawings for configuration of each IDF and MDF.
- j. All cabling at the MDF and IDFs shall be neatly bundled and dressed to the termination blocks. All appropriate cable management materials (slotted duct, D rings) should be utilized for this purpose. All wiring at IDF cabinets shall be installed concealed.
- k. All labeling of cables shall be 6 in. back from the termination with machine generated labels, hand written labels are not permitted.
- l. All cable pulls in conduit, raceway, innerduct, shall have pull string left in place for future use.
- m. Color code identification of cables must be maintained throughout all splices.
- n. All station cabling shall be clearly and legibly labeled at both the faceplate end and the IDF/MDF termination blocks. In addition to labeling both the inside of the faceplates and IDF/MDF termination blocks, the cable jacket shall be labeled six inches back from the terminations on both ends. Labeling shall be machine generated.
- o. Labeling of the outside of the jack with identification numbers shall be made using a Panduit LS8 handheld label machine or equal. Samples shall be provided to Engineer for approval prior to installation.
- p. In order to qualify for installation of the data communications system, Contractor must possess the required license classification, a performance history, experience in the installation and termination of optical fiber cable systems, and proof of time in business. Contractor must be trained and certified for the communications cable and hardware which it installs, and must furnish proof of certification.
- q. License Classification: Contractor must possess a valid state Contractor's License.

- B. Unless otherwise indicated, the following work is not included as part of the systems integrator's responsibilities in this section, except for coordination, and is to be performed by others as indicated:
1. Raceway shall be provided by the electrical contractor.
 2. Empty conduits to accessible point above ceiling or below floor shall be provided by the electrical contractor.
 3. Floor boxes and poke through devices shall be provided by the electrical contractor.
 4. Standard device boxes with plaster rings for data and Integrated Instructional Technology Network System shall be provided by the electrical contractor.
 5. Clock system backboxes and custom pigtails shall be installed by the electrical contractor and provided by this systems integrator. 120V wiring by Electrical Contractor.
 6. Speaker/paging system backboxes shall be installed by the electrical contractor and provided by this systems integrator.
 7. Structural blocking to support wall and ceiling mounted televisions/monitors shall be provided by the General Contractor.
 8. Interface with public utilities telephone service shall be arranged by the owner, and coordinated with this systems integrator.
 9. Telephone equipment and handsets will be provided under a separate contract.

1.6 DEFINITIONS

- A. Main Cross Connect (MC): The MC is the location, within a building or complex of buildings, where the entire telecommunications system originates. It may include: the physical location, enclosure, wire and cable management hardware, termination hardware, distribution hardware, and patching and equipment racks.
- B. Horizontal Cross Connect (HC): The HC is the location in a building where a transition between the backbone or vertical riser system and the horizontal distribution system occurs.

1.7 SYSTEM DESCRIPTION

- A. The data communications system shall consist of four components, active switch equipment, an optical fiber backbone, a copper twisted-pair backbone, and twisted pair copper work station cabling.
- B. The audio visual systems shall consist of wiring, jacks, amplification equipment, control equipment, and head end video equipment.

1.8 SCOPE OF WORK

- A. The work under this section includes providing of all material, labor, equipment and supplies and the performance of all operations to provide a complete working Integrated Instructional Technology Network System indicated by the Drawings and details and as specified herein. Where the Drawings, Specifications, Codes, Regulations, Laws, or the requirements of the local Authority conflict, provide the higher quality and higher quantity indicated or required and follow the strictest requirement. In general, the work includes, but is not limited to, the following:
1. Cabling for Sound and Clock per manufacturers requirements.
 2. Equipment Racks and Cabinets.
 3. Relay Brackets.
 4. Terminations.

5. Protection of all work.
 6. Record Drawings and Documentation.
 7. Staging.
 8. Telephone and data cabling.
 9. Data network racks, patch panels, and patch cables.
 10. Network fiber optic back bone cabling and patch panels.
 11. Operation and Maintenance Instructions and Manuals for the section's work.
 12. Nameplates, Labels and Tags.
 13. Testing and certification.
 14. Coordination with manufacturers, other trades and Owner.
 15. CATV wiring, amps and splitters.
 16. Sound, Public Address, Master Clock and Intercom.
 - a. Integrated Sound, System Computer and Software.
 - b. Classroom/Staff/Administrative Telephone System Outlets.
 - c. Telephone System Integration Requirements.
 - d. Ceiling / Wall Mounted Speaker Assemblies.
 - e. Bell/Class Change Signaling System.
 - f. Public Address System.
 - g. Controls, Amplifiers, and Terminal Equipment.
 - h. Power Supplies.
 - i. Battery Backup for System Programming.
 - j. Program Distribution System.
 - k. Wireless Master Clock System.
 - l. Wireless Secondary Clocks.
 - m. Accessories.
 - n. Local sound system interface with paging system.
- B. Provide and maintain in safe adequate condition all staging and scaffolding required for the proper execution of the work of this section.
- C. Coordinate work with that of all other trades affecting or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the Contract.
- 1.9 PROTECTION OF WORK AND PROPERTY
- A. Be responsible for the care and protection of all work included under this section until it has been tested and accepted.
 - B. Protect all equipment and materials from damage from all causes including theft. All materials and equipment damaged or stolen shall be replaced with equal material or equipment at the option of the Architect and Owner.
 - C. Materials and equipment stored for this project shall be protected and maintained according to the manufacturer's recommendations and requirements and according to the applicable requirements of NFPA 70B.
 - D. Protect all equipment, outlets and openings with temporary plugs, caps and covers. Protect work and materials of other trades from damage that might be caused by work or workmen and make good any damage caused.
 - E. Use caution to avoid damage to existing work, and to prevent harm to personnel working in all areas.
 - F. Observe all safety precautions and requirements for the construction.

- G. When open-flame or spark producing tools such as blower torches, welding equipment, are required in the process of executing the work, the General Contractor shall be notified not less than twenty four hours in advance of the time that the work is to begin and the location where the work is to be performed. Provide, where necessary, fire protective covering and maintain a constant non-working fire watch where work is being performed and until it is completed.
- H. The General Contractor and the Installer are responsible for initiating, maintaining, and supervising all safety precautions and requirements during construction.

1.10 SEQUENCING AND SCHEDULING

- A. Coordinate the work of this section with the respective trades responsible for installing interface work, and ensure that the work performed hereunder is acceptable to such trades for the installation of their work.
- B. Continuity of all services shall be maintained in all areas which will be occupied or temporarily relocated during the construction period. If an interruption of service becomes necessary, such shall be scheduled in advance, made only upon consent of the Owner and at a time outside normal working hours as the Owner shall designate.
- C. Refer to the overall scheduling of the work of the project. Schedule work, process Submittal and order materials and equipment to conform to this schedule and install work to not delay nor interfere with the progress of the project.
- D. Inform Architect immediately of any delays or potential delays. Furnish manufacturer's letter to verify order date, equipment delays, expected shipment date, order number, and potential remedies to speed up delivery. Any costs to speed up delivery shall be implemented at no cost to the project if the equipment or material was not ordered as soon as possible after Contract award or within the time frames indicated with the Submittal.
- E. Include premium time required to comply with the project scheduling and phasing.
- F. Be aware of, and plan for, project scheduling and phasing. Provide for complete continuous operation of all systems. Coordinate scheduling and phasing with the Architect, Owner, other Trades, and the General Contractor.

1.11 WARRANTY

- A. Voice and Data Cabling Warranty: The products that shall best support the needs of the project, and provide the highest level of system performance over the life of the facility, shall be a voice and data cabling system that is made up of system components designed, manufactured and installed as a total system solution. This requirement also applies to data patch cords specified in this section; e.g. Ortronics patch cords shall be used with Ortronics jacks and patch panels.

- B. Provide a Manufacturer's Extended Product Warranty that covers product defects for all passive components of the Voice and Data Cabling System. Passive components are defined as those exhibiting no gain or contributing no energy to the Data Cabling System and include but are not limited to cabling, connectors, outlets, patch panels, patch cords, racks as outlined in PART 2 of this Specification.
1. The following shall be covered by the Manufacturer's Extended Product Warranty:
 - a. All passive components that comprise the Voice and Data Cabling System will be free from manufacturing defects in material of workmanship under normal and proper use.
 - b. All passive components that comprise the Voice and Data Cabling System shall exceed the specifications of ANSI/TIA/EIA 568B series, and exceed ISO/IEC 11801 standards, including all subsequent changes to these standards that are in effect at the time of bidding, and shall meet or exceed the performance specifications as outlined in PART 2 of this Specification.
 - c. The installation shall exceed the insertion and return loss, attenuation and near end crosstalk (NEXT) requirements of ANSI/TIA/EIA 568B series and the ISO/IEC 11801 standards for cabling links/channel configurations specified in these standards including all subsequent changes to these standards that are in effect at the time of bidding.
 - d. Each Voice and Data Channel shall be capable of delivering data at 1.2 Gbps between active network electronics. A Data Channel is comprised of all passive components including cabling, connectors, patch panel port, and patch cords, with up to a total of 4 connections between Owner's network electronics (not in the contract).
 2. Upon successful completion of the Voice and Data Cabling System installation by the Communication Systems Installer, and subsequent inspection by an authorized representative of the Manufacturer of the passive components, the Owner shall be provided with Registration Certificate, from the Manufacturer, registering the Installation.
 3. Duration of Warranty: The warranty shall run for 20 years from the Date of Substantial Completion of the Project, unless the Registration Certificate is issued by the Manufacturer at a later date, in which case the warranty shall run for 20 years from the date that the Registration Certificate is issued.
 4. The Extended Product Warranty is applicable to the Voice and Data Cabling System passive components at the original site of installation. Under the Extended Product Warranty, the Manufacturer of the passive components shall either repair or replace the defective product(s) at the Manufacturers cost. This includes the replacement or repair cost of defective materials and the cost of labor to repair or replace any and all defective products.
 5. The Communication Systems Installer shall be able to provide a Manufacturer's warranty that the Voice and Data Cabling System shall be free from failures which prevent operation of the specific applications for which the original Voice and Data Cabling System was designed to support, including but not limited to: 10Base-T; 100Base-T; 52/155 Mbps ATM; 622Mbps 64-CAP ATM; 1000Base-T Gigabit Ethernet.

1.12 MAINTENANCE

- A. Provide installers maintenance contract quote, upon request, for a period equal to warranty.
- B. Upon receipt of notice from the Owner of failure of any part of the systems during the warranty period, the affected parts shall be replaced. Any equipment requiring excessive service consisting of more than two unscheduled service calls, shall be considered defective and shall be replaced.

- C. Response times to warranty issues shall differ according to the level of the problem.
 - 1. A problem is considered to be corrected when the system and its components operate according to specified requirements.
 - 2. Warranty work shall be performed according to the procedures of the Owner, its staff and tenants and their normal operations.

1.13 SEISMIC REQUIREMENTS

- A. Equipment and work shall meet the restraint requirements for a Seismic Zone - 2 location including installation and connections of material and equipment to the building structure.

1.14 FUNCTION AND OPERATION

- A. The intended function of the data communications cable system is to transmit data signals from a central location to several individual data outlet locations. Upon completion of the work outlined in this specification, the system shall be capable of transmitting data signals at a rate of 1000 Mbps.
- B. The multimode optical fiber cable system shall be capable of transmitting signals with a minimum bandwidth of 160 MHz at both 850 or 1300 nm. The cumulative signal loss, through connectors, jumpers, couplers, and fiber cable, shall be less than 10 dB. The single mode optical fiber cable system shall be capable of transmitting signals with a bandwidth of up to 500 MHz at both 1300 and 1550 nm. The cumulative signal loss, through connectors, jumpers, couplers, and fiber cable, shall be less than 10 dB.
- C. Work station cable, from the HC to the work area, shall be installed in accordance with EIA/TIA-568-A specified installation practices, EIA/TIA TSB 67 recommended installation practices, manufacturer specified installation practices, and shall be capable of transmitting a signal at 1000 Mbps with acceptable attenuation and cross-talk measurements. The entire work station cable system, including wiring blocks, cable, and telecommunications outlets shall be tested for Category 6 compliance.

1.15 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Connecting Blocks: One of each type.
 - 2. UTP 4-pair Station Cable: 1,000 feet.
 - 3. UTP Backbone Cable: 300 feet.
 - 4. Patch-Panel Units: One of each type.
 - 5. Device Plate: 10 of each type.
 - 6. Patch Cables: 80 – Color and length to be determined.
 - 7. Fiber optic patch cable: two of each type.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Throughout Part 2, material quantities are given. These quantities are given for reference purposes only. It is the responsibility of the Contractor to provide appropriate quantities of materials to provide a complete, functional system.
- B. Equipment shall be installed in accordance with Technology drawings. General installation provisions are as follows:
1. Equipment Racks: Equipment racks shall be assembled and mounted in locations shown in the Drawings and as described herein. Each rack shall be assembled in accordance with the manufacturer's instructions and recommendations. Each rack shall be mounted such that the side rails are plumb. Each rack shall be affixed to the building structure at each of the mounting holes provided. Attachment shall be by 1/2 in. X 1-1/4 in. lag bolts. A 3/8 in. pilot hole shall be drilled for each lag bolt. Each bolt shall be tightened to the extent that it holds the mounting hardware firmly, but not so tight as to distort the hardware or strip the threads. Equipment racks are to be co-located with the quadplex power outlets to allow for easy connection of racked equipment to the power system of the school.
 2. Wiring Blocks and Wire Management Components: Where required, wiring blocks and wire management components shall be mounted to the plywood backboard. Wiring blocks and wire management shall be mounted in accordance with the attached drawings. Each device shall be mounted such that its horizontal dimension is level. In cases where more than one device is mounted, they shall be aligned vertically. Each device shall be affixed to the plywood backboard by means of screws suitable for fastening to plywood. A minimum of four (4) of the mounting holes provided shall be utilized for fastening. Screws shall be tightened to the extent that they hold the device snug to the backboard, but not so tight as to distort or damage the device. Wiring blocks shall be terminated in accordance with the manufacturer's instructions and recommendations. Installation of accessories shall also be conducted in accordance with the manufacturer's instructions and recommendations.

2.2 COMMUNICATION EQUIPMENT ROOM FITTINGS

A. SUMMARY

Section Includes:

1. Telecommunications mounting elements.
 2. Pathways
 3. Telecommunications equipment racks and cabinets
 4. Grounding.
- B. COORDINATION: Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.
1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
 2. Record agreements reached in meetings and distribute them to other participants.

3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.
5. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

C. PATHWAYS

1. General Requirements: Comply with TIA/EIA-569-A.
2. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.
 - a. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
 - b. Support brackets with cable tie slots for fastening cable ties to brackets.
 - c. Lacing bars, spools, J-hooks, and D-rings.
 - d. Straps and other devices.

D. EQUIPMENT FRAMES (RACKS)

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. APC
 - b. Cooper B-Line, Inc.
 - c. Hubbell Premise Wiring.
 - d. Panduit
 - e. Or equal
2. General Frame Requirements:
 - a. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - b. Module Dimension: Width compatible with EIA 310 standard, 19-inch panel mounting.
 - c. Finish: Manufacturer's standard, baked-polyester powder coat.
3. Floor-Mounted Racks: Modular-type, four-post quick rail, aluminum construction.
 - a. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and two power strips.
 - b. Baked-polyester powder coat finish.
4. Equipment Cabinets:
 - a. 42RU, 24 in. W x 42 in. D.
 - b. Steel construction.
 - c. Treated to resist corrosion.
 - d. Perforated front and rear doors.
 - e. Lockable front and rear doors.
 - f. Louvered side panels.
 - g. Cable access provisions top and bottom.
 - h. Grounding lug.
 - i. Rack-mounted, 250-cfm fan.
 - j. 19 in. Dual slide rack mount monitor keyboard drawer (provide two)
 - k. Power strip (two).
 - l. All cabinets keyed alike.
 - m. Regulatory approvals: EIA-310-D
 - n. Warranty: 5-years
 - o. Standards: UL 60950

5. Cable Management for Equipment Frames:
 - a. Metal, with integral wire retaining fingers.
 - b. Baked-polyester powder coat finish.
 - c. Vertical cable management panels shall have front and rear channels, with covers.
 - d. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.
 6. Power Strips: Comply with UL 1363.
 - a. Rack mounting.
 - b. Receptacles: Six 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles for each power strip. Provide two in each rack.
 - c. LED indicator lights for power and protection status.
 - d. LED indicator lights for reverse polarity and open outlet ground.
 - e. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
 - f. Cord connected with 15-foot line cord.
 - g. Rocker-type on-off switch, illuminated when in on position.
 - h. Peak Single-Impulse Surge Current Rating: 33 kA per phase.
 - i. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all 3 modes shall be not more than 330 V.
- E. GROUNDING
1. Comply with requirements in 260000 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.
 2. Telecommunications Main Bus Bar:
 - a. Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
 - b. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide with 9/32-inch holes spaced 1-1/8 inches apart.
 - c. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.
 - d. Comply with ANSI-J-STD-607-A.
- F. LABELING
1. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.3 FIBER OPTIC CABLE:

- A. Fiber: The following cable specifications shall also be met by the cable manufacturer for fiber optic cable:
1. Multimode Optical Fiber Cabling: Multimode optical fiber cables shall meet all of the requirements delineated within the specifications of ANSI/TIA/EIA-568-B1, B2, B3 and ISO/IEC 11801, 50/125 fiber shall be as noted in Table 1 and 2. Fiber shall be laser optimized type OM3.

Table 1 Minimum Performance Parameters for LightSystem™ Cables Containing 50/125 Multimode Fiber						
Fiber	Maximum Attenuation (dB/km)		Minimum Bandwidth (MHz-km)		Guaranteed Transmission Distance (m)	
	@ 850 nm	@ 1300 nm	@ 850 nm	@ 1300 nm	@ 850 nm	@ 1300 nm
50/125	3.5	1.0	200	500	275	550

TABLE 2 Minimum Performance Parameters for LightSystem Plus™ Cables Containing 50/125 or 50/125 Multimode Fiber						
Fiber	Maximum Attenuation (dB/km)		Minimum Bandwidth (MHz-km)		Guaranteed Transmission Distance (m)	
	@ 850 nm	@ 1300 nm	@ 850 nm	@ 1300 nm	@ 850 nm	@ 1300 nm
50/125	3.5	1.0	220	1000	300	550

2. Singlemode Optical Fiber Cable: Singlemode mode LightSystem™ fiber cables shall meet all of the requirements delineated within the specifications as listed in Section 1 except that the attenuation and zero dispersion limits shall be as noted in Table 3 and 4.

TABLE 3 Minimum Performance Parameters for LightSystem™ Cables Containing Singlemode Fiber					
Fiber	Cable Type	Maximum Attenuation (dB/km)		Zero Dispersion	
		@ 1310 nm	@ 1550 nm	Wavelength (nm)	Slope (nm ² -km)
Singlemode	Inside Plant	1.0	1.0	1300-1324	< 0.093
	Outside Plant	0.5	0.5		

TABLE 4 Minimum Performance Parameters for LightSystem Plus™ Cables Containing Singlemode Fiber					
Fiber	Cable Type	Maximum Attenuation (dB/km)		Zero Dispersion	
		@ 1310 nm	@ 1550 nm	Wavelength (nm)	Slope (nm ² -km)
Singlemode	Inside Plant	0.5	0.5	1300-1320	< 0.092
	Outside Plant	0.4	0.3		

3. Attenuation: The LightSystem™ cable as noted in Tables 1 and 3 and LightSystem Plus™ as noted in Tables 2 and 4 cable shall perform in accordance with the attenuation limits when tested per ANSI/EIA/TIA-455-46, -53, -61 or -78 (as applicable).

4. Bandwidth: LightSystem™ as noted in Table 1 cable and LightSystem Plus™ cable as noted in Table 2 shall perform in accordance with the bandwidth limits when tested per ANSI/EIA/TIA-455-51 or ISO/IEC 793-1-C2A
5. Transmission distance: The protocol pertinent to the transmission distance noted in Table 1 for LightSystem™ and Table 2 for LightSystem Plus™ cable is Gigabit Ethernet per IEEE 802.3z.
6. Zero Dispersion Wavelength and Slope: LightSystem™ cable shall perform as noted in Table 3 and LightSystem Plus™ cable as noted in Table 4 in accordance with the Zero Dispersion wavelength and slope limits when tested per ANSI/EIA/TIA-455-168, -169, or -175 (as applicable).
7. Fiber 50/125 μm Multimode Optical fiber cables shall be manufactured by one of the following:
 - a. Belden
 - b. Berk-Tek
 - c. Commscope
 - d. General Cable
 - e. Mohawk
 - f. Or equal
 - g. Be a minimum of twelve strands of 50/125 μm multimode optical fiber for horizontal cabling.
 - h. Be appropriate for the environment in which it is installed.
8. Fiber equipment cords shall:
 - a. Be available in standard lengths of 1, 3, and 5 meters, custom lengths shall also be available, and shall meet or exceed standards as defined in ANSI/TIA/EIA-568-A and ISO/IEC 11801.
 - b. Utilize duplex fiber cable that is 50/125 micron multimode, OFNR riser grade, and meets the requirements of UL 1666.
 - c. Utilize cable where the attenuation shall not exceed 3.5 dB/km @ 850 nm wavelength or 1.0 dB/km @ 1300 nm.
 - d. Have a cable jacket color for 50/125 in gray.
 - e. The connectors shall be SC or ST in accordance with TIA/EIA-568-A and must include a ceramic ferrule.
 - f. Have ST connectors with a metal coupling nut.
 - g. Have a minimum return loss of 20 dB (25 dB typical) at both 850 nm & 1300 nm.
 - h. Be made by an ISO 9001 and 14001 Certified Manufacturer.
 - i. Be UL 1666 approved.
 - j. Siemon Company FJ Series Fiber Jumpers Recommended Category 6:
9. Coordinate fiber patch cords with Owner prior to release. Provide SC to LC, ST to LC, or any combination of the two. Provide one per fiber port.
10. Warning Tags: At each location where the fiber cable is exposed to human intrusion, it shall be marked with warning tags. These tags shall be yellow or orange in color, and shall contain the warning: "CAUTION FIBER OPTIC CABLE". The text shall be permanent, black, block characters, and at least 3/16 in. high. A warning tag shall be permanently affixed to each exposed cable or bundle of cables, at intervals of not more than five feet. Any section of exposed cable which is less than five feet in length shall have at least one warning tag affixed to it.
11. T-Bar Suspended Ceilings: Copper station cabling may be run outside of conduits and above T-Bar suspended ceilings when available, at the option of the installer. Cables installed in this fashion are to be run horizontally in bundles and tied down neatly, well clear of any light fixtures or other electrical appliances that may affect data transmissions.

- B. Optical fiber Interconnect Equipment: Interconnect equipment may be mounted either on the plywood backboard or in the equipment racks, depending on the particular application. When mounted on the backboard, the horizontal dimension shall be level. A minimum of four of the mounting holes provided shall be utilized for fastening. Screws shall be tightened to the extent that they hold the device snug to the backboard, but not so tight as to distort or damage the device. Interconnect equipment mounted in racks shall be affixed to the rack by at least four screws. The screws shall be of the correct size and thread configuration for the holes in the rack. They shall be tightened to the extent that they hold the equipment firmly to the rack, without distorting the equipment or stripping the threads. All optical fiber interconnect devices shall be assembled and installed in accordance with the manufacturer's instructions and recommendations. All large openings into wall mounted cabinets shall be covered by a grommet.

2.4 UTP CABLE (BACKBONE)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Belden CDT Inc.; Electronics Division.
 2. CommScope
 3. Mohawk; a division of Belden CDT.
 4. Molex
 5. Superior Essex Inc.
 6. Or equal

- B. Description: Multi-pair Backbone Cable: Category 5e, 100-ohm, 25-pair UTP binder groups covered with a gray thermoplastic jacket.
1. Comply with ICEA S-90-661 for mechanical properties.
 2. Comply with TIA/EIA-568-B.1 for performance specifications.
 3. Comply with TIA/EIA-568-B.2, Category 5e.
 4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - a. Communications: Type CMP, complying with NFPA 262.

- C. Multi-pair backbone cables: Provide copper backbone cable that meets or exceeds the following specifications:

1. Electrical Specifications:

Maximum DC Resistance	28.6 Ω /1,000 ft (9.4 Ω /100m)
Maximum DC Resistance Unbalanced	5 percent
Maximum Capacitance Unbalanced (pair to ground)	1,000 pF/1000 ft. (328 pF/m)
Mutual Capacitance @ 1kHz	18 nF/1000 ft (5.9 nF/100 m), max.

2. Attenuation (dB/100 m [328 ft.]):

Frequency	Attenuation (Max.)
1.00 MHz	2.3 dB
4.00 MHz	4.9 dB
10.00 MHz	8.5 dB
16.00 MHz	12 dB

3. Worst Pair Near-End Crosstalk (NEXT) dB/100 m [328 ft]:

<u>Frequency</u>	<u>Pair-To-Pair NEXT (Max.)</u>
1.0 MHz	13.8 dB
4.0 MHz	11.2 dB
10.0 MHz	10.2 dB
16.0 MHz	9.2 dB

2.5 FIBER INNERDUCT

- A. DESCRIPTION: From the MDF to each IDF, segments of optical fiber innerduct shall be installed.
1. Quantities Required: Innerduct runs do not have to be continuous throughout, breaks are expected at the pull boxes. Contractor is responsible for determination of actual lengths of innerduct required. Enough innerduct shall be provided and installed to extend from the fiber service loop in the MDF to the fiber service loop in each IDF. If the route passes through a pull box, the segments of innerduct shall extend twelve inches into the pull box. If the route passes through an enroute HC, each segment of innerduct shall extend at least twelve inches beyond the end of the service conduit.
- B. INSTALLATION: Fiber innerduct shall be installed in accordance with manufacturer's instructions and industry standards. Within the equipment rooms, the innerduct shall extend from the end of conduit to four feet above the floor and shall be affixed to the backboard by means of clamps designed for that purpose. Care shall be taken to avoid kinking the innerduct or applying excessive tension during the installation process.

2.6 FIBER DISTRIBUTION

- A. DESCRIPTION: From the MDF to each IDF a continuous segment of fiber cable shall be provided.
1. Product: 12 strands multi-mode 50/125 UM OM3 laser optimized and 6 strands single-mode 8.3/125 UM.
 2. Quantities Required: The contractor is responsible for determination of actual segment lengths. Actual quantities will be determined by the routing established by the electrical engineer.
 3. Required Accessories and Quantities:
 - a. Kit of Parts: Sufficient quantities to block and buffer both ends of each cable segment.
 - b. Sealant: Sealant sufficient quantities to block each end of each cable segment.
- B. INSTALLATION: Installation shall be conducted following guidelines established by the product manufacturer and industry standards.
1. Fiber Optic Cable: During installation of the optical fiber cable segments into the conduit system, special care shall be taken to avoid damage to the cable. While under pulling tension, the cable shall not be bent into a curve with a radius of less than 20 times the cable diameter. Pulling tension shall not exceed manufacturer's recommended maximum tensile load. Contractor shall utilize a winch with tension control or a "break-away" link designed to break away at or below the recommended maximum tension.

- C. The optical fiber cable shall be routed through the existing conduit and onto the appropriate HC backboard. Routing on the backboard shall be straight and plumb. A minimum ten foot service loop shall be provided at each terminal location. Refer to Drawings for cable configuration.

2.7 WORK STATION CABLE

- A. DESCRIPTION: From each MDF or IDF, 4-pair enhanced Category 6 cables shall be routed to each work station (data outlets). Category 6A shall be installed for wireless access node outlets per Technology Drawings.
1. Product:
 - a. Copper 4-pair UTP:
 - 1) UTP cables shall:
 - a) Be manufactured by one of the following:
 - Hitachi Cable Manchester
 - Berk-Tek
 - Commscope
 - General Cable
 - Mohawk
 - Or equal
 - Be 100 Ω 4-pair, category 6 cable/6A cable.
 - Shall be plenum rated.
 2. Required Accessories and Quantities (Hard Wall Locations):
 - a. Work Station: shall be metal with ivory or white finish (refer to drawings), Single Gang, Single Port Face plate. Using Panduit CMB**-X blank modules to fill unused ports. Refer to drawings for two, three, and four gang configurations. Modules shall be CJ688TP** – color to be selected by engineer.
 3. Work Area Equipment Cords: The Work Area Equipment Cords shall meet or exceed the following criteria:
 - a. Modular Equipment Cords: Category 6/6A cable
 4. Category 6, modular equipment cords shall:
 - a. Be round, and consist of eight insulated 24 AWG, stranded copper conductors, arranged in four color-coded twisted-pairs within a flame-retardant jacket.
 - b. Be equipped with modular 8-position (RJ45 style) plugs on both ends, wired straight-through with standards compliant wiring.
 5. Use modular plugs which exceed FCC CFR 47 part 68 subpart F and IEC 60603-7 specifications, and have 50 micrometers minimum of gold plating over nickel contacts.
 6. Be resistant to corrosion from humidity, extreme temperatures, and airborne contaminants.
 7. Utilize cable that exhibit power sum NEXT performance.
 - a. Be available in several colors with or without color strain relief boots featuring a snagless design.
 - b. Provide one 10 foot cord per data jack shown on drawings.
 - c. Be made by an ISO 9001 and 14001 Certified Manufacturer.
 - d. Electrical Specifications:
 - e. DC resistance per lead: 9.38 Ω / 100 m maximum.
 - f. Input impedance without averaging: 100 Ω + 15 percent from 1 to 100 MHz.
 - g. 100 percent transmission tested with laboratory grade network analyzers for proper performance up to 1000 MHz. Vendor shall guarantee cords are compatible with category 6 links/3A links.

8. UL VERIFIED (or equivalent) for TIA/EIA proposed category 6/6A electrical performance.
9. UL LISTED 1863.
10. All information outlets for 100 Ω 22-26 AWG copper cable shall:
 - a. Be available in black, white, gray, ivory and light ivory.
 - b. Accommodate a minimum of two 8-position / 8-conductor modular jacks.
 - c. Utilize compliant pin technology 110 style insulation displacement connectors which allows the use of a 4-pair impact tool.
 - d. Allow for a minimum of 200 re-terminations without signal degradation below standards compliance limit.
 - e. Be constructed of high impact, flame-retardant thermoplastic.
 - f. Be available in a screened version for 100 Ω ScTP cable.
 - g. Be made by an ISO 9001 and 14001 Certified Manufacturer.
 - h. Electrical Specifications:
 - i. ANSI/TIA/EIA-568-B1, B2, B3 and ISO/IEC 11801 proposed category 6 compliant.
 - j. The following requirements shall also be met (NEXT Loss and FEXT tested in both Differential and Common Mode):

Parameters	Performance	Performance @ 100 MHz *
NEXT Loss	+ 3.0 dB	43.0 dB
FEXT	+ 3.0 dB	43.0 dB **
Insertion Loss (Attenuation)	+ 40 percent	.24 dB
Return Loss	+ 6 dB	20 dB
LCL	40 dB (1-100 MHz)	**

- B. **INSTALLATION:** Installation shall be conducted in accordance with guidelines established the manufacturer and industry standards. Wall Plates shall be mounted such that their vertical dimension is plumb. Each wall plate shall be labeled with its respective work station number. Each modular mounting frame shall be labeled with its respective work station number.
- C. **Technical Requirements:** Horizontal cabling: the horizontal subsystem is the portion of the telecommunications cabling system that extends from the work area telecommunications outlet/connector to the horizontal cross-connect in the Telecommunications room/closet. It consists of the telecommunications outlet/connector, the horizontal cables, optional consolidation point, and that portion of the cross-connect in the telecommunications room/closet serving the horizontal cable.
 1. **Cable Types:** All UTP and fiber optic cables shall conform to the following standards:
 - a. ANSI/TIA-568C.0 Generic Telecommunications Cabling for Customer Premises
 - b. ANSI/TIA-568C.1 Commercial Building Telecommunications Cabling
 - c. ANSI/TIA-568C.2 Balance Twisted Pair Telecommunications Cabling
 - d. ANSI/TIA-568C.3 Optical Fiber Cabling and Components Standard
 - e. Including all applicable addenda) and ISO/IEC 11801 (International) Generic Cabling for Customer Premises standard (latest amendment and including all applicable addenda).

f.	Input Impedance	Bonded-Pair	Non-bonded Pair
	100 ±	12	1-20 MHz -----
	100 ±	15	20-250 MHz 1-100 MHz
	100 ±	20	250-350 MHz -----
	100 ±	22	350-625 MHz 100-200 MHz
	100 ±	32	----- 200-625 MHz

g. Copper: The following cable specifications shall also be met by the cable manufacturer for 4-pair UTP, premium category 6 cables:

- 1) Attenuation: Qualified Cables shall exhibit worst case attenuation less than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable attenuation performance for selected frequency points of interest is also provided.

Attenuation Limits Table		System 6SM
Frequency Range		1-350 MHz
Worst Case		$\leq 1.82\sqrt{f} + .017 \cdot f + \frac{0.20}{\sqrt{f}}$
Frequency Points of Interest	MHz	
	100	19.8 dB
	200	29 dB
	300	35.3 dB

h. Near End Crosstalk (NEXT) Loss:

- 1) Qualified Cables shall exhibit worst case NEXT Loss greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable NEXT Loss performance for selected frequency points of interest is also provided.

NEXT Loss Limits Table		System 6SM
Frequency Range		1-350 MHz
Worst Case Cable NEXT Loss		$\geq 76 - 15\log\left(\frac{f}{0.772}\right)$
Frequency Points of Interest	MHz	
	100	44.3 dB
	200	39.8 dB
	300	37.1 dB

- i. Power Sum Near-End Crosstalk (PSNEXT) Loss:
 1) Qualified Cables shall exhibit worst case PSNEXT Loss greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable PSNEXT Loss performance for selected frequency points of interest is also provided.

PSNEXT Loss Limits Table			
		System 6SM	
Frequency Range		1-350 MHz	
Worst Case PSNEXT Loss		$\geq 74 - 15\log\left(\frac{f}{0.772}\right)$	
Frequency Points of Interest	MHz		
	100	42.3 dB	
	200	37.8 dB	
	300	35.1 dB	

- j. Equal Level Far-End Crosstalk (ELFEXT):
 1) Qualified Cables shall exhibit worst case ELFEXT greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable ELFEXT performance for selected frequency points of interest is also provided.

ELFEXT Limits Table			
		System 6SM	
Frequency Range		1-350 MHz	
Worst Case ELFEXT		$\geq 70 - 20\log\left(\frac{f}{0.772}\right)$	
Frequency Points of Interest	MHz		
	100	27.8 dB	
	200	22.7 dB	
	300	18.2 dB	

- k. Power Sum Equal Level Far-End Crosstalk (PSELFEXT):
 1) Qualified Cables shall exhibit worst case PSELFEXT Loss greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable PSELFEXT performance for selected frequency points of interest is also provided.

PSELFEXT Loss Limits Table			
		System 6SM	
Frequency Range		1-350 MHz	
Worst Case PSELFEXT		$\geq 67 - 20\log\left(\frac{f}{0.772}\right)$	
Frequency Points of Interest	MHz		
	100	24.8 dB	
	200	18.7 dB	
	300	15.2 dB	

l.

m. Return Loss:

- 1) Qualified Cables shall exhibit worst case Return Loss greater than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable Return Loss performance for selected frequency points of interest is also provided.

Return Loss Limits Table				
		System 6SM		
Frequency Range		1-350 MHz		
Worst Case Return Loss		Frequency (MHz)	Return Loss (dB)	
		$\leq f < 10$	21 +4·log(f)dB	
		$10 \leq f < 20$	25 dB	
		$20 \leq f \leq 300$	25 -7·log(f/20)	
Frequency Points of Interest	MHz			
	100	-		20.1 dB
	200			18 dB
	300			16.8 dB

n. Propagation Delay (ANSI/TIA/EIA-568-A-1):

- 1) Qualified Cables shall exhibit worst case Propagation Delay less than the values derived using the equations shown in the chart below from 1 MHz to the highest referenced frequency value. Worst case qualified cable Propagation Delay performance for selected frequency points of interest is also provided.

Propagation Delay Limits Table				
		System 6SM		
Frequency Range		1-350 MHz		
Worst Case Propagation Delay		$< 476 + \frac{36}{\sqrt{f_{MHz}}}$		
Frequency Points of Interest	MHz			
	100			480 ns
	200			479 ns
	300			478 ns

o. Delay Skew (ANSI/TIA/EIA-568-A-1):

- 1) Qualified Cables shall exhibit worst case Delay Skew less than the values specified in the chart below per 100 m from 1 MHz to the highest referenced frequency value.

Delay Skew Limits Table				
		System 6SM		
Frequency Range		1-350 MHz		
Worst Case Delay Skew	MHz			
	100			25 ns
	200			25 ns
	300			25 ns

- p. Longitudinal Conversion Loss (LCL):
- 1) For all categories of 100 Ω unshielded and screened cables, the worst case calculated LCL for any pair in a 100 m cable shall not be less than 35 dB, from 1 MHz to the highest referenced frequency for each performance category. LCL measurements shall be performed in accordance with ITU-T Recommendation O.9 (November, 1988) or equivalent. Calculated LCL performance shall be determined by subtracting the test balun loss correction factor (as specified by the balun manufacturer) from the measured value at all frequencies.

LCL Limits Table			
		System 6SM	
Frequency Range		1-350 MHz	
Worst Case Delay Skew	MHz		
	100		35 dB
	200		35 dB*
	300		35 dB

- q. Longitudinal Transfer Conversion Loss (LCTL):
- 1) For all categories of 100 Ω unshielded and screened cables, the worst case calculated LCTL for any pair in a 100 m cable shall not be less than 35 dB, from 1 MHz to the highest referenced frequency for each performance category. LCTL measurements shall be performed in accordance with ITU-T Recommendation O.9 (November, 1988) or equivalent. Calculated LCL performance shall be determined by subtracting the test balun loss correction factor (as specified by the balun manufacturer) from the measured value at all frequencies.

LCTL Limits Table			
		System 6SM	
Frequency Range		1-350 MHz	
Worst Case Delay Skew	MHz		
	100		35 dB
	200		35 dB*
	300		35 dB*

- r. Attenuation to Crosstalk Ratio (ACR):
- 1) Using "pair-to-pair NEXT Loss", all Qualified Cables shall exhibit worst case ACR performance for the specified frequency range shown in the following table.

ACR Limits Table			
		System 6SM	
Frequency Range		1-350 MHz	
Worst Case ACR	1-80 MHz	24.1 dB	
	80-100	24.1 dB	
	1-100	24.1 dB	
	100-300	.5 dB	
PSACR Limits Table			
		System 6SM	
Frequency Range		1-350 MHz	
Worst Case PSACR	1-80 MHz	22.1 dB	
	80-100	22.1 dB	
	1-100	22.1 dB	
	100-300	-1.5 dB	

- s. Transfer Impedance:
- 1) Surface Transfer Impedance is specified for ScTP cables and is determined by the formula below in mΩ/m where f = frequency. All qualified ScTP cables shall have a margin greater than or equal to the values specified in the following table.

$$T_{cable} = 37 + 4f + 4\sqrt{f} + 5\sqrt[3]{f}$$

Transfer Impedance Limits Table			
Margin 1-100 MHz		System 6SM	
Transfer Impedance		10 percent	

2.8 MAIN DISTRIBUTION FACILITY (MDF)

- A. DESCRIPTION: The equipment shall be installed in accordance with Drawings.
1. Products and Quantities:
 - a. Equipment Rack: - As specified.
 - b. Fiber Interconnect: Panduit FRME24 rack mount fiber optic enclosure or equal. Supply and install as many as necessary to service all fiber strands entering the MDF.
 - c. Modular Patch Panels: Panduit angled patch panel or equal: 48-port patch panel wired Category 6 Patch Panel. One port for each workstation served from the MDF with a minimum of 12 spare ports are required. Provide CAT6A angled patch panel for wireless CAT6A ports. If the number of workstation cables, plus required spare count 12 is greater than 48, then a second 48-port patch panel is required. Supply and install as many patch panels in the MDF as necessary to service all workstation cables plus the required spare count. Provide separate CAT 6A patch panels for CAT 6A cables serving wireless access point outlets.

- d. Patch Cables: Panduit UTPSPXX-** or equal where XX is the length in feet and ** is the color. The length shall vary between 3 ft. and 15 ft. and shall be determined by the owner. Colors shall also be determined by the owner. A minimum of five different color patch cables shall be carried for different systems.
2. Required Accessories and Quantities:
 - a. Adapter Panels: Panduit FAP6WEIDSC – 6 Port Duplex Multimode SC Adapter Panels.
 - b. Fiber Jumpers: Panduit F6D3-3M3Y, 3 meter, Duplex, 50 micron OM3, SC to LC Fiber and ST to LC Fiber Jumper or equal.
 - c. Cable Management: Panduit WMPH2E Front/Rear cable manager or Panduit WMPLS Low Profile Cable Manager or equal.
 - d. Cable Management Rings and Strain Relief: Panduit WMBV1 21 in. x5 in. Vertical Manager Ring, Panduit WMBV2 2 in. x5 in. Vertical Manager Ring and/or Panduit WMSRC1 or WMSRC2 strain relief clips. Provide and install sufficient quantities to conform to the attached Drawings.
- B. INSTALLATION: Installation shall be conducted in accordance with manufacturer's recommendations, industry standards, and this specification. Installation includes complete assembly and mounting of the fiber interconnect equipment, dressing the fiber and copper cables, complete assembly and mounting of the equipment rack, and mounting of the wiring blocks. Equipment shall be mounted in accordance with attached Drawings.

2.9 INTERMEDIATE DISTRIBUTION FACILITIES

- A. DESCRIPTION: The equipment shall be installed in accordance with Drawings.
 1. Products and Quantities:
 - a. Equipment Rack: - As specified.
 - b. Fiber Interconnect: Panduit FRME24 rack mount fiber optic enclosure or equal. Supply and install as many as necessary to service all fiber strands entering the IDF.
 - c. Modular Patch Panels: Panduit CPPLA48WBLY or equal: 48-port patch panel wired Category 6 Patch Panel. One port for each workstation served from the IDF with a minimum of 12 spare ports are required. Provide CAT6A angled patch panel for wireless CAT6A ports. If the number of workstation cables, plus required spare count 12 is greater than 48, then a second 48-port patch panel is required. Supply and install as many patch panels in the IDF as necessary to service all workstation cables plus the required spare count. Provide separate CAT 6A patch panels for CAT 6A cables serving wireless access point outlets.
 - d. Patch Cables: Panduit UTPSPXX-** or equal where XX is the length in feet and ** is the color. The length shall vary between 3 ft. and 15 ft. and shall be determined by the owner. Colors shall also be determined by the owner. A minimum of five different color patch cables shall be carried for different systems.
 2. Required Accessories and Quantities:
 - a. Adapter Panels: Panduit FAP6WEIDSC – 6 Port Duplex Multimode SC Adapter Panels.
 - b. Fiber Jumpers: Panduit F6D3-3M3Y, 3 meter, Duplex, 50 micron OM3, SC to LC Fiber and ST to LC Fiber Jumper or equal.
 - c. Cable Management: Panduit WMPH2E Front/Rear cable manager or Panduit WMPLS Low Profile Cable Manager or equal.

- d. Cable Management Rings and Strain Relief: Panduit WMBV1 21 in. x5 in. Vertical Manager Ring, Panduit WMBV2 2 in. x5 in. Vertical Manager Ring and/or Panduit WMSRC1 or WMSRC2 strain relief clips. Provide and install sufficient quantities to conform to the attached Drawings.
- B. INSTALLATION: Installation shall be conducted in accordance with manufacturer's recommendations, industry standards, and this specification. Installation includes complete assembly and mounting of the fiber interconnect equipment, dressing the fiber and copper cables, complete assembly and mounting of the equipment rack, and mounting of the wiring blocks. Equipment shall be mounted in accordance with Drawings.
- 2.10 TESTING AND DOCUMENTATION
- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 - B. Perform tests and inspections.
 - C. Tests and Inspections:
 1. Visually inspect UTP jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
 2. Visually confirm Category 5e marking of outlets, cover plates, outlet/connectors, and patch panels.
 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 4. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Provide test instruments that meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 5. Multi-pair Voice Riser Tests:
 - a. Test each pair of multi-pair voice riser cables for proper polarity; no reversals; no transpositions; continuity; no shorts; no AC voltages; no DC voltages; no opens; and proper numbering at each termination.
 - b. Bring cables and/or pairs not meeting the requirements of the standard into full compliance, at no additional cost to the Owner.
 - c. Document cable testing in accordance with Submittals Article. Provide a table of test results in a 3-ring binder submitted with the as-built Drawings.
 6. Category 6 Data, and Voice UTP Cable Testing:
 - a. Test voice and data jack in each Outlet for Category 6 ANSI/TIA/EIA 568B series compliance, using a Certified Level III testing instrument. Tests shall verify both the integrity of all conductors and correctness of the termination sequence. Tests shall also include length, mutual capacitance, characteristic impedance, attenuation and near-end and far-end crosstalk. Testing shall be performed between modular jacks at the Outlets and the modular jacks at the patch panel field.
 - b. The Communication Systems Installer shall bring cables and/or pairs not meeting the requirements of the standard into full compliance, at no additional cost to the Owner.

- c. Document cable testing in accordance with Submittals Article. Provide a table of test results in a 3-ring binder submitted with the as-built Drawings.
 7. Fiber Optic Cable Testing:
 - a. Test all fibers in the completed end-to-end system. Testing shall consist of a bi-directional end to end OTDR trace, or a bi-directional end to end power meter test performed per ANSI/TIA/EIA 455 53A. The system loss measurement shall be provided at 850 and 1310 nanometers.
 - b. Pre-installation cable testing: Test all fiber optic cable prior to the installation of the cable. Assume all liability for the replacement of the cable should it be found defective after the installation.
 - c. Loss Budget: Fiber links shall have a Maximum Loss of:
 - d. Maximum Loss = (allowable loss per km) (km of fiber in link) + (.4dB)(number of connectors) Note: A mated connector-to-connector interface is defined as a Single connector.
 - e. Loss numbers for the installed link shall be calculated by taking the sum of the bi-directional measurements and dividing that sum by two. Any link not meeting the requirements of the Maximum Loss shall be brought into compliance at no additional charge to the Owner.
 - f. Prepare a certification report listing the test results and both the calculated and measure loss for each fiber. Submit this report with the test results as called for in the Submittals Article.
 - g. Bring cables and/or strands not meeting the requirements of the standard into full compliance.
 - D. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.
 1. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
 - E. Document data for each measurement. Print data for submittals in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
 - F. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
 - G. End-to-end cabling will be considered defective if it does not pass tests and inspections.
 - H. Prepare test and inspection reports.
- 2.11 INTEGRATED SOUND, PUBLIC ADDRESS SYSTEM
- A. DEFINITIONS
 1. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
 2. VU: Volume unit.
 3. Zone: Separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

B. PERFORMANCE REQUIREMENTS

1. Delegated Design: Design supports and seismic restraints for control consoles, equipment cabinets and racks, and components, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Seismic Performance: Provide supports and seismic restraints for control consoles, equipment cabinets and racks, and components that withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

C. SUBMITTALS

1. Product Data: For each type of product indicated.
2. Shop Drawings: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Console layouts.
 - c. Control panels.
 - d. Rack arrangements.
 - e. Calculations: For sizing backup battery.
 - f. Wiring Diagrams: For power, signal, and control wiring.
 - 1) Identify terminals to facilitate installation, operation, and maintenance.
 - 2) Single-line diagram showing interconnection of components.
 - 3) Cabling diagram showing cable routing.
3. Delegated-Design Submittal: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of supports and seismic restraints for control consoles, equipment cabinets and racks, and components.
4. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings are shown and coordinated with each other, using input from installers of the items involved.
5. Qualification Data: For qualified Installer and testing agency.
6. Seismic Qualification Certificates: For control consoles, equipment cabinets and racks, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
7. Field quality-control reports.
8. Operation and Maintenance Data: For public address and mass notification systems to include in emergency, operation, and maintenance manuals.

D. QUALITY ASSURANCE

1. Installer Qualifications: Installer must be or use a qualified Systems Integrator who is a manufacturer's authorized representative and who has NICET certified Audio Systems Personnel on his staff to oversee the installation, testing and commissioning of the units required for this project
2. Testing Agency Qualifications: Qualified agency, with the experience and capability to conduct testing indicated.
 - a. Testing Agency's Field Supervisor: Currently certified by NICET at Level III to supervise on-site testing.
3. Source Limitations: Obtain public address and mass notification systems from single source from single manufacturer.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Comply with NFPA 70.

E. COORDINATION

1. Coordinate layout and installation of system components and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

F. EXTRA MATERIALS

1. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - a. Admin Console: One.
 - b. Ceiling Speakers: Four
 - c. Intercom speakers: Two

G. MANUFACTURERS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. SimplexGrinnell 5120 (upon which this specification is based). Point of contact is Michael Chames, SimplexGrinnell, 35 Progress Avenue, Nashua NH. 603-521-1154.
 - b. Bogen Communications, Inc.
 - c. Toa Corporation

H. FUNCTIONAL DESCRIPTION OF SYSTEM

1. Items of particular note related to this section – System shall have intercom/talkback speakers in all classrooms and offices. Individual paging zones will be:
 - 1) Classroom corridors
 - 2) Gym
 - 3) Cafeteria
 - 4) Outside speakers
 - 5) All call
 - 6) Page by grade – coordinate with school for page groups
 - 7) System shall use distributed technology whereby all rooms within a section of the building will wire back to the nearest IDF/MDF. The IDF will contain a network connected card cage with the necessary cards to allow for intercom functionality without having to wire all the way back to the head end system. Refer to drawings for details.
 - 8) Include software to be installed on owner furnished computer that permits owner with the ability to program class change times/schedules as they see fit.

- 9) Include an interconnection to the customer's VoIP phone system. Provide a SIP compliant interface module for this purpose and coordinate with the owner's phone system provider as necessary.
- b. A system comprised of all solid state electronics, utilizing a microprocessor based central processor unit, power supplies, audio interface cards, control cards, input/output cards, telephone interface cards, transformers, paging amplifiers, and associated components for a complete system.
- c. Modular design utilizing plug-in circuit cards to enable quick on-site replacement or addition of components for system expansion and modification.
- d. Connect station wiring to the system using insulation displacement connectors to allow quick disconnection of field cables from the System terminal boards.
- e. Storage of user programmable data in a non-volatile EEPROM memory to prevent memory loss during a power failure. Provide a system time clock that is capable of maintaining correct time for a period of 14 days in the event of a power failure. Return the system programming to the original factory default settings by keying a special code form the Console.
- f. User capability to change system programming for all paging functions, bell functions, and clock functions – both master and slave. Provide the owner with the required training, documentation, and software to accomplish these functions.
- g. Rack mount the Public Address main equipment including card cages and all cards, power amplifiers, program sources, and related components in the MDF. Provide remote system programming capability of Public Address and Master Clock features by an Administrative Control Console. Attending to the main equipment in the MDF for normal day-to-day operation of the system is not a necessary requirement. Systems requiring regular adjustment will be rejected.
- h. User capability to selectively connect any zone to any available signal channel.
- i. User capability to selectively control sound from microphone outlets and other inputs.
- j. "All-call" feature that connects the all-call sound signal simultaneously to all zones regardless of zone or channel switch settings.
- k. Telephone paging adapter capability to allow paging by dialing an extension from any local telephone instrument and speaking into the telephone.
- l. Administrative Control Console for facilitating all Public Address System announcements and programming, to include but not be limited to: Emergency all-call; paging zone and number assignments; call-in priority levels with tone characteristics; Master Clock event and tone signaling; monitor and reporting on call-in line faults; and manually distribute unique tones to all zones and speakers in the system.
- m. Cabling, appropriate adapters and connection to a local building digital VoIP System (by Owner), allowing any telephone handset that is part of the telephone system to page and conduct hands free open voice communication with any speaker in the system; the Control Console; or any other classroom telephone. Connection to the local phone system shall not diminish or restrict any of the capabilities of local telephone system. Public Address System interfaces shall allow any programmed telephone to perform but not be limited to the following intercommunication system functions: all-call, zone call, intercom call to classroom speakers, distribute class change signals.
- n. User programmable zone paging to all classroom and office speakers using microphone, Control Console or telephone. Public address zones shall be software programmable to include 2, 3, 4 digit numbers or a letter and a 3-digit number, or any combination. Zone paging shall be independent of time and program zones and shall provide easy access to groups of zones or all-zone pages.

- o. Distribution of general announcements over school loudspeakers using a microphone, Control Console, or telephone handset, on an All-Call basis, pre-selected zone basis, or multiple-zone basis to any of eight paging zones. Speaker assignments to any of eight zones shall be user-programmable from the Control Console.
- p. Distribution of emergency paging announcements over school loudspeakers using a microphone, Public Address Control Console, or telephone handset. Emergency announcements shall have the highest priority over other system functions.
- q. Ability to designate individual room station within the system as a fixed zone by the simple entering of a single keystroke at the Control Console during a page selection.
- r. Selection and monitoring of individual program sources (Microphone, AM/FM Tuner, or CD, MP3) and distribution by the Control Console.
- s. Control Console programming of administrative microphone for control and distribution of public announcements, to eliminate the need to go to the central electronics for microphone set up. Keying the microphone shall automatically mute all other audio programs at a lower priority in the system. A preset shall be provided to mute all local sound systems by contact closure allowing the Public Address system to override local sound system programs. Microphone shall transmit to all rooms or specific speakers' zones as programmed in the system software.
- t. The capability of multiple open voice intercom paths. Intercom paths shall be global.
- u. Automatic gain control of intercom speech to assure constant speech level.
- v. Automatic sounding of a warning tone over any loudspeaker selected for two-way communications to alert the classroom teacher to an incoming announcement.
- w. A minimum of four channels for intercom communications or audio program distribution.
- x. Emergency Calls that can be initiated from a single call key programmed at the classroom telephone.
- y. The ability to monitor the school building either on or off the premises from a single telephone.
- z. Audio program distribution to eight different areas of the building selected by the Control Console. Inputs shall be provided for 5 low impedance microphones, tuner, CD player and auxiliary source. Program material shall include audio programs from standard AM/FM tuner, CD player, or auxiliary source. Provide program source equipment including AM/FM tuner, CD player. Provide Control Console with the ability to monitor program sources being distributed.
- aa. Audio zones that are different than paging and time zones. Audio source equipment shall have the ability to be located remotely from the main system control electronics, and shall have the ability to distribute two channels of audio simultaneously if so desired. School shall be equipped with 1 rack mounted AM/FM tuner, 1 Rack Mounted CD player.
- bb. RS232 Input/Output Interface, Personal Computer, Modem, and Printer for monitoring activity within System and for displaying and printing system management information. System shall perform diagnostics, or logging transactions either on or off premises.
- cc. The ability to interface to the power supplies of door strikes (provided by others), to allow remote control of door strike through the paging system. The ability to control at minimum the exterior doors with Door Signally (DS) devices is required.

- dd. Time Signal tones of an integrated Master Clock System to be distributed throughout zone selected for time signaling over programmed loudspeakers on a manual or automatic basis.
- ee. Power amplifiers that provide a minimum power capacity of 2 watts per cone speaker location and Door Signaling device plus 15 watts of power per horn type speaker locations.
- ff. Cabling that is specified by the manufacture, which provides shielding of conductors so that the Public Address System does not interfere with the Telephone Systems and Telephone System cabling.
- gg. Produce a program-signal tone that is amplified and sounded over all speakers, overriding signals currently being distributed.
- hh. Reproduce high-quality sound that is free of noise and distortion at all loudspeakers at all times during equipment operation including standby mode with inputs off; output free of non-uniform coverage of amplified sound.

I. GENERAL EQUIPMENT AND MATERIAL REQUIREMENTS

- 1. Compatibility of Components: Coordinate component features to form an integrated system. Match components and interconnections for optimum performance of specified functions.
- 2. Equipment: Comply with UL 813. Equipment shall be modular, using solid-state components, and fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.
- 3. Equipment Mounting: Where rack, cabinet, or console mounting is indicated, equipment shall be designed to mount in a 19-inch housing complying with TIA/EIA-310-D.
- 4. Weather-Resistant Equipment: Listed and labeled by a qualified testing agency for duty outdoors or in damp locations.

J. PREAMPLIFIERS

- 1. Preamplifier: Integral to power amplifier.
- 2. Output Power: Plus 4 dB above 1 mW at matched power-amplifier load.
- 3. Total Harmonic Distortion: Less than 1 percent.
- 4. Frequency Response: Within plus or minus 2 dB from 20 to 20,000 Hz.
- 5. Input Jacks: Minimum of two. One matched for low-impedance microphone; the other matchable to cassette deck, CD player, or radio tuner signals without external adapters.
- 6. Minimum Noise Level: Minus 55 dB below rated output.
- 7. Controls: On-off, input levels, and master gain.

K. POWER AMPLIFIERS

- 1. Mounting: Console.
- 2. Output Power: 25-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.
- 3. Total Harmonic Distortion: Less than 3 percent at rated power output from 50 to 12,000 Hz.
- 4. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
- 5. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.
- 6. Output Regulation: Less than 2 dB from full to no load.
- 7. Controls: On-off, input levels, and low-cut filter.
- 8. Input Sensitivity: Matched to preamplifier and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphone or handset transmitter.

- L. TRANSFER TO STANDBY AMPLIFIER
 - 1. Monitoring Circuit and Sensing Relay: Detect reduction in output of power amplifier of 40 percent or more and, in such event, transfer load and signal automatically to standby amplifier.

- M. VOLUME LIMITER/COMPRESSOR
 - 1. Minimum Performance Requirements:
 - a. Frequency Response: 45 to 15,000 Hz, plus or minus 1 dB minimum.
 - b. Signal Reduction Ratio: At least a 10:1 and 5:1 selectable capability.
 - c. Distortion: 1 percent, maximum.
 - d. Rated Output: Minimum of plus 14 dB.
 - e. Inputs: Minimum of two inputs with variable front-panel gain controls and VU or decibel meter for input adjustment.
 - f. Rack mounting.

- N. CONTROL CONSOLE
 - 1. Cabinet: Modular; complying with TIA/EIA-310-D.
 - 2. Housing: Steel, 0.0478 inch minimum, with removable front and rear panels. Side panels are removable for interconnecting side-by-side mounting.
 - 3. Panel for Equipment and Controls: Rack mounted.
 - 4. Controls:
 - a. Switching devices to select signal sources for distribution channels.
 - b. Program selector switch to select source for each program channel.
 - c. Switching devices to select zones for paging.
 - d. All-call selector switch.
 - 5. Indicators: A visual annunciation for each distribution channel to indicate source being used.
 - 6. Self-Contained Power and Control Unit: A single assembly of basic control, electronics, and power supply necessary to accomplish specified functions.
 - 7. Spare Positions: 20 percent spare zone control and annunciation positions on console.
 - 8. Microphone jack.

- O. EQUIPMENT CABINET
 - 1. Comply with TIA/EIA-310-D.
 - 2. House amplifiers and auxiliary equipment at each location.
 - 3. Cabinet Housing:
 - a. Constructed of 0.0478-inch steel, minimum, with front- and rear-locking doors and standard TIA/EIA-310-D-compliant, 19-inch racks.
 - b. Arranged for floor or wall mounting as indicated.
 - c. Sized to house all equipment indicated, plus spare capacity.
 - d. Include 20 percent minimum spare capacity for future equipment in addition to space required for future cassette deck and CD player.
 - 4. Power Provisions: A single switch in cabinet shall disconnect cabinet power distribution system and electrical outlets, which shall be uniformly spaced to accommodate ac-power cords for each item of equipment.
 - 5. Ventilation: A low-noise fan for forced-air cabinet ventilation. Fan shall be equipped with a filtered input vent and shall be connected to operate from 105- to 130-V ac, 60 Hz; separately fused and switched; arranged to be powered when main cabinet power switch is on.

- P. EQUIPMENT RACK
 - 1. Racks: 19 inches standard, complying with TIA/EIA-310-D.
 - 2. Power-Supply Connections: Compatible plugs and receptacles.

3. Enclosure Panels: Ventilated rear and sides and solid top. Use louvers in panels to ensure adequate ventilation.
 4. Finish: Uniform, baked-enamel factory finish over rust-inhibiting primer.
 5. Power-Control Panel: On front of equipment housing, with master power on-off switch and pilot light; and with socket for 5-A cartridge fuse for rack equipment power.
 6. Service Light: At top rear of rack with an adjacent control switch.
 7. Vertical Plug Strip: Grounded receptacles, 12 inches o.c.; the full height of rack.
 8. Maintenance Receptacles: Duplex convenience outlets supplied independent of vertical plug strip and located in front and bottom rear of rack.
 9. Spare Capacity: 20 percent in rack for future equipment.
- Q. TELEPHONE PAGING ADAPTER
1. Adapters shall accept voice signals from telephone extension dialing access and automatically provide amplifier input and program override for preselected zones.
 2. Minimum Frequency Response: Flat, 200 to 2500 Hz.
 3. Impedance Matching: Adapter matches telephone line to public address equipment input.
 4. Rack mounting.
- R. TONE GENERATOR
1. Generator shall provide clock and program interface with public address and mass notification system.
 2. Signals: Minimum of seven distinct, audible signal types including wail, warble, high/low, alarm, repeating and single-stroke chimes, and tone.
 3. Pitch Control: Chimes and tone.
 4. Volume Control: All outputs.
 5. Activation-Switch Network: Establishes priority and hierarchy of output signals produced by different activation setups.
 6. Mounting: Rack.
- S. MONITOR PANEL
1. Monitor power amplifiers.
 2. Components: VU or dB meter, speaker with volume control, and multiple-position rotary selector switch.
 3. Selector Switch and Volume Control: Selective monitoring of output of each separate power amplifier via VU or dB meter and speaker.
 4. Mounting: Rack.
- T. LOUDSPEAKERS
1. Cone-Type Loudspeakers:
 - a. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
 - b. Frequency Response: Within plus or minus 3 dB from 50 to 15,000 Hz.
 - c. Size: 8 inches with 1-inch voice coil and minimum 5-oz. ceramic magnet.
 - d. Minimum Dispersion Angle: 100 degrees.
 - e. Rated Output Level: 10 W.
 - f. Matching Transformer: Full-power rated with four taps. Maximum insertion loss of 0.5 dB.
 - g. Surface-Mounting Units: Ceiling, wall, or pendant mounting, as indicated, in steel back boxes, acoustically damped. Front face of at least 0.0478-inch steel and whole assembly rust proofed and shop primed for field painting. Flush-Ceiling-Mounting Units: In steel back boxes, acoustically damped. Metal ceiling grille with white baked enamel is the standard for color. Refer to the floor plans and consult with the Architect for final approval of speaker grill colors in the Auditorium, Large Group Instruction Room, Gym, and other specialty spaces.

- h. All speaker housings recessed in ACT ceilings shall be rectangular type 1 ft. x 2 ft. with white finish. Wall-mounted speakers shall be provided in a square housing with a white finish.
 - 2. Exterior Horn-Type Loudspeakers:
 - a. Reentrant type: flush mount installation.
 - b. Frequency Range: 700Hz to 6.5K +/- 3dB.
 - c. Power Handling: 16 Watts
 - d. Variable screw taps: 25 V transformer.
 - e. Sound Pressure Level: 107 dB at 1 meter with 1-watt input.
 - f. Exterior horn speakers shall be simplex weatherproof loudspeaker model 5120-9411 or equal.
 - g. Flush Mounting Units: Square 10" stainless steel grille with (4) #8 spanner tamper head stainless steel screws into the 5120-9494 back box.
 - 3. CTC/Shop Location Loud Speakers
 - a. Power Rating (RMS): 15 watts continuous
 - b. Frequency Response: 600Hz to 14 kHz
 - c. Impedance: 70/25 volts
 - d. Power Taps: 70V: 15, 7.5, 3.6, 1.8, or 0.9 watts
25V: 15, 7.0, 1.8, 0.9, 0.5, 0.25, or 0.125 watts
 - e. Sound Pressure Level: 115 dB @ 1m on axis @ 15 watts
 - f. 104 dB @ 1m on axis @ 1 watt
 - g. Dispersion: 100°
 - h. Controls: Tap selector switch
 - i. Connections: Screw terminals
Dimensions: Flange dia.: 6-7/8"
Body dia.: 5-3/8"
Depth: 5-1/2"
Mounting hole pattern: dia.: 6-1/8"
Mounting hole spacing: 45° from adjacent hole
 - j. Product Weight: 3 lb.
 - k. All speaker housings recessed in ACT ceilings shall be rectangular type 1 ft. x 2 ft. with white finish. Wall-mounted speakers shall be provided in a square housing with a white finish.
 - l. Bogen Model FMH15T
- U. NOISE-OPERATED GAIN CONTROLLER
 - 1. Design gain controller to continuously sense space noise level and automatically adjust signal level to local speakers.
 - 2. Frequency Response: 20 to 20,000 Hz, plus or minus 1 dB.
 - 3. Level Adjustment Range: 20 dB minimum.
 - 4. Maximum Distortion: 1 percent.
 - 5. Control: Permits adjustment of sensing level of device.
 - 6. Provide gain control capabilities for the Gym, Auditorium, Cafeteria, Metal Fabrication Shop, Carpentry Wood Shop, and Automotive Tech Shop.
- V. OUTLETS
 - 1. Volume Attenuator Station: Wall-plate-mounted autotransformer type with paging priority feature.
 - a. Wattage Rating: 10 W unless otherwise indicated.
 - b. Attenuation per Step: 3 dB, with positive off position.
 - c. Insertion Loss: 0.4 dB maximum.
 - d. Attenuation Bypass Relay: Single pole, double throw. Connected to operate and bypass attenuation when all-call, paging, program signal, or prerecorded message features are used. Relay returns to normal position at end of priority transmission.
 - e. Label: "PA Volume."

2. Microphone Outlet: Three-pole, polarized, locking-type, microphone receptacles in single-gang boxes. Wall outlets shall be metal with ivory finish plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed outlet covers.
 3. Headphone Outlet (for the Hearing Impaired): Microphone receptacles in single-gang boxes. Wall outlets shall be metal with ivory finish plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed-outlet covers.
- W. BATTERY BACKUP POWER UNIT
1. Provide rack mounted unit, consisting of time-delay relay, sealed lead-calcium battery, battery charger, on-off switch, "normal" and "emergency" indicating lights, and adequate capacity to supply maximum equipment power requirements for one hour of continuous full operation.
 2. Provide unit that supplies public address equipment with 12- to 15-V dc power automatically during an outage of normal 120-V ac power.
 3. Provide battery on float charge when not supplying system and to transfer automatically to supply system after three to five seconds of continuous outage of normal power, as sensed by time-delay relay.
 4. Provide unit that automatically retransfers system to normal supply when normal power has been reestablished for three to five seconds continuously.
- X. CONDUCTORS AND CABLES
1. Jacketed, twisted pair and twisted multipair, untinned solid copper.
 - a. Insulation for Wire in Conduit: Thermoplastic, not less than 1/32 inch thick.
 - b. Microphone Cables: Neoprene jacketed, not less than 2/64 inch thick, over shield with filled interstices. Shield No. 34 AWG, tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.
 - c. Plenum Cable: Listed and labeled for plenum installation.
- Y. UNSPECIFIED EQUIPMENT AND MATERIAL.
1. Provide any item of equipment or material not specifically addressed on the Drawings or in this Document and required to provide a complete and functional installation in a level of quality consistent with other specified items. Includes Lockable Equipment Cabinet sized for up to 25 percent future equipment expansion.
- Z. WIRING METHODS
1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
 - a. Install plenum cable.
 - b. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway and Boxes for Electrical Systems."
 2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
 3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- AA. INSTALLATION OF RACEWAYS
1. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.
 2. Install manufactured conduit sweeps and long-radius elbows whenever possible.

BB. INSTALLATION OF CABLES

1. Comply with NECA 1.
2. General Cable Installation Requirements:
 - a. Terminate conductors; allow no cable to contain un-terminated elements. Make terminations only at outlets and terminals.
 - b. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
 - c. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - d. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
 - e. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - f. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Do not use heat lamps.
3. Open-Cable Installation:
 - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - b. Suspend speaker cable not in a wireway or pathway a minimum of 8 inches above ceiling by cable supports not more than 60 inches apart.
 - c. Do not run cable through structural members or be in contact with pipes, ducts, or other potentially damaging items.
4. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

CC. INSTALLATION

1. Meet with the Owner prior to installation to determine and clarify all zoning requirements. Installation of the system will not begin until this meeting has occurred and the Contractor has provided a zoning plan to and received written approval from the Owner and Architect. Confirm locations of all control consoles with Owner and Architect prior to installation.
2. Design Criteria:
 - a. Provide rooms with one speaker (as indicated on the drawings) with one circuit for intercom and a dedicated address.
 - b. Provide rooms with more than one speaker as indicated on the drawings (i.e. the Metal Fabrication Shop, Carpentry Wood Shop, and Automotive Tech Shop and others) with two circuits as follows:
 - 1) Dedicate the speaker nearest the front of the room to a circuit to be used as intercom.
 - 2) Install the additional speaker(s) on a separate circuit. Run these speakers series, programmed to mimic the paging, time tone and program zones as the intercom circuit
 - c. Install corridor speakers on individual circuits not to exceed 12 speakers. These speakers will also be used for audio monitoring of zones in crisis situations. Strict adherence to this criteria will be enforced
 - d. Program exterior speakers circuits as one individual zone
3. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

4. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
5. Equipment Cabinets and Racks:
 - a. Group items of same function together, either vertically or side by side, and arrange controls symmetrically. Mount monitor panel above the amplifiers.
 - b. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
 - c. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by panels.
6. Volume Limiter/Compressor: Equip each zone with a volume limiter/compressor. Install in central equipment cabinet. Arrange to provide a constant input to power amplifiers.
7. Wall-Mounted Outlets: Flush mounted.
8. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 18 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.
9. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating. Seal back boxes and baffles at building surfaces using silicone caulking. Refer to SECTION 079200 for Joint Sealant specifications.
10. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.
11. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

DD. GROUNDING

1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
3. Install grounding electrodes as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."

EE. FIELD QUALITY CONTROL

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
3. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
4. Tests and Inspections:
 - a. Schedule tests with at least seven days' advance notice of test performance.
 - b. After installing public address and mass notification systems and after electrical circuitry has been energized, test for compliance with requirements.
 - c. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.

- d. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
 - 1) Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.
 - 2) Repeat test for each separately controlled zone of loudspeakers.
 - 3) Minimum acceptance ratio is 50 dB.
 - e. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
 - f. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
 - g. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
 - h. Signal Ground Test: Measure and report ground resistance at public address equipment signal ground. Comply with testing requirements specified in Division 26 Section "Grounding and Bonding for Electrical Systems."
5. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.
 6. Public address and mass notification systems will be considered defective if they do not pass tests and inspections.
 7. Prepare test and inspection reports.
 - a. Include a record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.

FF. STARTUP SERVICE

1. Engage a factory-authorized service representative to perform startup service.
 - a. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
 - b. Complete installation and startup checks according to manufacturer's written instructions.

GG. ADJUSTING

1. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.
2. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal occupancy hours for this purpose.

HH. DEMONSTRATION

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the public address and mass notification systems and equipment.

2.12 WIRELESS MASTER CLOCK SYSTEM

A. DEFINITIONS

1. NIST: The National Institute of Science and Technology.
2. PC: Personal computer.
3. UTC: Universal time coordinated. The precisely measured time at zero degrees longitude; a worldwide standard for time synchronization.

B. PERFORMANCE REQUIREMENTS

1. Seismic Performance: Master clock and housing shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

C. SUBMITTALS

1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes (including available colors) for each product indicated and describe features and operating sequences, both automatic and manual, for the following:
 - a. Master unit.
 - b. Indicating clocks.
 - c. Signal equipment.
 - d. Equipment enclosures and back boxes.
 - e. Accessory components.
2. Shop Drawings: For clock systems. Include plans, elevations, sections, details, and attachments to other work.
 - a. Wiring Diagrams: For power, signal, and control wiring and correction circuits.
 - 1) Identify terminals and wiring color codes to facilitate installation, operation, and maintenance.
 - 2) Indicate recommended wire types and sizes, and circuiting arrangements for field-installed system wiring. Show protection from over-current, static discharge, and voltage surge.
 - b. Details of seismic restraints including mounting, anchoring, and fastening devices for the following system components:
 - 1) Surface-mounted and semi-recessed secondary indicating clocks.
 - 2) Master clock enclosures.
 - 3) Clock circuit power boosters.
 - c. Details of seismic strengthening of master clock enclosures.
 - d. Dimensioned Outline Drawings of the Mounting Rack for the Master Clock: Show internal seismic bracing, and locate center of gravity of fully equipped and assembled unit. Locate and describe mounting and anchorage provisions.
3. Samples for Initial Selection:
 - a. Manufacturer's color photographs or color chips showing the full range of colors available for clocks, signal equipment, and control panels.
4. Delegated-Design Submittal: For the master clock and housing indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - a. Detail fabrication and assembly of the master clock and housing.
 - b. Design Calculations: Calculate requirements for selecting seismic restraints.

5. Seismic Qualification Certificates: For the master clock, accessories, and components, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 6. Field quality-control reports.
 7. Operation and Maintenance Data: For clock and program control to include in emergency, operation, and maintenance manuals.
- D. QUALITY ASSURANCE
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with NFPA 70.S
- E. MASTER AND SECONDARY CLOCK SYSTEM
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:
 - a. SimplexGrinnell
 - b. Sapling, Inc.
 - c. Valcom
 3. Master Clock System
 - a. Time programming shall be accomplished by way of a microprocessor-based and user-programmable master control system integrated within the Integrated Sound and System. The unit will further permit programming, diagnostics, and activity logging through connection to an external computer. The system shall be provided with a GPS antenna mounted to the roof as shown on the riser diagram with the necessary hardware-software to interface to the integrated communications system. Include a wireless tone generator to interface with the intercom/paging system to ensure clocks are synchronized with classroom tone changes.
 - b. Correction to the second, the master time controller shall provide all secondary clocks correction to the second.
 - c. The master time controller shall provide the following functions:
 - 1) Wireless control of the slave 12 in. and 16 in. clocks located throughout the building
 - 2) Wireless repeaters shall be provided in the MDF and IDF on each floor linked via a RS485 loop between the master clock and each repeater
 - 3) Capacity for storing 900 events and up to 100 Holidays in nonvolatile memory.
 - 4) Ability to review, edit and delete events
 - 5) Review events from any entered time of day
 - 6) Events shall be programmable to any or all of eight zone circuits
 - 7) Selection of any of eight schedules to allow flexibility due to seasonal changes or special events
 - 8) Fully automatic Holiday program execution.
 - 9) User programmable Automatic Daylight Savings Time Change
 - 10) Separate bell duration for each zone circuit
 - 11) Latched operation of zones to control lighting or other devices

- 12) User-programmable custom slave clock correction. Output relays rated at five amperes shall be provided on all zone circuits.
- d. The secondary clock shall be a square wireless clock 12 or 16 inch depending on location. The clock will be capable of receiving a signal from multiple clocks. The clock shall receive and transmit with 915–928 MHz frequency-hopping technology. The clock is to be capable of transmitting the time simultaneously without interfering with each other. The clocks shall include automatic calibration, as well as a diagnostic function that allows the user to view the quality of the signal, the last time the clock received a correction signal, a gearbox test and a comprehensive analysis of the entire clock. The clock shall have a maximum correction time of five minutes. It shall be designed to be used with the Repeater 1 for each of the 2 floors located in the data MDF and IDF, which can be regulated via wireless communication protocol. Upon receipt of the wireless signal, the clock will immediately self-correct. The clock shall have a semi-flush smooth surface ABS case. The dial is to be made of durable polystyrene material. The crystal is to be shatterproof, side molded polycarbonate. Glass and visible molding marks are unacceptable. The clock shall have black hour and minute hands as well as a red second hand.
- e. Clocks in the gymnasium shall be square 16 in. and provided with wire guards.
- f. Digital LCD Multi-Line Administrative telephones integration, the time on the Digital LCD Multi-Line Administration telephones shall be automatically and continually synchronized with the schools Master Clock System which supports all the schools secondary clocks and class change tones. System that requires the owner to do periodic manual synchronization between the telephone systems clock and the schools Master Clock shall not be acceptable.
- g. All clocks shall be 120V type and provided with pig tail connectors. 120V by electrical contractor. Battery powered clocks will be rejected.

F. INSTALLATION

1. Mount system components with fastening methods and devices designed to resist the seismic forces indicated in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

G. IDENTIFICATION

1. Comply with Division 26 Section "Identification for Electrical Systems."
2. Color-code wires, and apply wire and cable marking tape to designate wires and cables so they are uniformly identified and coordinated with wiring diagrams throughout the system.

H. FIELD QUALITY CONTROL

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installation, including connections.
2. Perform tests and inspections.
 - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
3. Tests and Inspections:
 - a. Perform operational-system tests to verify compliance with the Specifications and make adjustments to bring system into compliance. Include operation of all modes of clock correction and all programming and manually programmed signal and relay operating functions.
 - b. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

4. Clock system will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

I. ADJUSTING

1. Program system according to Owner's requirements. Set system so signal devices operate on Owner-required schedules and are activated for durations selected by Owner. Program equipment-control output circuits to suit Owner's operating schedule for equipment controlled.
2. Adjust sound-output level of adjustable signal devices to suit Owner's requirements.
3. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal occupancy hours for this purpose.

J. DEMONSTRATION

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain clock-and-program-control system components.

2.13 AUDIO/VISUAL CABLING

- A. Provide all cabling for all systems specified per manufacturer's recommendations for completely operational systems.

B. Audio/Video Patch Cabling System:

1. Provide products meeting the requirements of the Drawings and Specifications for the following components. Acceptable manufacturers are: Rapid Run by Cables to go, TrippLite, L-Com or equal. All of the listed components shall be part of a complete A/V patch cabling assembly made by a single manufacturer. Provide testing per manufacturer with a spreadsheet of all test results and lifetime manufacturer warranty.
 - a. Digital Runner Cables (Rapid Run or equal)
 - 1) Detailed Specifications:
 - a) Color Code: Red
 - b) Each connector includes a protective pulling cap that can withstand 30 points of pulling tension.
 - c) Uses for 24 AWG shield twisted pairs with drain wire, one 24 AWG twisted pair, and five 24 AWG conductors.
 - d) Aluminum foil shield and tinned copper braid overall.
 - e) Supports HDMI® and DVI-D high resolution video up to 1080p.
 - f) CL2-rated for in-wall installations.
 - g) Requires passive break-away flying lead or passive wall plate on the source end, and an active break-away flying lead or active wall plate on the display end.
 - h) Warranty: Lifetime
 - i) Color: Black
 - j) Length: 50ft/100ft
 - k) Weight: 5.65lbs
 - l) Jacket Rating: In Wall

- b. CL-2 Rated Multi-Format Runner Cable (Rapid Run or equal)
 - 1) Detailed Specifications:
 - a) Color Code: Orange
 - b) CL2-rated for in-wall installations
 - c) Each connector includes a protective pulling cap that can withstand 30 points pulling tension
 - d) Uses three 28 AWG coaxial cables with braided copper shielding, and three 24 AWG twisted pair plus a single 24 AWG pair.
 - e) Supports resolutions up to 1600 x 1200 pixels (UXGA resolution)
 - f) Warranty: Lifetime
 - g) Color: Black
 - h) Length: 50ft/75ft/100ft/125ft/150ft
 - i) Weight: 4.050lbs
 - j) Jacket Rating: In Wall
- c. Double gang integrated brushed aluminum wall plate (Rapid Run or equal) (configuration shall be provided as shown on the Drawings).
 - 1) Detailed Specifications:
 - a) Color Code: Orange (for use with one Multi-Format runner)
 - b) Supports transmission of PC video signals (UXGA resolution), 3.5mm stereo audio, RCA composite audio/video.
 - c) Fits into a standard double gang J-box.
 - d) Due to variations in dimensional tolerances inherent to most metal decora inserts, this product is only compatible with plastic decora inserts.
 - e) Warranty: Lifetime
 - f) Color: White
 - g) Weight: 0.44lbs
 - h) Jacket Rating: Standard
- d. Digital HDMI passive wall plate (Rapid Run or equal)
 - 1) Detailed specifications:
 - a) Color Code: Red (for use with digital runners)
 - b) Supports HDMI high resolution video up to 1080p.
 - c) Fits into a standard J-box.
 - d) Recommend use with SonicWave™ HDMI cables up to two meters (six feet) in length, or cables manufactured using 28 AWG or larger conductors.
 - e) Warranty: Lifetime
 - f) Color: White
 - g) Weight: 0.350lbs
- e. Digital HDMI active wall plate (Rapid Run or equal)
 - 1) Detailed specifications:
 - a) Color Code: Red (for use with digital runners)
 - b) Supports HDMI high resolution video up to 1080p
 - c) Fits into a standard J-box.
 - d) Recommend use with SonicWave™ HDMI cables up to 2 meters (six feet) in length, or cables manufactured using 28 AWG or larger conductors.
 - e) Warranty: 1 year.
 - f) Color: White
 - g) Weight: 0.36.lbs

2.14 MISCELLANEOUS CABLING SYSTEM

- A. Provide and terminate all speaker, clock, microphone, antenna, cabling per manufacturer's recommendations for a completely operational system as specified.
- B. Sound/Speaker cabling shall be home run and looped directly to applicable headend termination board, as specified. All cable runs shall be free from in-line splices. Insulate all cable shields (at field device end) from field grounds by cutting and taping shields.
 - 1. Classroom speakers, office speakers, conference room speakers, work room speakers, exterior horn speakers and others areas that have only one (1) public address speaker shall each be individually home run, without splices, back to their respective sound or master clock headend. Provide 22 AWG solid shielded speaker cables.
 - 2. Hallways and other areas that have multiple speakers, may have a maximum of eight (8) speakers per speaker loop home run, without splices, back to their respective sound headend. Provide 18 AWG stranded speaker cables.
 - 3. Horn Speakers areas that have multiple speakers, may have a maximum of four (4) speakers per speaker loop home run, without splices, back to their respective sound headend. Provide 18 AWG stranded speaker cables.

2.15 TWO WAY COMMUNICATIONS CALL BOXES

A. SUMMARY

- 1. Section Includes: Area of Refuge Base Stations, call boxes and signage
 - a. The Area of Refuge Base Station is to be located at a central control point on the first floor or as determined by local Authority having jurisdiction. Rath Call Boxes are to be located on all floors above and below the first floor, ideally next to a stairwell emergency exit on each floor.
 - b. The Area of Refuge Base Station must be capable of handling a minimum of 5 Rath Call Boxes. Visual indicators on the base station allow Rescue personnel to know which Area of Rescue Call Box needs assistance. The Base Station must allow Rescue personnel to speak to all Call Boxes or individual Call Boxes.
 - c. The Emergency communication hardware shall comply with the Americans with Disabilities Act (ADA). The phone shall have the ability to be programmed with up to 5 emergency phone numbers. Upon activation of the emergency push button, a call will be automatically placed to the Base Station. If no one answers at the Base Station, the Call Box must dial a secondary location outside the building to activate **two way off-site person to person voice communications.**

B. MANUFACTURERS

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Rath Area of Refuge
 - b. Aiphone
 - c. Housing Devices, Inc.
 - d. Or Equal.

C. FUNCTIONAL DESCRIPTION OF SYSTEM

1. Construction
 - a. The Area of Refuge Base Station (models 2500) must have a stainless steel or powder coated steel housing, red coil cord emergency Handset, be 120vac powered, and maintain back-up power for 4 hours.
 - b. The Area of Refuge Call Boxes (models 2100) must be in full compliance with Americans with Disabilities ACT (ADA). Call Boxes require a hands-free speakerphone with an LED to indicate status of call.
 - c. The Area of Refuge Call Boxes must allow the programming in of a specific location message of the Call Box. This allows Rescue personnel to know the location of the activated Call Box.
 - d. The Area of Refuge Call Boxes are to be located no higher than 48" above ground level to ensure conformance with the ADA requirements.
 - e. The Area of Refuge Call Boxes must have a Braille faceplate located no higher than 48" for front reach and 54" for side reach above ground level to ensure conformance with the ADA requirements.
 - f. The Area of Refuge Base Station must provide an audible and visual indicator that a Call Box has been activated.
 - g. The area of Refuge 24vac Power Supply model 2500-PWR24 must be capable of supplying power to a minimum of 40 Call Boxes. (does not power Base Station)
2. Mounting
 - a. The Area of Refuge *Base Station* is to be mounted on a wall surface or flush mounted.
 - b. Areas of Refuge *Call Boxes* are to be wall surface or flush mounted.
3. Electrical
 - a. The *Base Station* is to be powered by 120vac. *Call Boxes* are to be powered by Rath 24vac Power Supply model 2500-PWR24.
 - b. *Call Boxes* must have a battery back-up capable of providing up to 4 hours of electrical back-up in case of building power failure.
 - c. *Base Station* must have a battery back-up capable of providing up to 4 hours of electrical back-up in case of building power failure.
 - d. System shall be in compliance with all state and local Electrical Codes.
4. Communications
 - a. The Call Boxes shall have an ADA compliant and vandal resistant speakerphone.
 - b. The Call Boxes shall be Hands-Free and be a push-button-once to talk system. Once the button has been pushed, the Call Box will call the Base Station. If no answer at the Base Station, it will automatically call preprogrammed emergency numbers. The Call Box must be capable of being programmed with up to 5 emergency numbers.
 - c. *Call Box* shall have Location Message capability. *Call Box* must have a minimum 18 second recordable message capability, programmable to play 1 or 2 times. *Call Box* shall notify called party of the location of the call upon being received at the emergency dispatch center.
 - d. Call Box shall be capable of allowing the called party to replay the Location Message if necessary to ensure an understanding of the caller location.
 - e. If system is not attended to 24 hours a day, the Call Box must dial a secondary location outside the building to activate two way off-site person to person voice communications.
 - f. Once call has been made (button pushed), the call can only be terminated by the called party.

- g. Call Box must have a red LED that will light up upon push of the button. The light shall be a solid color when the Call Box is activated, and will flash when call has been answered.
 - h. The Call Box must be capable of being programmed and reprogrammed
 - i. on-site and remotely.
 - 5. Standard Call Box features:
 - a. Five number programming.
 - b. Operating Temperature of between -40°F to +150°F (-40° to + 65° C)
 - c. Programmable passwords.
 - d. On-Site or Remote Programmable.
 - e. EEPROM memory to protect programming.
 - 6. Signage
 - a. System shall consist of a minimum of one photoluminescent (Part #7041) sign or one 120vac edge light sign (Part #7050), "location" and "instruction" sign (Part #7049) stating, "Area of Refuge" to clearly indicate location of designated area. A tactile sign (Part #7043 or #7044) with raised letter and Braille shall be located at entrance to Area of Refuge.
 - 7. Monitoring
 - a. Off-Site monitoring of the system shall be provided by Rath Monitoring.
 - b. Must be a UL Listed monitoring service provider
 - c. Minimum 3 year agreement for monitoring of the system.
 - d. Call Boxes shall dial Rath Monitoring at 800-xxx-xxxx.
 - 8. Graphics
 - a. Area of Refuge Base Station must include wording identifying the location of each Call Box and light an LED when a particular Call Box has been activated.
 - b. Call Box wording must include "Help Phone", "International Phone symbol" and raised Braille lettering.
- D. STARTUP SERVICE
 - 1. Engage a factory-authorized service representative to perform startup service.
 - a. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
 - b. Complete installation and startup checks according to manufacturer's written instructions.
- E. ADJUSTING
 - 1. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.
 - 2. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal occupancy hours for this purpose.
- F. DEMONSTRATION
 - 1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the public address and mass notification systems and equipment.

PART 3 - EXECUTION

3.1 GENERAL

- A. Do not install equipment and materials which have not been reviewed by the Architect. Equipment and materials which are installed without the Architect's review or without complying to comments issued with the review shall be removed from the project when so instructed by the Architect. No payment will be made for unapproved or removal if it is ordered removed. The Installer shall be responsible for any ancillary costs incurred because of its removal and the installation of the correct equipment and materials.
- B. Obtain detailed information on installation requirements from the manufacturers of all equipment to be furnished, installed or provided. At the start of construction, check all Contract Documents, including all Drawings and all sections of the specifications for equipment requiring electrical connections and service and verify electrical characteristics of equipment prior to roughing.
- C. Equipment and systems shall not be installed without first coordinating the location and installation of equipment and systems with the General Contractor and all other Trades.
- D. Any and all material installed or work performed in violation of above requirements shall be re-adjusted and corrected by the Installer without charge.
- E. Refer to all Drawings associated with the project, prior to the installation or roughing-in of the electrical outlets, conduit and equipment, to determine the exact location of all outlets.
- F. After installation, equipment shall be protected to prevent damage during the construction period. Openings in conduits and boxes shall be closed to prevent the entrance of foreign materials.
- G. Home runs indicated are not to be combined or reduced without written consent from the Architect.
- H. All connections to equipment shall be made in accordance with the approved submittal and setting drawings.
- I. Delivery, Storage and Handling:
 - 1. Deliver, store, protect and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.
 - 2. Deliver equipment in individual shipping splits for ease of handling, mount on shipping skids and wrap for protection.
 - 3. Inspect and report concealed damage to carrier within specified time.
 - 4. Store in a clean, dry space. Maintain factory protection or cover with heavy canvas or plastic to keep out dirt, water, construction debris, and traffic. Heat enclosures to prevent condensation. Meet the requirements and recommendations of NFPA 70B and the Manufacturer. Location shall be protected to prevent moisture from entering enclosures and material.
 - 5. Handle in accordance with NEMA and the Manufacturer's recommendations and instructions to avoid damaging equipment, installed devices and finish.
 - 6. The equipment shall be kept upright at all times. When equipment has to be tilted for ease of passage through restricted areas during transportation, the Manufacturer shall be required to brace the equipment suitably to insure that the tilting does not impair the functional integrity of the equipment.

- J. Site Observation:
1. Site observation visits will be performed randomly during the project by the Architect. Reports will be generated noting observations. Deficiencies noted on the site visit reports shall be corrected. All work shall comply with the Contract Documents, applicable Codes, regulations and local Authorities whether or not a particular deficiency has been noted in a site visit report.
 2. Be responsible to notify the Architect ten working days prior to closing in work behind walls, raised access floors, ceilings, so that installed work can be observed prior to being concealed.
 3. Areas shall stay accessible until deficiencies are corrected and accepted. Notify the Architect when all deficiencies are corrected. Return reports with items indicated as corrected prior to re-observation by the Architect.
- K. Project Open House:
1. If the Owner elects to have an open house at the end of the project, provide assistance to the Owner. Cooperate and provide manpower to operate and demonstrate systems during the open house as requested by the Owner.

3.2 EQUIPMENT RACKS, CABINETS AND BRACKETS

- A. Securely mount equipment racks, cabinets and wall mounted relay brackets to the building structure. Proper supports such as 3/8 in. lag screws and expansion anchors shall be used. Proper quantity of supports shall be utilized. Dry wall screws and other types of supports not specifically approved to support equipment are specifically prohibited. Submit mounting supports for approval before installation.
- B. Position racks, cabinets, and wall mounted relay brackets in order to have minimum 3 foot clearance for easy access. Equipment racks, cabinets and relay brackets mounted on or against walls shall have 3 foot clearance in front of deepest component. Free standing equipment racks and cabinets shall have 3 foot clearance in front and rear of deepest components. Provide 3 foot clearance between free standing equipment racks or cabinets and any other obstruction to allow access from front to rear of rack or cabinet for maintenance.
- C. The Electrical Contractor shall provide cable tray over each rack and cabinet to facilitate a neat and orderly installation of cables and to secure the top of the racks to the structure. Cables shall drop straight down to equipment racks. Cable trays shall be secured at both ends to the structure and connected together for a complete contiguous installation. Utilize proper supports to support the cable tray to the building structure as well as the equipment rack and cabinet. Submit mounting supports for approval before installation.
- D. Cable Management: All cables shall enter the wiring closet to within the equipment racks and/or brackets. Secure the bundle(s) to the rack strain relief and wire management behind the patch panels and cross connect block panels. Install horizontal and side-mounted vertical cable management panels and brackets for routing and management of patch cables. Maintain EIA/TIA and BICSI standards on bundling, supporting and bend radii.
- E. Once the cabling system has been installed and terminated, install all active components and surge protected power strips into the racks, cabinets and wall mounted relay brackets.
- F. Surge Protected Outlet Strips: Mount UPS and surge protected outlet strips per Manufacturer's directions. Refer to details on the Drawings for mounting location.

3.3 TERMINATIONS

- A. All copper conductors of every cable shall be completely terminated at both ends.

3.4 CABLE PATHWAYS

- A. Install cables in pathways provided by the Electrical Subcontractor or required under execution part of this section.
- B. Provide all equipment and cabling for a complete installed operating system. In general, pathways, outlet boxes and grounding are provided by the Electrical Subcontractor.
- C. All pathways provided under this section shall comply with fill capacities as per Code, EIA/TIA 569 and BICSI.
- D. Cable bending radius shall not be less than minimum required by EIA/TIA and BICSI.
- E. Cabling installed concealed shall be supported from the building structure (e.g. cable trays, J-Hooks).
- F. Cables shall be installed no closer than 12 inches (305mm) to electrical equipment and wiring. When cables are required to cross power wiring, they shall only do so perpendicular to the power wiring. Telecommunications cabling and power wiring shall only cross each other at minimal number of times and only due to building design limitations.
- G. Clearances: Clearances between cabling and other building systems listed by EIA/TIA 569 and BICSI shall be maintained throughout the building.
- H. All cables shall be installed in a neat and workman-like manner. Cables shall be installed parallel and perpendicular to building elements.
- I. Provide expansion fittings and adequate cable slack at all building expansion joints.
- J. Fire/smoke seal all conduits, raceways, sleeves, and slots where cables pass from one location to another.

3.5 SEALING OF PENETRATIONS AND OPENINGS

- A. Environmental Seals
 1. Provide seals on raceways exposed to widely different temperatures, as in refrigerated or cold storage areas. Install seal to prevent circulation of air from warmer to colder sections through the raceway.
 2. Provide seals under device plates for outlets on walls between conditioned and non-conditioned spaces.
 3. Provide outlet plate gasket seals at all work area outlets on interior and exterior walls.

3.6 SEISMIC SUPPORTS, SUPPLEMENTARY STEEL AND CHANNELS

- A. Provide all supports, supplementary steel and channels required for the proper Seismic installation, mounting and support of all work installed under this section.

- B. All supports, supplementary steel and channels shall be furnished, installed and secured with all fittings, support rods and appurtenances required for a complete support or mounting system.
- C. Supplementary steel and channels shall be firmly connected to the building construction in a manner approved by the Architect prior to the installation of same. Submit to the Architect, via the General Contractor, the locations proposed for using supplementary steel and channels for the support of equipment, fixtures and raceways. The submittal shall indicate the mounting methods, size and details of the supports, channels and steel; it shall indicate also that weight which the supports, channels and supplementary steel is to carry.
- D. The type and size of the supporting channels and supplementary steel shall be of sufficient strength and size for seismic restraint and to allow only a minimum deflection in conformance with the channel and supplementary steel manufacturer's requirements for loading.
- E. All supplementary steel and channels shall be installed in a neat and workmanlike manner parallel to the walls, floor and ceiling construction. All turns shall be made with 90 degrees and 45 degrees fittings to suit the construction and installation conditions.
- F. All supplementary steel, channels, supports, and fittings, shall be Underwriters' Laboratories, Incorporated, approved, be galvanized steel and be manufactured by Steel City, Unistrut, Power-Strut, T. J. Cope, Chalfant or approved equal.
- G. Provide supports to meet the required Seismic rating as indicated under "Part One" of this Specification.
- H. Provide beam clamps with set screws (C-clamp type).
- I. Work under this section shall be held in place by seismic rated methods.
- J. Supporting from the roof decking will not be acceptable.
- K. Provide expansion anchors on masonry units or brick work. Power actuated supports will not be accepted.
- L. Provide stainless steel or corrosion resistant supports in corrosive areas on wet or damp areas.
- M. Support work from the building structure, independent of suspended ceilings, roof deck or other trades work. Where duct work, pipes, pipe racks, type of building construction materials or structural framing members provide obstruction or difficult support means, hanger rods shall be used in association with horizontal sections of steel support channels, in an approved manner.
- N. All work shall be installed in a rigid and satisfactory manner and shall be supported by bar hangers in frame construction or shall be fastened directly with wood screws on wood, bolts with expansion shields on concrete or brick toggle bolts on hollow masonry units, and machine screws or welded threaded studs on metal. Threaded studs of the proper type and holding capacity driven in by a power charge and provided with lock washers and nuts are acceptable for mounting of equipment on solid concrete walls or slabs.
- O. Obtain written permission from the General Contractor allowing use of power activated charges. Use only properly trained and licensed operators.

- P. Do not use power charge driven supports for any work that is to be hung from a horizontal surface without written permission from the Architect.
- Q. Preset inserts of the proper type and holding capacity shall be used in overhead slab construction wherever possible.
- R. Provide lateral supports for work to prevent excessive movement during a seismic event using rods, braces or galvanized or stainless steel cables.
- S. Pendants, supports or hanging rods longer than 12 inches (300mm) shall be laterally braced.
- T. Where installed in damp, wet and areas requiring wash down, all surface mounted panels, boxes, junction boxes, and conduit shall be supported by spacers to provide a clearance between wall and equipment.

3.7 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in SECTION 260000 "Identification for Electrical Systems."
 - 1. Confirm labeling scheme with the Owner prior to final labeling.
 - 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
- C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.
- E. Cable and Wire Identification:
 - 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.

4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
 - b. Label each unit and field within distribution racks and frames.
 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- F. Provide preprinted or computer-printed type labels with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA 606-A, for the following:
1. Cable Labels: Use flexible vinyl or polyester that flexes as cables are bent.

3.8 CABLE SUPPORTS

- A. Provide strain relief hardware for backbone cables at each floor level as they pass from one floor to the next.
- B. Provide hook and loop (Velcro) cable wraps at all panels, equipment racks and cabinets. Cable ties are specifically prohibited.
- C. Cable ties for horizontal cables shall be secured with minimum required compression in order to secure the cables properly without impeding the signal transmission rating (geometry) of the cable. Hook and loop (Velcro) cable wraps may be used in lieu of cable ties for copper cables only. Cable-ties are specifically prohibited for fiber optic cables.
- D. When pathways are not provided or specified, provide J-Hook supports from the building structure for cable runs to the cable drop location. Maximum distance between supports shall be five feet depending on the structural elements of the building. Maximum number of cables per support shall be thirty. Provide additional supports when cable quantities exceed thirty and to maintain required bending radius of cables. Cables installed exposed or in areas subject to abuse (below 10 feet (3m) above finished floor) or in accessible areas shall be installed in conduit.
- E. All cables shall be supported directly from building structure. Under no circumstance shall cable be installed using cross bracing, plumbing/sprinkler pipes, ceiling systems or any other system that is not a specifically approved method to independently support cables. Cables shall not be allowed to rest on ceiling tiles, duct work, and piping. Supports shall be provided in order for cables to avoid contact with any other building system. Bundle cables in groups by Room.

3.9 CABLE PROTECTION

- A. Provide bushings in all metal studs and the like where cables will pass through. Bushings shall be of two piece construction with one piece inserted through the opening and the second piece locking it into place. Single piece bushings with locking tabs or friction fit are specifically prohibited.
- B. Cables to be installed in existing enclosed open bays or furred spaces where conduit stubs are not provided shall be protected from chafing or any damage. The Installer shall verify that the warranty shall not be violated before installing any cabling in these locations.

- C. Provide cutting, coring, sleeves and bushings and seal at all penetrations.
- D. Fiber optic backbone cables shall be installed in inner duct.
- E. Cables damaged during installation shall not be repaired. They shall be completely replaced with new cable.

3.10 INSTALLATION

- A. All cabling shall be installed in conduit where indicated on plans, or shall be installed open using other methods, approved by architect, such as J-Hooks.
 - 1. Install wiring, per manufacturers recommendations. Use UL listed plenum cable in environmental air spaces including plenum ceilings.
- B. All wiring shall be new and concealed in pipe where exposed.
- C. All conduits and raceways shall have pull strings remaining after cable is pulled.
- D. Impedance and Level Matching:
- E. Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
- F. Control Circuit Wiring:
 - 1. Install control circuits in accordance with NFPA 70 and as indicated. Provide number of conductors as recommended by system manufacturer to provide control functions indicated or specified.
 - 2. Make installation in strict accordance with approved manufacturer's drawings and instructions.
 - 3. The Installer shall provide necessary transient protection on the AC power feed, all station lines leaving or entering the building, and all central office trunks. All protection shall be as recommended by the equipment supplier and referenced to earth ground.
- G. Weatherproofing:
 - 1. Provide weatherproof enclosures for items to be mounted outdoors or exposed to weather.
- H. Typical Layouts and requirements of the specified systems:
 - 1. Typical layout:
 - a. Equipment racks and cabinets
 - b. Backbone cabling
 - c. Headend equipment
 - 2. Typical layout of telecommunications equipment racks and cabinets.
 - a. Each equipment rack and cabinet shall contain the following equipment:
 - 1) Fiber optic patch panel
 - 2) Fiber optic cable management
 - 3) Surge protector power strip
 - 4) Patch panels - Horizontal distribution
 - 5) Horizontal distribution cable management
 - 6) Vertical cable management
 - 7) Patch cords
 - b. Provide space for the installation of network electronics equipment in the equipment racks.

- c. Furnish and install horizontal cable management between each patch panel (fiber optics, Hub distribution, Horizontal distribution, and telephone distribution).
 - d. Furnish and install horizontal distribution patch panels in each wire center with sufficient ports to terminate all modular jacks shown on the drawings plus twenty percent spares. The exact number of modular jacks and horizontal distribution patch panels shall be obtained from the drawings.
 - e. Furnish and install all equipment racks and cabinets required to support the aforementioned equipment.
 - f. The MDF room shall contain fiber optic patch panel quantities which correspond to the total number of fiber optic patch panels located in the IDF rooms.
 - g. Grounding bars shall be installed under SECTION 260000. Furnish and install the required grounding to ensure that all of the aforementioned equipment is grounded and bonded.
3. Headend
- a. The headend consists of connecting hardware for the following:
 - 1) Video System
 - 2) Sound System
 - 3) Paging System
 - 4) Master Clock System
 - b. Final terminations from IDC cross connect block panels to telephone equipment and PBX by -Telephone Company and Equipment Installer. Coordinate with Telephone Company and Equipment Installer for final terminations.
 - c. Final terminations from the IDC cross connect block panels to the headend equipment shall be provided by the headend equipment installer.
 - d. Coordinate with the headend equipment installer and the electrical contractor for:
 - 1) The installation of all the IDC cross connect block panels at the headend equipment. Installation shall be neat in appearance.
 - 2) The final terminations at the headend.

3.11 TRAINING

- A. As a minimum, training sessions shall consist of the following:
1. General project information and review shall be by the General Foreman or Superintendent of the Trade.
 2. Specific system training shall be by a Factory Trained Representative.
 3. Provide a complete review of the project and systems including, but not limited to, the following:
 - a. In a classroom environment review each Record Drawing (use of typicals is acceptable).
 - b. Note equipment layouts, locations and control points.
 - c. Review each system.
 - d. Review system design operation and philosophy.
 - e. Review alarms and necessary responses.
 - f. Review standard troubleshooting techniques for each system.
 - g. Review areas served by equipment.
 - h. Identify color codes used.
 - i. Review features and special functions.
 - j. Review maintenance requirements.
 - k. Review operation and maintenance manuals.
 - l. Respond to questions (record questions and answers).

4. After classroom training, walk the entire project, review each equipment room and typical locations. Explain equipment and proper operation.
- B. During the instruction period the Owner and Maintenance Manual shall be used and explained.
- C. The Owner and Maintenance Manual material shall be bound in 3-ring binders and indexed. On the edge of the binder provide a clear see-through plastic holder with a typed card indicating the Project name, the Architect's name, the installer's name and the Volume number (e.g., Vol. No. 1 of 2).
- D. Provide name, address and telephone number of the manufacturer's representative and Service Company for all items supplied so that the source of replacement parts and service can be readily obtained.
 1. Include copies of manufacturers and installer's warranties and maintenance contracts and performance bonds properly executed and signed by an authorized representative.
 2. Include copies of all test reports and certifications.

3.12 ACCEPTANCE DEMONSTRATIONS

- A. Systems installed under this Section shall be demonstrated to the Owner and Architect. Demonstrations are in addition to necessary testing and training sessions. Notify all parties at least 7 days prior to the scheduled demonstration. Schedule demonstrations, in cooperation with and at times convenient to all parties, so as to not disturb ongoing activities.
- B. Systems shall be tested prior to the demonstrations and each system shall be fully operational and tested prior to arranging the Acceptance Demonstration. Final payments will be withheld until a satisfactory demonstration is provided for all systems indicated or requested.
- C. If the demonstration is not totally complete, performing all functions, features and connections or interfaces with other systems, or if there is a failure during the demonstration, additional demonstrations shall be arranged. Provide and pay for all costs, labor and expenses incurred for all attendees for each additional demonstration required for acceptance and demonstration of complete system operation.
- D. Demonstrations shall be scheduled in ample time to complete all activities prior to final acceptance and Owner occupancy. Demonstrations shall take place at least 30 days prior to the scheduled project completion date and 30 days prior to owner's use and occupancy.
- E. As a minimum, provide demonstrations for systems indicated under "Work Included" under Part One of the Specifications. Provide demonstrations of additional systems as requested by the Owner, or Architect.

3.13 PROJECT OWNER COORDINATION

- A. Prior to Substantial Completion of the project and in ample time to address and resolve any coordination issues, request and arrange meetings between the Owner, Owner's Vendors and Consultants, Architect and General Contractor to discuss the Scope of Work for each system being provided and the interface required for a fully functional and operational system upon project completion. Initial meetings shall be scheduled three months prior to the scheduled Substantial Completion date or as soon as Submittals are submitted and reviewed for projects with shorter schedules.
- B. At these meetings the required interface with the Owner shall be reviewed, requests for information required to complete programming or for coordination shall be presented and system operation and philosophy shall be discussed.
- C. Additional meetings shall be held as requested by any party so that all issues are resolved and with the goal and intent being that all systems are fully operational and functional upon project Substantial Completion and that the responsibility for all components required is clearly established.

3.14 CLEANING UP

- A. Upon completion of all work, and testing, thoroughly inspect all exposed portions of the installation and completely remove all exposed labels, markings, and foreign material.
- B. The interior of all boxes and cabinets shall be left clean; exposed surfaces shall be cleaned and plated surfaces polished.
- C. Repair damage to finish surfaces resulting from work under this section.
- D. Remove material and equipment from areas of work and storage areas.
- E. All equipment shall be clean from dirt, dust, and fingerprints prior to final acceptance.
- F. Touch up all damaged pre-finished equipment using materials and methods recommended by the Manufacturer.

3.15 PROJECT CLOSEOUT

- A. Provide close out submittals as specified herein and in SECTION 017700 - CLOSEOUT PROCEDURES including the following close out submittals.
 - 1. Operation and Maintenance Manuals
 - 2. Record Drawings.
 - 3. Test Reports.
 - 4. Extra Materials.
- B. Obtain written receipts of acceptance close out submittals submitted. Receipts shall specifically detail what is being delivered (description, quantity and specification section) and shall be dated and signed by firm delivering materials and by the Owner's Representative.

- C. Telecommunications:
 - 1. Provide fifteen (15 percent) spare patch cables and line cord for each cable length provided.
 - 2. Provide record drawings indicating actual cable routing and cable terminations and all required identifiers. Provide copy mounted in each telecommunications closet and the main cross connect.
 - 3. All sketches, drawings, and charts herein are for the purpose of providing for specifications in a simplified format. Errors and omissions in such does not relive the Contractor of the responsibility for providing a fully complete, secure and properly operating integrated instructional technology network system suitable for the intended use. Bidders must obtain a complete set of Project Drawings and Specifications to determine the full scope of work. In case of conflict the Project Drawings and Specifications shall prevail.
- D. Construction Waste Management
- E. Comply with Division 01 requirements for construction waste management and recycling.

END OF SECTION

SECTION 274116
INTEGRATED AUDIOVISUAL SYSTEMS AND EQUIPMENT

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. The Trade Contractor for this Section shall examine all Drawings and all Sections of the Specification for requirements therein that may affect the Work of this Section, not just those Drawings and Specifications particular to the Work of this Section. The Work of this Section is shown primarily on the following listed Drawings:
 - 1. Architectural
 - 2. Electrical
 - 3. Audiovisual
 - 4. Theatrical Lighting
 - 5. Theatrical Rigging
- B. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- C. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- D. Coordinate work with that of all other trades affecting, or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 EXAMINATION OF SITE AND DOCUMENTS

- A. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from General Contractor's or Trade Contractor's failure to familiarize themselves with the Contract Documents or existing conditions. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results.

1.3 RELATED DOCUMENTS

- A. Refer to AV drawings and project architectural, structural and electrical drawings for information related to the work specified herein.

1.4 RELATED WORK SPECIFIED ELSEWHERE

- A. Carefully examine all of the Contract Documents for requirements which affect the Work of this Section.
- B. Other Specification Sections which directly relate to the Work of this Section include, but are not limited to, the following:
 - 1. Section 01 00 00 - General Requirements
 - 2. Section 11 06 40 - Theatrical Lighting Control and Fixtures
 - 3. Section 26 00 00 - Electrical
 - 4. DIVISION 27 - COMMUNICATIONS; including all Sections contained therein

1.5 DESCRIPTION OF WORK

- A. Furnish and install sound, video and communication systems as shown on drawings and as specified herein, complete with all apparatus, equipment, power supplies, wiring, labor, and services necessary to ensure a complete working system. Verify completeness of equipment listed and correctness of type numbers. Furnish and install supplementary equipment needed to meet system requirements, without claim for added payment.
- B. The work includes, but is not limited to, the following:
 - 1. Submission of shop drawings prior to fabrication.
 - 2. Verification of dimensions and conditions at the job site.
 - 3. Installation in accordance with these specifications, manufacturer's recommendations, and all applicable code requirements.
 - 4. Setup and adjustment of signal processing, system tests and adjustments, written report, demonstration for approval, participation in acceptance tests, and final adjustments as required.
 - 5. Programming and documenting of all software controlled devices including initial setup of presets in all devices.
 - 6. Coordination with the Electrical contractor
 - 7. Coordination with the Lighting contractor.
 - 8. Coordination with the Fire Alarm Systems Contractor
 - 9. Coordination with Tel/Data Contractor and other Low Voltage Contractors
 - 10. Coordination with Owner's Audio-Visual Personnel
 - 11. Coordination with the Owner's IT department and installers
 - 12. Performance standards, without claim for additional payment
 - 13. System documentation.
 - 14. Instruction of owner's operating personnel.
 - 15. Maintenance services for one year.
 - 16. Guarantee.

1.6 SUBMITTALS

- A. Provide submittals in accordance with requirements of Section 01 33 00 – Submittal Procedures and as detailed herein.
- B. Alternates
 - 1. With system bid price, submit prices for equipment and installation of additional or reduced quantities of equipment as stated herein. Unless otherwise stated, all items herein are part of the base bid system. Input and output jacks, test points, terminal blocks and wiring for add or deduct alternate equipment should be included in the Alternate.
- C. First Submittal
 - 1. Timing: within 45 days of contract award
 - 2. Conduit size verification
 - a. Review and confirm that audiovisual system conduit as shown on the Drawings and where applicable, as built drawings, is sufficient and appropriately sized for system.
 - b. Note where conduit system is not sufficient and indicate any additional conduit required for system.
 - 3. Key project personnel
 - a. Provide names, resumes, addresses, mobile and office phone numbers, and e-mail addresses of key project personnel.
 - 4. Milestone dates
 - a. Dates for each Submittal
 - b. Shop fabrication complete
 - c. Initial equipment ship to site
 - d. Start of installation

- e. Second equipment ship to site
 - f. Control system programming complete
 - g. Field testing
 - h. Correction of punch list items
 - i. Training
- D. Second Submittal
- 1. Timing: 90 days before equipment purchase or commencement of wiring.
 - 2. Before ordering equipment or beginning work, submit list showing quantities and manufacturer and model number for items of equipment to be used in assembling this system, including all items of equipment specified herein. Attach copies of catalog sheets for all items of equipment submitted.
 - a. Submit cut sheets in same order as this specification with table of contents, specification paragraph reference and page numbers.
 - 3. Shop Drawings
 - a. Submit all drawings in a single submittal, except if specified otherwise.
 - b. Submit the following drawings for approval, prior to fabrication and installation:
 - 1) A block diagram indicating proposed interconnections of all equipment and indicating equipment types and model numbers.
 - 2) Drawings of loudspeaker mounting arrangements, equipment rack layouts, and receptacle and control plates and boxes.
 - 3) Plate and panel schedule listing all plates individually with size, mounting condition (surface or flush), back box size and plate finish color.
 - 4) Drawings of projector mounting arrangements and sight line studies showing proper alignment and dimensions with the projection screen and projection equipment.
 - 5) Drawings of custom plate and panel details, patch bay layouts and all other necessary wiring diagrams.
 - 6) Drawings showing cable pull assemblies and schedule complete with all wiring requirements for the project
 - 7) Drawings of all final assemblies of loudspeaker and projector suspension equipment stamped by a certified structural engineer.
 - 8) Drawings of anchoring system for loudspeaker suspension.
 - 9) Submit samples of all panels, custom loudspeaker grills, and loudspeaker cabinet finishes.
 - 10) List of radio frequencies used by system. Coordinate frequency usage with Owner's designated representative prior to submitting shop drawings.
 - 11) List of Ethernet devices in system with device name, manufacturer, purpose, MAC address and IP address.
- E. Touch Panel
- 1. Submit the following for approval prior to programming
 - 2. First Submittal
 - a. Timing: 150 before substantial completion
 - b. Line drawings of touch panel layouts button functions listed.
 - c. Detailed narrative and demonstration mockup/simulation of all touch panel programming based on design process specified herein.
 - d. Three fully designed sample screens for evaluation of graphical look.
 - 3. Second Submittal
 - a. Timing: 120 days before substantial completion
 - b. After approval of first touch panel submittal, submit electronic color images of touch panel layouts.
- F. Finishes

1. Obtain Consultant and Architect approval of all panel and furniture finishes prior to fabrication. The Architect will specify exact finishes.
- G. Field Supervisor
 1. Before beginning installation, submit the name of the employee who will be the on-site field supervisor through the completion of this project.
- H. Copies
 1. Submit a minimum five (5) copies of all required submittals.
- I. Qualifications
 1. Bidder shall be a system contractor, normally engaged in the full time business of audiovisual and sound reinforcement system installation. Provide evidence that the bidder has been in business for at least five years prior to bid date and has completed projects of similar size and scope.
 2. References, including names and telephone numbers of individuals who may be contacted, showing satisfactory completion of three or more projects similar in scope and type to that specified herein.
 3. Provide additional evidence of satisfactory completion of audio-visual system installations involving suspended loudspeakers and complex control system integration.
 4. Evidence of ability and affirmation of intent to meet the guarantee and service requirements stated herein.
 5. Qualifications of certified control system programmer who will be working on this project.
 6. Each vendor shall include a description of the professional and technical experiences background, qualifications and expertise of the organization's key personnel assigned to this project. The description shall show that bidder possesses the demonstrated skills and experience in specific areas of the project scope. In addition, Bidder shall identify a project manager for the project and shall provide resumes of all personnel who shall be assigned to this project. Bidder shall estimate the percentage of time each individual shall be working on this project.

1.7 MATERIALS AND EQUIPMENT

- A. All systems proposed herein shall meet the best commercial practices of the applicable industries, except where alternatives are noted. Publications of issues of the following standards form a part of this specification:
 1. American Institute of Architects (AIA)
 2. Americans with Disabilities Act (ADA)
 3. American National Standards Institute (ANSI)
 4. Audio Engineering Society (AES)
 5. Computer Security Institute (CSI)
 6. Federal Communications Commission (FCC)
 7. Institute of Cable Engineers (ICEA)
 8. Institute of Electrical and Electronic Engineers (IEEE)
 9. International Standards Organization (ISO)
 10. International Telecommunications Union (ITU)
 11. National Association of Broadcasters (NAB)
 12. National Electric Code (NEC)
 13. National Electrical Manufacturers Association (NEMA)
 14. National Fire Protection Association (NFPA)
 15. National Institute for Certification in Engineering Technology (NICET)
 16. Occupational Safety and Health Administration (OSHA)
 17. Society of Motion Picture and Television Engineers (SMPTE)
 18. Telecommunications Industry Association (TIA)

- 19. Underwriters Laboratories (UL)
- 20. Nationally recognized standards of the various construction trades, as may be applicable.

- B. References shall meet the latest edition of that standard
- C. Certain items of equipment are specified by manufacturers' type numbers to indicate an acceptable standard of quality and performance. Substitutions of equal equipment beyond the alternatives listed will be permitted only if such equipment is listed in an addendum to this specification. Address requests for listing of substitutions to the Architect. With any request for substitution, include measured data proving the equivalence of the proposed substitute in quality and performance. The Architect shall be the final judge of the validity of the data submitted.
- D. Provide only current-model materials and equipment. Do not provide obsolete or discontinued models unless specifically directed to do so in the Equipment section of this specification. Review all materials and equipment immediately prior to installation, and inform the Architect of any obsolete or discontinued items.

1.8 COORDINATION AND CLARIFICATION

- A. Refer to the Architect before the bid date for coordination and clarification of any discrepancies among drawings and specifications. Where discrepancies occur and pre-bid instructions have not been obtained, abide by the Architect's reasonable decisions.
- B. No extras will be allowed because of the audio-visual system contractors or any installation subcontractor's misunderstanding as to the amount of work involved or his lack of knowledge of any of the conditions pertaining to the work based on neglect or failure to visit or make a proper examination of the site.

1.9 EXISTING CONDITIONS

- A. Verify all existing conditions. Refer to the Architect for coordination and clarification before the bid date of any discrepancies concerning existing conditions. Clarify with the Architect all locations including conduit and cable routings. Where discrepancies occur and pre-bid instructions have not been obtained, abide by the Architect's reasonable decision.
- B. Furnish, install, and terminate all required wire and cable into conduit provided under Division 26.
- C. Comply with all requirements regarding the use of cable with respect to spread of fire. Refer to the General Construction drawings for identification of air plenum and other spaces having special cabling requirements. Field-survey the jobsite to determine spaces having special cabling requirements. It is the responsibility of the Audiovisual Contractor to provide wiring that is in compliance with all applicable building codes of the authority(ies) having jurisdiction.

1.10 DELIVERY, STORAGE AND HANDLING

- A. All equipment shall be appropriately packed for shipment.
- B. All shipping costs to the job site are the responsibility of the Audiovisual Contractor. Determination of the shipping method and company is the responsibility of the Audiovisual Contractor in order to meet the published project schedule.
- C. Completed systems shall be shipped FOB inside and in place.
- D. Note that drop shipment of equipment to the Owner's site directly from the manufacturer, or other supplier will not be allowed.
- E. Upon delivery all materials shall be stored under cover in a clean and dry location. Materials which are damaged during shipping, storage or handling or are otherwise not suitable for installation shall be removed from the job site and replaced, at no additional cost to the Project, with acceptable materials.

1.11 FUNCTIONAL REQUIREMENTS

- A. The systems shall provide the following functions:
 - 1. Auditorium Sound Amplification System

- a. Reinforcement of speech and music from wired microphone receptacles and wireless microphone systems to listeners in the auditorium through a centralized group of loudspeakers located above the stage.
 - b. Supplemental reinforcement of audio signals to listeners in the front of the Auditorium through front-fill loudspeakers installed in the stage apron.
 - c. Supplemental reinforcement of audio signals to listeners in the rear seating section of the Auditorium through electronically delayed loudspeakers.
 - d. Operator controlled mixing of microphone signals using a mixing console.
 - e. Automatic mixing of dedicated wired microphone receptacles and wireless microphone systems (lavalier and handheld) using an automatic mixer system.
 - f. Assistive listening system using portable wireless FM receivers.
 - g. Reproduction of pre-recorded audio material using a compact disc player unit located unit in a portable equipment rack for use with mixing console.
 - h. Loudspeaker receptacles and wiring located in and around the stage for portable loudspeakers.
 - i. Recording from ceiling-suspended microphones and main audio system signals using a recording mixer and a solid state recorder.
 - j. Monitoring of audio system signals through wall-mounted control room monitor loudspeakers.
 - k. Two-channel production intercom system for cueing of technical personnel with wired headsets at locations throughout the Auditorium and related spaces.
 - l. Reinforcement of announcements from the Auditorium to backstage zones through ceiling mounted loudspeakers.
 - m. Monitoring of Auditorium activities using a ceiling suspended microphone to backstage zones through ceiling mounted loudspeakers.
 - n. Preset switching and routing for preset event modes and loudspeaker configurations.
 - o. Overflow audio to and from the Gymnasium and Town Square sound systems.
 - p. Muting of all audio signals in response to fire alarm control signal from fire alarm system.
2. Auditorium Video System
 - a. Switching of video signals from a Bluray player, multiple computer inputs and multiple composite video inputs for output to a video projector.
 - b. Remote control of Bluray player, switcher, video projector, and projection screen.
 - c. Reproduction of Bluray and computer audio.
 - d. Reproduction of program material from AV switcher.
 - e. Monitoring of video system signals using a flat panel display located in the control room.
 - f. Automatic shut down of video projector and retraction of projection screen in response to fire alarm control signal from fire alarm system.
3. Gymnasium Sound System
 - a. Announcements for games and small speech events from a rolling portable equipment rack.
 - b. A hand-held wireless microphone system and wired microphones connected to a portable equipment rack.
 - c. Reproduction of pre-recorded audio material using a compact disc player, iPod dock and auxiliary interfaces located in a portable equipment rack.
 - d. Mixing of microphone and program signals using a small mixer located in a portable equipment rack.
 - e. A distributed loudspeaker system with multiple full-range loudspeakers suspended above the playing surfaces and bleachers.
 - f. Wall box inputs for connecting audio sources in the portable equipment rack to the installed loudspeaker system.
 - g. Assistive listening system using portable wireless FM receivers.
 - h. Flexible presets that allow loudspeaker zones to be turned off when not in use.

- i. Overflow audio to and from the Auditorium and Town Square sound systems.
 - j. Muting of all audio signals in response to fire alarm control signal from fire alarm system.
4. Town Square Sound System
- a. Reinforcement of speech from wired and microphone receptacles and wireless microphones to listeners in the Cafeteria through a distributed system of surface-mounted and ceiling-mounted loudspeakers.
 - b. Automatic mixing of microphone inputs using a digital signal processor.
 - c. Reproduction of pre-recorded audio material using playback devices located in an equipment rack, including the following:
 - 1) compact disc player
 - 2) iPod interface
 - 3) Auxiliary source inputs
 - d. Control of loudspeaker zones with DSP via rack-mounted and remote volume controls.
 - e. Reinforcement of announcements through ceiling-mounted loudspeakers.
 - f. Assistive listening system using portable wireless FM receivers.
 - g. Overflow audio to and from Auditorium and Gymnasium Center sound systems.
 - h. Muting of all audio signals in response to fire alarm control signal from fire alarm system.
 - i. Act as lobby space for Auditorium.
5. Music Classroom Systems
- a. Reproduction of pre-recorded music to listeners through wall-mounted left and right loudspeakers.
 - b. Reproduction of pre-recorded audio material using a compact disc player unit with pitch control.
 - c. Reproduction of pre-recorded audio material from owner supplied equipment using AV inputs intended for portable devices.
 - d. Reinforcement of announcements and monitoring of activities in Auditorium for events.
 - e. Ethernet-based recording interface for use with Owner-furnished computer.
 - f. Assistive listening using portable wireless FM receivers.
 - g. Muting of all audio signals in response to fire alarm control signal from fire alarm system.
6. Weight/Cardio Room System
- a. Background music and program playback using devices located in local equipment rack including the following:
 - 1) MP3 player interfaces
 - 2) Bluetooth interface
 - 3) Compact disc player
 - b. Ceiling loudspeakers mount in suspended ceilings
7. Portable Sound System
- a. Couple with existing powered loudspeakers and portable digital IO interface, the portable system will provide audio for events in the Town Square and in the outdoor plaza.

1.12 ACOUSTICAL PERFORMANCE CRITERIA

- A. The overall space-average acoustical frequency response criterion, as measured within the coverage area of the system loudspeakers, is within ± 3 dB of a spectrum which is flat from 125 to 2500 Hz and slopes downward thereafter at a rate of 3 dB per octave to 12,500 Hz. Test signals shall be broad-band "pink" noise applied to any system input, measured using 1/3-octave filters centered on ANSI preferred frequencies.

- B. Measurements of system performance will be made using a calibrated ANSI or IEC precision sound level meter set for "slow" meter damping and flat response, 4 feet above the floor (seated ear height) within the system coverage area. All interior finishes and furnishings shall be in place, and system gain shall be adjusted to provide levels of at least 70 dB, or 10 dB above background noise levels, whichever is higher, at the measuring locations for these tests.
- C. The spatial level uniformity criterion, throughout the sound system coverage areas, is that amplified sound levels shall not vary more than ± 2 dB as measured using a test signal consisting of an octave band of "pink" noise centered at 2,000 Hz.
- D. To meet the acoustical performance criteria, be responsible for:
 - 1. Use of the equipment specified in the manner specified.
 - 2. Each component's conformance with its manufacturer's published specifications and other requirements as stated herein.
 - 3. Detailed checking of each item of equipment provided, each portion of the installation, and of the complete installation to find and remedy any defects therein.
 - 4. Setting and documenting the adjustments of loudspeakers, equalizers, and other signal-processing equipment, pads, and gain controls, and if so directed by the Architect making the further adjustment of these items, providing additional field-assembled resistive pads and/or resistor-capacitor equalizers.
 - 5. Adjust all equalizers to realize maximum gain and optimal tonal balance from the sound system throughout the audience area.
- E. Output level of all program sources arriving at switching or routing equipment shall be within ± 0.25 dB of each other as measured at the input to the switcher or router. Provide pads, line amplifiers or other gain control devices as required to achieve this specification.
- F. System frequency response shall be 20 - 20 KHz ± 3 dB, unless the known, published specifications of a particular piece of mixing, processing, amplification or transducing equipment limit this specification.
- G. System signal to noise ratio shall be 60 dB or greater, unless the known, published specifications of a particular piece of mixing, processing, amplification or transducing equipment limit this specification.

1.13 VIDEO PERFORMANCE CRITERIA

- A. Provide systems that meet the performance requirements stated in this section. Perform any work required to modify the performance of the system in order to meet these requirements. Perform whatever tests are necessary to confirm compliance with these requirements, before commencement of acceptance testing.
- B. Analog Signal Distribution and Cabling
 - 1. The video distribution and cabling system shall meet or exceed the following electrical specifications, measured at any point in the system. Compliance with these specifications shall be determined by introducing a standard video reference signal at points normally used for origination (e.g., camera, DVD player, workstation) and measuring the signal characteristics at points normally serving as destinations (e.g., monitor, projector, DVD player). Note that these are end-to-end performance requirements to be met under all conditions of switcher re-entrance.
 - 2. For purposes of this paragraph, the distribution and cabling system shall include all equipment and cabling normally within the signal path.
 - 3. Frequency Response shall be ± 1.5 dB, DC to 100 MHz for computer and component video signals and ± 0.5 dB; DC to 5.0 MHz for NTSC encoded composite video signals.
 - 4. Rise time shall be 250 V/microseconds minimum.
 - 5. Crosstalk shall be 45-dB minimum below nominal signal level, unweighted DC to 70 MHz.
 - 6. Signal to Noise Ratio shall be 45-dB minimum, peak noise to RMS signal, unweighted DC to 70 MHz.
 - 7. Signal Gain shall be unity (1.00) terminated into 75 ohms.

8. Line and Field Tilt shall be less than 2 percent.
9. Differential Gain shall be less than 3 percent.
10. Differential Phase shall be less than 3 degrees.
11. Color Timing (where applicable) shall be within 2 degrees at 3.58 MHz.
12. Input Return Loss shall be 40-dB minimum, DC to 70 MHz.
13. Path Length Inequality for Y/C and RGBS cable sets where the signals are not subject to subsequent matrixing or encoding shall be within 12 inches of cable length, or 1.6 nsec.
14. If cable length results in the deterioration of gain and frequency response characteristics and cable compensation equipment are not specified, the system shall be adjusted for best performance. The Audiovisual Contractor shall be able to demonstrate that any inability to meet gain and frequency response specification is due solely to length of cable.

C. Digital Signal Distribution and Cabling

1. Provide digital signal distribution system with the following features:
 - a. EDID management
 - b. HDCP compliant
 - c. HDMI, DVI and DisplayPort signal transport
 - d. Troubleshooting tools
 - e. Support for video formats up to and including 1920x1200.
 - f. Manufacturer-approved cabling

D. Displays (Monitors and Projectors)

1. All displays shall meet manufacturers' published specifications for brightness, contrast, focus, convergence, linearity, distortion, and purity, across the entire range of horizontal and vertical scan frequencies of which the display is capable. In the absence of such specifications, no convergence, linearity, distortion, or purity errors shall be visible from a viewing distance equal to the image width, and brightness, contrast, and focus shall meet standard performance guidelines.
2. Projectors shall be installed and adjusted so that the resultant images are free from all keystone and barrel distortion and vignetting.
3. Projectors shall exhibit correct color balance, both at black and at peak white, and proper gray scale tracking.
4. All displays shall meet manufacturers' published specifications for horizontal and vertical scan frequency ranges. Where appropriate, adjustments shall be made to allow for automatic scan locking across specified ranges. Image quality specifications discussed above shall be met throughout the horizontal and vertical scan frequency ranges.

1.14 CONTROL SYSTEM CRITERIA

A. General Requirements

1. Provide programming and otherwise configure control system to achieve fully functional system. Coordinate with the Owner. In addition to all other operating controls, ensure that the conditions in this section are met.
2. Provide programming and otherwise configure control system to achieve control as identified below. Sections below do not define panel layouts; refer to drawings.
3. Reliability
 - a. Operation shall be 100% reliable. Occasional spurious operation shall not be acceptable.
 - b. Every control panel pushbutton shall work as intended when pressed just once. The excuse of "Try it again" shall not be acceptable.
 - c. Equipment shall remain operable from its own front panel even when under control from the remote control system. For example, unused outputs on a video router shall be available for manual operation even when other outputs are being switched by the control system.

- d. When a portable control panel is disconnected and re-connected, the panel shall return to normal operation with system status correctly indicated for all functions. If necessary, an initialization pushbutton may be used to force a panel update.
4. Usability
 - a. A sub-page or individual function which appears on two different pages shall operate in the same way on each page.
 - b. Feedback (tally) shall be accurate 100% of the time. If true feedback cannot be achieved, then feedback generated by the control system must be 100% accurate. If such feedback cannot be accurately generated, then momentary tally (to confirm pushbutton press only) shall be used.
 - c. Every function required for proper operation of the audiovisual system shall be under the control of the remote control system, regardless of whether or not that function is in use. For example, a video document camera may have an Internal/External mode function, permitting the display of an external device such as a notebook computer. If the user inadvertently selects External mode, the document camera will be inoperable. The Internal/External mode function shall therefore be under control of the remote control system, so that when the document camera is selected for display, Internal mode is forced.
 - d. Functions with an inherent delay (eg. video projector turn-on and warm-up) shall be accompanied by an indication of time remaining until ready (touch panels only). Otherwise, there shall be no perceptible delay either in system response or in status indication.
 - e. Ramping functions (such as volume control) shall operate smoothly, with a ramp rate of approximately 5 seconds from minimum to maximum. System response to ramping commands shall be immediate, and there shall be no perceptible delay in the response of any bargraph indicator.
 5. Control Panel Graphics
 - a. A conservative graphical standard suitable for a educational application shall be developed and adhered to. This standard shall include the following:
 - 1) Limited color palette, generally with colored pushbuttons on a light background
 - 2) No background texture or wallpaper
 - 3) Limited number of typefaces and type sizes for legends
 - 4) Pushbuttons properly aligned horizontally and vertically
 - 5) Consistent and logical use of color - ie. green for normal condition, red for alert.
 - 6) There shall be no perceptible delay in control panel page flips. Page flips shall be executed without any spurious flashes of unwanted pages or sub-pages.
 - 7) Control panel pushbuttons shall not be present for functions which will not be required (eg. DVD record) or which are not supported in the application (MCU functions for a video codec without an integral MCU).
 - 8) In absence of specific direction from Owner or Consultant use Crestron "Standard" Theme or similar as a basis for touch panel graphics.
 - b. Develop panel graphics within an independent graphics design program, Adobe PhotoShop or similar, that provides 32-bit color selection and color matching, color and grey scale shading, infinitely-variable light source direction and intensity, and custom typefaces. Import panel graphics thus developed into Crestron VisionTools or AMX TPDesign panel creation software. Do not perform initial graphics development within these Crestron or AMX applications.
 6. Other
 - a. Configure control system hardware and programming so that the system will recover from a loss of power to any portion of the system or to the system as a whole without

operator intervention. Configure so that control system does not lockup during loss of power, and that manual operation of equipment is possible under all conditions.

- b. Provide resistive pull-ups or other means as required to reliably interface to low-voltage remote control systems provided by others, including (but not limited to) projection screens.
- c. Provide other hardware and programming not specifically enumerated herein in order to provide a complete and functioning system that meets the performance requirements identified in this section.

1.15 DIGITAL AUDIO NETWORKING

- A. Implement Quality of Service on all Ethernet switches as recommended by Digital Audio Networking Best Practices.
- B. Coordinate IP addressing scheme with Owner for possible connection of AV network to Owner's building network.

1.16 DIAGRAMS, INSTRUCTION MANUALS

- A. Provide draft copies of all required diagrams and instruction manuals on-site for inspection during the demonstration and acceptance testing of the system; submit final copies thereafter.
- B. Simplified Line Diagram
 1. Show the essential parts of the completed installation and their functional relations, including all jacks, numbered according to their position on the system patch panels (A, B, etc., for horizontal rows, 1-26 for vertical columns). Mount one copy of the diagram behind clear plastic on the wall near the equipment rack, or as directed. Bind one copy of the diagram into each instruction manual. Reduce the mounted copy to 11" x 17" maximum; insure that it is legible at that size.
- C. Receptacle Plans
 1. Provide 11x17 plans showing the location and designation of all receptacles and loudspeakers. Provide separate plans for line/microphone receptacles, loudspeaker receptacles and other receptacles. Indicate jack numbering on plans. Mount one copy and bind other copies into manuals as specified for the line diagram.
- D. Operating Manual
 1. Create system specific user manual for the complete system including user instructions for accessing all the system functionality specified in Function Requirements. Manual should describe how to use individual components in their context as part of a larger system. A compilation of manufacturer's manuals for components does not meet this requirement.
- E. Complete Instruction Manuals
 1. Provide complete instruction manuals which include the following:
 - a. Table of contents.
 - b. List of loose items furnished (microphones, stands, cables, etc.).
 - c. List of functional requirements.
 - d. Operating manual (described above).
 - e. List of settings and adjustments for semi-fixed controls.
 - f. Manufacturer's sheets of specifications, operating instructions, and service information arranged alphabetically by manufacturer and then by model number, for each item of equipment specified herein.
 - g. Detailed system wiring diagrams, including cable schedules, DSP functional diagram print-outs and copies of all drawings specified above. Also include all submitted shop drawings to indicate as-built conditions.
 - h. Provide to Owner and retain a copy of all operating software, if any, and manuals, including custom software.

- i. Provide source code for all custom programming created for this project on USB drive.
 - j. Provide print-out of all touch panel pages.
 - k. Submit a copy of the manufacturer's standard software and firmware licensing agreement for the Owner's signature. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.
 - l. Provide five (5) bound copies.
- F. Record Drawings
1. Provide record drawings of as-built conditions in AutoCAD and PDF file format based on contractor's updated base drawings. Drawings shall include at a minimum:
 - a. Device location plan
 - b. Functional diagram with wire numbering
 - c. Panel and rack details.
 - d. Wiring details
 - e. Loudspeaker suspension details.
 2. Provide USB key with AutoCAD files and one (1) blackline print of drawings.
- G. Control System
1. Provide a control system. User interface will be through wireless and wired touch panels.
 2. Provide the services of a Manufacturer Certified programmer. Programming by non-certified personnel is not acceptable.
 3. Perform all terminations and wiring required to connect to third-party systems as shown on the Drawings including, but not limited to:
 - a. Theatrical Lighting System
 4. Touch Panel Pages
 - a. Splash Screen
 - b. Main Screen Source Selection Page
 - 1) Sources on left hand side of page
 - 2) Destination selection
 - a) Auto-select between HDMI and VGA in floor boxes
 - 3) Speech and Program volume and mute on right hand side of page
 - 4) Audio-only mode
 - 5) Video mute
 - 6) Indication of which source has been routed to which output
 - c. Projection Screen Source Selection
 - 1) Sources on left hand side of page
 - 2) Destination selection
 - 3) Video mute
 - 4) Indication of which source has been routed
 - d. Preview monitor source selection
 - 1) Break-away and setting to make output follow projector
 - e. Advanced Routing Page
 - 1) Full access to all inputs and outputs with matrix switcher style source/destination/take sequence.
 - 2) Option for audio breakaway.
 - f. Blu-Ray Player
 - 1) Transport controls, disc menu, player menu setup, return, menu navigation
 - g. Audio Switcher
 - 1) Source select
 - h. Audio Recorder

- 1) Transport controls, media select, recording time
- i. Chime
 - 1) Trigger audience recall chime.
- j. Digital Signal Processor
 - 1) Program and Speech Volumes
 - 2) Muting Presets
 - 3) Mode Presets
 - 4) Put Town Square in Lobby Mode
 - 5) Return Town Square to Standard Mode automatically at 1 AM each night.
 - 6) Additional functions per Functional Diagram
- k. Lighting
 - 1) Sixteen presets
 - 2) Push and hold preset selection button to rename preset with soft keyboard entry
- l. Projector
 - 1) On, off, native, zoom to fit, stretch to fit, video mute
 - 2) Lamp hour usage readout for each projector

1.17 INSTRUCTION

- A. Provide instruction of Owner's designated operating personnel. Include a minimum of six sessions for a total of twenty-four hours of instruction in the operation, care and maintenance of the installation. Schedule multiple sessions over a one or two year period across both Fall and Spring School Sessions.
- B. Schedule instruction at the mutual convenience of the Owner and contractor, **after demonstration and acceptance testing**. Provide a DVD recording or otherwise coordinate with the Owner the recording of all instruction sessions and provide a copy of each major session to the Owner.
- C. Six months after completion of the installation, the Audiovisual Contractor shall provide a control system review making any minor changes to the control system as the Owner may request based on the configuration at system sign-off.

1.18 GUARANTEE AND SERVICE

- A. Guarantee all equipment and installations to be free of faulty workmanship and defective components for a period of one year from date of final acceptance.
- B. During this period, replace defective materials and repair faulty workmanship within 24 hours of report of malfunction at no additional cost to the Owner. If specified materials and installations cannot be made good within 24 hours of report of malfunction, provide approved temporary alternate equipment and facilities, complete and operational, within 24 hours of report of malfunction, at no additional cost to the Owner.
- C. Maintain a 24-hour-per-day, 365-day-per-year telephone response facility for receipt of service calls.
- D. Respond to service calls and provide restoration of service within the time limits stated, weekends and holidays included.
- E. Provide at no additional charge preventive maintenance service for a period of one year after final acceptance of installation. This service shall consist of at least two semi-annual visits to the site for checking and adjustment of equipment.
- F. Provide with bid annual cost to extend the preventive maintenance agreement from two to five years after completion.

PART 2 - EQUIPMENT

2.1 WIRING AND CONNECTORS

A. Audio Installed Lines

1. For cables installed in conduit and entirely within racks, use cable with a foil-shielded pair of stranded #22 AWG conductors, with a stranded shield drain wire. For single pair, use a miniature cable, nominal outside diameter 0.135". Use of multi-pair cable is optional. Provide plenum rated equivalent as required.
 - a. Belden 8451
 - b. Liberty 22-1P-EZ
 - c. West Penn 452

B. Audio Portable Cables

1. For line and microphone level audio umbilical cords use cable with stranded #20 AWG conductors, braided shield, and EPDM rubber jacket.
 - a. Belden 8412
 - b. Equal

C. Loudspeaker Wiring

1. Provide unshielded loudspeaker wiring for connection to loudspeakers and loudspeaker receptacles. For lines in rigid conduit or electrical tubing, use stranded or solid conductors. For lines in flexible conduit or electrical tubing and for all wiring to equipment within equipment racks, use only stranded conductors.
2. Use color-coded #12 AWG conductors for all loudspeakers and electronically-delayed loudspeakers except for 70 V ceiling-mounted loudspeakers and loudspeaker receptacles.
 - a. Belden 8477
 - b. West Penn 227
 - c. Approved Equal
3. For all ceiling-mounted loudspeaker wiring using 70.7 Volt lines provide color-coded #18 AWG loudspeaker wiring.
 - a. Belden 8461
 - b. West Penn 224
 - c. Approved Equal
4. Use color-coded #14 AWG conductors for all loudspeaker receptacle wiring.
 - a. Belden 8473
 - b. West Penn 226

D. 75 Ohm Video Input/Output Lines

1. Provide video lines with a maximum loss of 30dB at 750Hz for single run.
2. For cable length runs between 0 and 300 feet:
 - a. Canare L-5CFB
 - b. Belden 1505A
 - c. West Penn 819
3. For cable length runs between 300 and 500 feet:
 - a. Canare L-7CFB
 - b. Belden 1694A
 - c. West Penn 6350
4. For multi-cable RGBHV runs under 100 feet:
 - a. Belden 1279P
 - b. Extron MHR-5
 - c. West Penn 255CRGB

E. Fiber-Optic Wiring, Two Fiber

1. Provide multi-mode, OM3, two-fiber cable for connection from wall plates to patch bays.
 - a. Belden B9C037
 - b. Equal
- F. Fiber Optic Wiring, Six Fiber
 1. Provide multi-mode OM3, six-fiber cable for connection between equipment racks. Terminate all fibers with connectors.
 - a. Belden B9C039
 - b. Equal
- G. Antenna Wiring
 1. Provide coaxial antenna wiring for connections from wireless transmitters and receivers to antenna connection panels.
 - a. Belden 7810A
 - 1) Equal
- H. Category Wiring
 1. Provide shielded Category 6 8-conductor twisted pair cable with 23 AWG solid conductors and bandwidth of 250 Mhz for computer data and audiovisual transport wiring.
 - a. Belden DataTwist series
 - b. Equal
- I. HDBT Wiring
 1. Provide shielded Category5e 8-conductor twisted pair cable tested to 350 Mhz and suitable for use with the supplied video distribution system.
 - a. Crestron DM-CBL-8G
 - b. Equal
- J. Microphone and Line Level Patch Panel
 1. Provide programmable patch panels to fulfill the requirements shown on the functional diagram. Wire jacks with bridging and normalled-through connections as detailed. Use patch panels which include designation strips with transparent plastic label covers; vertical strips at each side and a three-line (minimum) horizontal strip for each row of jacks. Place jacks close to each other on the patch panel which are shown close to each other on the functional diagram. Locate each bridging jack above the associated normalled-through jack. Use bantam type tip-ring-sleeve jacks with cross-bar palladium or Western Electric #1 gold alloy switching contacts. Both factory-wired and shop-wired patch panels are acceptable. Insulation-displacement terminals are included with the factory-wired patch panels specified herein; other terminal strips or terminal blocks may be substituted, including both solder and screw types. Supply two-foot long red patch cords with nickel-plated plugs. Attach patch cord holder to side of rack or wall near jack field.
 - a. Acceptable patch panel:
 - 1) BittreeB48DC-NNPIT/E3 M20U12L
 - a) Quantity: As required
 - b. Acceptable patch cord:
 - 1) Bittree LPC 24 00-110
 - 2) Approved equal
 - a) Quantity: 40
 - c. Acceptable patch cord holder:
 - 1) Audio Accessories MAXI
 - 2) Pomona 4408
 - a) Quantity: 1
- K. Video Patch Panel

1. Provide 75 ohm patch panels for video signals.
 - a. Acceptable patch panel:
 - 1) Bittree B48T-2WTHD
 - 2) ADC equal
 - a) Quantity as required
 - b. Acceptable patch cord:
 - 1) Bittree VPCM 24 00 – 75
 - 2) ADC equal
 - a) Quantity: 20
- L. Category Patch Panel
 1. Provide 48-port rack-mount category 6 patch panel. Provide one 2-foot patch cable per wired port on patch bay.
 - a. Leviton eXtreme
 - b. Hubbell NextSpeed
 - c. Approved equal
 - 1) Quantity: per Drawings
- M. Connectors
 1. Connectors from the following manufacturers shall be considered acceptable. Install connectors appropriate for the installed cable and equipment interface.
 - a. ADC
 - b. Amp
 - c. Amphenol
 - d. Canare
 - e. H.H. Smith
 - f. Kings
 - g. Neutrik
 - h. Pomona
 - i. Switchcraft
 - j. Trompeter
 - k. Approved equal
- N. Input Connection Plates
 1. All plates are black anodized aluminum with engraved or laser etched white lettering unless otherwise noted.
 - a. Wall-mounted plates: custom color/finish by architect OR stainless/brushed aluminum
 - b. Wall-mounted plates in stage areas (behind proscenium): black
 - c. Wall-mounted plates at catwalk and overhead areas: black
 - d. Wall-mounted plates in Control Room: black
 - e. Floor-Box Mounted plates: white
- O. AV Input Plate, Analog
 1. Provide custom plate with balancing and to transformer unbalanced input to balanced output.
 - a. ProCo iPlate
 - b. Equal
- P. AV Input Plate, Networked
 1. Provide Dante-based input/output plate with 2-channel Bluetooth audio input, pairing button, RCA and 3.5 mm stereo analog input, 3.5mm stereo analog output. Provide unit that that receives power and signal via Power Over Ethernet.
 - a. Atterotech unD6IO-BT

- b. Equal
- Q. Surface Mount Electrical Gang Boxes
 - 1. Provide surface mount electrical gang boxes for all surface and pipe mount audiovisual devices in project. Coordinate mounting condition and requirements with electrical contractor. Provide in black or white as required to match faceplate.
 - a. FSR SMWB Series
 - b. Leviton BKBX Series
 - c. Electronic Theatre Controls Equal
- R. Press Feed
 - 1. Provide jacks and transformer as shown to combine low-impedance line level outputs and match them to inputs of consumer-type ("Hi-Fi") recording equipment. Provide three-pin receptacles to interface "pro-level" recording equipment to same low-impedance line level outputs. Locate in audio equipment rack. Provide custom assembly on panel using the following components:
 - a. Phono Receptacles
 - 1) Use female phono ("RCA") panel mounted jacks, as shown below, which are insulated from the mounting panel and which use D-holes or other positive means to prevent jack rotation. Provide sufficient clearance so that inserted plugs do not short to the plate.
 - b. Three-pin Receptacle
 - c. Provide three-pin receptacle with black finish, for connection to "pro-level" equipment.
- S. Microphone Extension Cable
 - 1. Provide 25-foot long rubber-covered flexible microphone extension cables. Fit each flexible extension cable with black three conductor XLR microphone receptacles. Provide one microphone cable per microphone.
 - a. Wireworks C25
 - b. Pro Co M25
 - c. Approved equal assembly
 - 1) Quantity: As required by number of microphones provided.
- T. Isolation Transformer
 - 1. Jensen Transformer JT-11SSP-6M
 - 2. ProCo LOT-1
 - a. Quantity: As required
- U. Dual Line Output Transformer
 - 1. Jensen Transformer DIN-2LO-11FL
 - 2. Equal
- V. Dual Two-Way Microphone Splitter
 - 1. Jensen Transformer DIN-MS-2P
 - 2. Equal
- W. Audio Combiner
 - 1. Provide passive audio combiner network. Provide with power supply as required. Mount in equipment rack.
 - a. RDL STD series
 - b. Equal
- X. Speaker Level Interface

1. Provide device to convert speaker level to line level for use with paging system. Coordinate with paging system contractor.
 - a. RDL TX-70A
 - b. Equal
 - Y. 2x2 Audio Interface, Networked
 1. Provide two input, two output interface to Dante audio network. Provide surface-mounted unit with balanced audio inputs and outputs, selectable microphone/line level input gain and all required power supplies.
 - a. Atterotech Dante unDIO2x2
 - b. Lectrosonics DNT22
 - c. Equal
 - Z. Terminal Blocks
 1. Provide DIN-rail mounted terminal blocks where indicated on functional diagrams for microphones and line level lines.
 - a. Acceptable manufacturers:
 - 1) Wago
 - 2) Entrelec
 - 3) Equal
 2. Provide DIN-rail terminal blocks, barrier strips or euro-style blocks for loudspeaker level lines.
 - AA. Rack-Mounted Power Strips
 1. For racks without sequenced power control provide vertical power strip as required for rack size and number of circuits. Provide power strip with only circuit breaker protection. No MOV surge protection is required. Provide power strip with NEMA 5-20R (IG) outlets.
 - a. Middle Atlantic PD series
 - b. Equal
- 2.2 AUDITORIUM AUDIO INPUT EQUIPMENT
- A. Lectern Microphone
 1. Provide microphone with shock isolation. Supply microphone with 18-inch long flexible extension tube, stand clamps and foam windscreen. These microphones are intended for general use at lecterns, or on stands for reception of speech or music at distances of approximately 12 to 24 inches from source to microphone. For units without electronic vibration isolation provide additional shock-mount stand adapter. Install one microphone on lectern. Second microphone is provided for portable use.
 - a. Countryman Isomax 4RF, M4HP5RF24EB
 - b. Clock Audio C 35E-RF
 - c. Equal
 - 1) Quantity: 2
 - B. Wireless Microphone System
 1. Provide all antennas, transmitters, and receivers by a single manufacturer.
 2. Provide digital wireless microphone system with AES 256-bit encryption, Dante audio networking, allow up to 16 active transmitters on one 6 Mhz TV channel, switching diversity.
 3. Provide all required power supplies and accessories to achieve intent of Drawings.
 4. Provide complete with rack-mounting kits.
 5. Provide with rack shelves for charging stations.
 6. Provide antenna with all required hardware to mount to wall and point at stage.
 - a. Four-Channel Receiver

- 1) Shure ULXD4Q
- 2) Equal
 - a) Quantity: 1
- b. Handheld Transmitter
 - 1) ULXD2/SM58
 - 2) Equal
 - a) Quantity: 2
- c. Belt Pack Transmitter
 - 1) ULXD1
 - 2) Equal
 - a) Quantity: 2
- d. Lavalier Microphone
 - 1) Shure MX150/O
 - 2) Equal
 - a) Quantity: 2
- e. Rechargeable Battery
 - 1) Shure SB900
 - 2) Equal
 - a) Quantity: 6
- f. Charging Station
 - 1) Shure SBC200-US
 - 2) Equal
 - a) Quantity: 4
- g. Active Directional Antenna
 - 1) Shure UA874
 - 2) Equal
 - a) Quantity: 2

C. Vocal Microphone

- 1. Provide microphone for "close-miked" use by popular, jazz, or folk singers. Provide complete with stand adapters as necessary. Provide with flexible microphone cable as specified above.
 - a. Shure SM58-LC
 - b. Electro-Voice N/D 267
 - c. Audix OM-3xb
 - d. Sennheiser E835
 - 1) Quantity: 2

D. Instrument/Vocal Microphone

- 1. Provide microphone for "close-miked" use with instruments. Provide complete with stand adapters as necessary. Provide with flexible microphone cable as specified above.
 - a. Shure Beta 57A
 - b. Electro-Voice N/D 478
 - c. Audix i5
 - d. Sennheiser E840
 - 1) Quantity: 2

E. Microphone Floor Stand (metal base)

- 1. Provide an adjustable black microphone stand with 5/8-inch thread and round, weighted metal base.
 - a. AKG KM-260/1-black
 - b. Atlas MS-12CE
 - c. On-Stage MS9201B
 - 1) Quantity: 4

- F. Boom for Floor Stand
 - 1. Provide black, counter-balanced, tiltable boom arm, 32-inches to 34-inches long, compatible with floor stand provided.
 - a. AKG KM-211/2-black
 - b. Atlas PB-21XE
 - c. On-Stage MSA9040TB
 - 1) Quantity: 4
 - G. Microphone Floor Stand (tripod base)
 - 1. Provide adjustable black microphone stand with 5/8-inch thread and tripod base. Provide with adjustable-length boom arm.
 - a. Atlas TL34-21XE
 - b. On-Stage MS7701TB
 - c. Equal
 - 1) Quantity: 4
 - H. Microphone Table Stand
 - 1. Provide a round base stand with 5/8" thread, round weighted metal base with adjustable height from approximately 8" - 13". Provide stand in black finish.
 - a. Atlas DS-7E
 - b. AKG Equivalent
 - c. On-Stage DS-7200QRB
 - 1) Quantity: 2
 - I. Headphone Interface
 - 1. Provide passive stereo 3.5mm to balanced XLR converter.
 - a. Switchcraft #318 Mini Audiostix
 - b. Equal
 - 1) Quantity; 2
 - J. Stage Floor Box (FB1)
 - 1. Provide floor box complete with back box, basket insert and hinged cover. Installation of floor box and back box by Electrical Contractor. Mount floor box cover flush with stage floor, unless directed otherwise by Architect. Provide for wiring of audiovisual receptacles. Coordinate installation with flooring installer. Provide flat or insert hinged cover, per Architect
 - a. FSR FL-600P-6 back box w/cover.
 - b. Equal
 - 1) Quantity; 2
 - K. Auditorium Floor Box (FB2)
 - 1. Provide floor box complete with back box, basket insert and hinged cover. Installation of floor box and back box by Electrical Contractor. Mount floor box cover flush with auditorium floor, unless directed otherwise by Architect. Provide for wiring of audiovisual receptacles. Coordinate installation with flooring installer. Provide flat or insert hinged cover, per Architect.
 - a. FSR FL-500P-6 back box w/cover.
 - b. Equal
 - 1) Quantity; 1
- 2.3 AUDITORIUM AUDIO CONTROL AND AMPLIFICATION EQUIPMENT
- A. Digital Mixing Console, Dante Interface Card

1. Provide Dante interface card for existing digital mixing console. Install in console and configure to work with system.
 - a. Behringer X-Dante
 - 1) Quantity: 1
- B. Digital Mixing Console Input/Output Box
 1. Provide rack-mountable remote I/O device compatible with digital mixing console. Provide device with 16 analog microphone inputs with console-controllable pre-amplifiers, 8 analog line level outputs on 3-pin XLR connectors which connects to the digital mixing console over AES50. Provide unit with AES50 daisy-chain capability for support of existing IO boxes.
 - a. Behringer S16
 - 1) Quantity: 2
- C. Virtual Soundcard Software
 1. Provide license for Dante Virtual Soundcard. Install on Owner's Computer.
 - a. Quantity: 1
- D. Digital Audio Software
 1. Provide license for Dante Via. Install on Owner's Computer.
 - a. Quantity: 1
- E. 8-Channel Automatic Mixer
 1. Provide rack-mounted mixer with at least 8 microphone/line inputs and Dante digital audio network connection. Provide with rack-mounting kit. Mount in stage equipment rack.
 - a. Shure SCM820-DAN
 - b. Equal
 - 1) Quantity: 1
- F. Uninterruptible Power Supply
 1. Provide 1000VA minimum rack-mounted UPS system to provide power-surge and power-loss protection to digital signal processor system.
 - a. APC SUA1000RM2U
 - b. Powerware 5125 1000 RM
 - c. Middle Atlantic UPS-1000R
 - 1) Quantity: 1
- G. Digital Signal Processor
 1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
 - a. Feedback suppression
 - b. Nine bands of parametric equalization per signal input group
 - c. Crossover
 - d. Compressor
 - e. Digital delay
 - f. Signal limiting
 - g. Digital audio signal routing
 - h. Signal flow as shown on sound system functional drawing(s)
 - i. Volume control
 - j. Dante digital audio networking
 - 1) BSS London BLU
 - 2) Biamp Tesira
 - 3) Symetrix EDGE

- a) Quantity: 1 complete system, as required
- H. Ethernet Switch
 - 1. Provide SNMP capable, POE enabled, managed, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.
 - 2. Provide switch with multi-mode fiber interfaces to create ring topology, per Drawings.
 - 3. Create VLANs per drawings.
 - a. Packedge
 - b. Netgear
 - c. Cisco
 - d. Equal
 - 1) Quantity: 2 – Main and Booth Equipment Rack
- I. Digital Signal Processor Preset Description
 - 1. Provide digital signal processing settings as described below. Exact determination of digital processor settings is an iterative process and final settings should be determined and documented with careful field measurements. Configure the default mode (with no muting) when master power switch is turned on. Configure so that all inputs are routed to appropriate outputs unless complete routing/rewiring of the internal DSP software devices is required. Presets are described below as parameter changes that do not require a muting and reinitializing of the digital signal processor. Provide access to muting presets through control system if included with project.
 - a. Presets required:
 - 1) Gymnasium overflow on/off
 - 2) Town Square overflow on/off
 - 3) Central Loudspeaker Cluster on/off
 - 4) Front-Fill Loudspeakers on/off
 - 5) Delay Loudspeakers on/off
 - 6) Backstage Loudspeakers on/off
 - 7) Town Square serve as Lobby
 - 8) Overflow volume
- J. Power Amplifiers Serving Central Cluster Loudspeakers (HF/MF)
 - 1. Provide four-channel, power amplifiers with balanced bridging inputs, continuously variable-speed fan(s). Provide amplifiers, which are 2-rack space units high. Provide amplifiers which provide at least 500 watts output (nominal) per channel into 4 ohms and 300 watts output (nominal) per channel into 8 ohms.
 - a. Crown DCi 4|300
 - b. Lab.gruppen C16:4
 - c. Equal
 - 1) Quantity: 1
- K. Power Amplifier Serving Central Cluster Loudspeakers (LF)
 - 1. Provide four-channel power amplifier with balanced bridging inputs and variable-speed fan(s). Provide amplifier which is 2-rack space units high. Provide amplifier which supplies at least 300-watts (nominal) per channel at 8-ohms and at least 500-watts (nominal) per channel at 4-ohms.
 - a. Crown DCi 4|600
 - b. Lab.gruppen C28:4
 - c. Equal
 - 1) Quantity: 1
- L. Power Amplifier Serving Front Fill and Delay Loudspeakers

1. Provide 8-channel power amplifier with balanced bridging inputs and variable-speed fan(s). Provide amplifier which is 2-rack space units high. Provide amplifier which supplies at least 200-watts (nominal) per channel at 8-ohms.
 - a. Crown DCi 8|300
 - b. Lab Gruppen C 20:8X
 - 1) Quantity: 1

2.4 AUDITORIUM EQUIPMENT RACKS AND ACCESSORIES

A. Main Equipment Rack

1. Locate in equipment rack closet in control room. Use modular rack with bolt-together frame, side panels, locking rear door, and vented, locking front door, which accepts extra panel-mounting angles. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Recess rack rails to allow front doors to close when patch cords are in use. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide rack with minimum 30-inch depth.
 - a. Raxxess GAR-XX-32 Series Assembly
 - b. Middle Atlantic WRK-XX32 Series Assembly
 - c. Lowell LGR-XX32 Series Assembly
 - 1) Quantity: 2

B. Main Equipment Rack Cooling Fan

1. Provide cooling fan compatible with and from same manufacturer as equipment rack specified above. Provide with thermostatic automatic fan control.
 - a. Middle Atlantic MW-4QFT-FC
 - b. Equal
 - 1) Quantity: 2

C. Swing-Out Equipment Rack

1. Provide floor-mounted equipment rack with pivoting center section, floor base, and vented, lockable front door. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide with thermostatically controlled fan kit.
 - a. Middle Atlantic SR-40-32 w/ DWR-FK32, FC-2-215-1CA
 - 1) Quantity: 2

D. Rack Power Wiring

1. Furnish equipment racks with permanently-mounted 3-conductor AC power receptacles with sufficient outlets to meet system needs plus at least 2 spares per rack. Provide raceway configured with separately circuited receptacle groups as required to distribute load across multiple circuits. Provide whip with plug to match for connection to power outlet box as indicated on the power plan drawings.
 - a. Juice Goose CQ-PD1-4, CQ2200, CQ2000 (special order IG version)
 - b. Middle Atlantic MPR Series w/ RLM-20IG modules
 - c. Equal
 - 1) Quantity: As required

E. Portable Playback Equipment Rack

1. Provide portable equipment rack for use of playback equipment by mixing console operator. Provide complete with rack mount power strip and cables as shown on the Drawings.
 - a. SKB 1SKB19-6U
 - b. Technomad (Hardigg) ProRack 6U
 - c. Gatorcases GR-6L

- 1) Quantity: 1
- F. Portable Input/Output Equipment Rack
 1. Provide portable equipment rack for use of stage box equipment. Provide complete with rack mount power strip and cables as shown on the Drawings. Provide with 25 foot extension cord and 25 foot hard-service Ethercon cable for connection to wall.
 - a. SKB 1SKB19-8U
 - b. Technomad (Hardigg) ProRack 8U
 - c. Gatorcases GR-8L
 - 1) Quantity: 1
- G. Portable Equipment Rack Power Strip
 1. Provide 1 rack unit 15-amp surge-protector and power strip with EMI/RFI filtering, series mode surge protection, and integrated gooseneck rack lighting receptacles.
 - a. Surge-X SX1115-RL w/ (2) LED gooseneck rack lights
 - b. Equal
 - 1) Quantity: 2 – portable equipment racks
- H. System Power Control
 1. Provide a relay-controlled power switching system with a master power switch and power-on indicator for the system. Connect the master power switch to control each receptacle in the rack except for one of the spare receptacles. Label unswitched receptacles "UNSWITCHED". Connect power for rack illumination to bypass the system master power switch. Provide a means to cycle the system power amplifiers on sequentially at intervals of approximately one second whenever the power switch is activated.
 - a. Middle Atlantic USC-6R
 - b. Atlas Sound SACR-191
 - c. Juice Goose CQ1520
 - 1) Quantity: 3
- I. Rack Work Light
 1. Provide locally switched utility lighting. Connect to unswitched receptacle. Mount in back of audio equipment rack.
 - a. Atlas Sound RWL-2
 - b. Equal
 - 1) Quantity: 3
- J. Rack Lighting
 1. Littlite Raklite RL-10-D-LED
 2. Equal
 - a. Quantity:
 - 1) 2
- K. 4 Rack Unit Locking Storage Drawer
 1. Provide 4 rack space locking rack mounted drawer.
 - a. Middle Atlantic D4-LK
 - b. Raxxess SDR-4 w/ lock
 - c. Equal
 - 1) Quantity:3
- L. 2 Rack Unit Locking Storage Drawer
 1. Provide 2 rack space locking rack mounted drawer.
 - a. Middle Atlantic D2-LK
 - b. Raxxess SDR-2 w/ lock

1) Quantity:1

2.5 AUDITORIUM LOUDSPEAKER COMPONENTS

A. Loudspeaker Manufacturer

1. All loudspeakers shall be supplied by the same manufacturer, except where that manufacturer does not make one of the specified loudspeakers.

B. Central Cluster Loudspeaker

1. Provide 3-way full range loudspeaker with 15-inch low-frequency drivers, 3-inch voice coil, rotatable waveguide. Provide with all necessary suspension hardware, including supplemental steel as required to create rigging points above loudspeaker. Provide loudspeaker and mounting hardware with finish as directed by architect.
 - a. Fulcrum Acoustic DX1565
 - b. Eastern Acoustic Works QX566i
 - c. Equal1) Quantity: 3

C. Delay Loudspeaker

1. Provide passive 2-way loudspeaker with 8-inch low frequency transducer, 2-inch voice coil high frequency compression driver, and rotatable waveguide. Provide with all necessary mounting hardware. Provide loudspeaker and mounting hardware with finish as directed by architect.
 - a. Fulcrum Acoustic CX896
 - b. Eastern Acoustic Works MK8196 (horn rotated)
 - c. Equal1) Quantity: 4

D. Front Fill Loudspeaker

1. Provide compact 2-way loudspeaker with 4-inch concentric driver. Flush-mount in vertical face of stage apron as shown on the Drawings. Provide with grille and bezel with finish as directed by Architect.
 - a. Tannoy iw4 DC
 - b. Equal1) Quantity: 5

E. Control Room Monitor Loudspeaker

1. Provide active 2-way compact monitor loudspeakers with 3 inch low-frequency driver and dome tweeter. Provide with table stand to elevate loudspeaker above mixing console.
2. Provide with short table stand to elevate loudspeakers above mixing console.
 - a. Genelec 8010A
 - b. M-Audio Studiophile AV 40
 - c. Equal1) Quantity: 2

F. Loudspeaker Rigging Suspension Equipment

1. Provide loudspeaker rigging for loudspeaker clusters and suspended loudspeakers. Suspend loudspeaker components from brackets and any necessary suspension frames to minimize total number of ceiling hanging points. Provide with a sufficient number of suspension points for field adjustment of loudspeaker aiming. Provide with color as designated by the Architect. During fabrication and installation verify that adequate clearance from all other hanging components and adequate clearance from structural steel is provided. Provide any additional rigging hardware necessary for the safe and proper installation of these loudspeakers.

2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
 - a. Ape Rigging
 - b. Polar Focus
 - c. ATM-Flyware
 - d. Approved Contractor-Fabricated Assembly (*Show evidence of successful completion of previous projects)
3. Submit all drawings of the complete final loudspeaker rigging assemblies to a certified structural engineer and obtain approval and stamped copies of the drawings. Drawings should detail all connections from attachment to building structure to loudspeaker.

2.6 AUDITORIUM PLAYBACK EQUIPMENT

A. Compact Disc Player

1. Provide 1U compact disc player with balanced outputs, pitch control, and IR remote.
 - a. Tascam CD-500B
 - b. Denon DN-C640
- 1) Quantity
 - a) 1 – stage equipment rack
 - b) 1 – portable equipment rack

B. Media Shelf

1. Provide rack-mounted compartment with cabling grommets designed for use with portable media players. Provide with Bluetooth Interface (1) pair stereo phone (RCA) connectors with 1/8-inch stereo phone plug to RCA cable for connection to other portable media players. Provide interfaces for connection to separate stereo audio inputs. Provide with integral power/USB outlets mounted on back panel of shelf, per Drawings.
 - a. Middle Atlantic SH-DMP-S w/ AV Plate, Networked
 - b. Equal Assembly
- 1) Quantity: 1 stage equipment rack

2.7 AUDITORIUM ASSISTIVE LISTENING EQUIPMENT

- ### A. Provide wireless assistive listening system consisting of an FM transmitter, an antenna mounted as indicated on drawings, and portable battery-operated receivers with earphones and inductive couplers (the latter for use with hearing aids with "T" switches). Provide frequencies separate and free from interference with other FM systems. Provide all assistive listening system components from the same manufacturer.

B. Transmitter

1. Listen Technologies LT800 with LA-326 rack mounting kit
2. Williams PPA T35 with RPK 006 rack mounting kit
3. Equal
 - a. Quantity: 1

C. Transmitter Antenna

1. Listen Technologies LA-122
2. Williams ANT 005 with extension cable
3. Equal
 - a. Quantity: 1

2.8 AUDITORIUM RECORDING SYSTEM

A. Recording Microphone

1. Provide ceiling suspended microphone with extension cables and mounting bracket. Suspend microphone assembly from catwalk. Provide phantom powered condenser microphone with cardioid pickup pattern. Secure rotation with mono-filament fishing line.
 - a. AKG C391B
 - b. Shure SM81
 - c. Equal
 - 1) Quantity: 2
 - B. Recording Microphone Suspension Mount (for spaced pair use)
 1. Ace Backstage Microphone Hanger Slug #42
 2. Equal
 - a. Quantity: 2
 - C. Recording Mixer
 1. Provide digital audio mixer with microphone inputs and Dante network connection.
 - a. Soundcraft Si Expression 1 w/ Dante Card
 - b. Behringer X32 Producer w/ Dante Card
 - c. Equal
 - 1) Quantity: 1
 - D. Combination Solid State and CD Recorder
 1. Provide 1U device capable of recording stereo audio either directly to a removable flash memory card in WAVE and MP3 format, or to compact disc. Provide device with balanced analog audio inputs and outputs and coaxial digital inputs and outputs. Mount in under counter equipment rack in control room.
 - a. Tascam SS-CDR200 w/ 32GB CF Card
 - b. Equal
 - 1) Quantity: 1
 - E. Headphones
 1. Provide monitor headphones for recording mixer.
 - a. Sony MDR7506
 - b. Sennheiser HD280
 - c. AKG K240S
 - 1) Quantity: 1
- 2.9 PROGRAM MONITOR/ANNOUNCEMENT SYSTEM
- A. Audience Suspended Microphone
 1. This microphone is intended for use with the backstage monitor system. Suspend below ceiling above the audience. Provide with color as directed by Architect. Secure rotation with mono-filament fishing line.
 - a. Countryman Isomax II-H, M2CP6F50
 - b. Shure MX202 X/C
 - c. Equal
 - 1) Quantity: 1
 - B. Audience Recall Chime
 1. Provide electronic chime generator for audience recall chime. Provide with all required power supplies and mounting hardware.
 - a. RDL FP-CH8
 - b. Equal
 - 1) Quantity: 1
 - C. Desktop Announce Microphone Console

1. Provide console assembly with gooseneck microphone and weighted base. Provide base with 2 momentary switches for paging zone selection and 6-pin output receptacle. Provide with cable for connection to wall plate in Control Room and at tech table location.
 2. Label buttons with black background, white text labels.
 - a. Clockaudio DMB 2 w/D43 Gooseneck
 - b. Equal
 - 1) Quantity: 1
- D. Desktop Announce Console Cable
1. Provide 15-foot 6-conductor microphone cable with 6-pin male and female XLR connectors.
 - a. Pro-Co
 - b. Whirlwind
 - c. Lex Products
 - 1) Quantity: 2
- E. Stage Equipment Rack Cue Microphone
1. Provide cardioid dynamic microphone for use in cue microphone rack assembly per Drawings. Provide push-to-talk close-talking microphone with 12-inch black gooseneck and flange mounted in custom 2 rack unit high open-front chassis.
 - a. Shure 515SBGX w/ G12B, A12HDB
 - b. Equal
 - 1) Quantity: 1
- F. Ceiling Mounted Loudspeaker (S)
1. Provide 70.7-volt loudspeaker/transformer assembly with back box enclosure and grille. Furnish back box enclosure to Electrical Contractor. Connect to 4-watt taps.
 - a. Atlas FA134T87 w/ FA720-4 Grill and FA97-4 loudspeaker enclosure
 - b. Equal
 - 1) Quantity: per Drawings
- G. 70-Volt Loudspeaker Volume Control
1. Provide wall and rack mounted loudspeaker attenuators for volume control. Coordinate exact electrical device box size requirements with electrical contractor.
 2. Wall-Mounted, 10W
 - a. Atlas AT10
 - b. Lowell 25LC2
 - c. Equal
 - 1) Quantity: per Drawings
 3. Wall-Mounted, 35W
 - a. Atlas AT35
 - b. Lowell 50LVC
 - c. Equal
 - 1) Quantity: per Drawings
 4. Wall-Mounted, 50W
 - a. Atlas AT35
 - b. Lowell 50LVC
 - c. Equal
 - 1) Quantity: per Drawings
 5. Wall-Mounted, 100W
 - a. Atlas AT100
 - b. Equal
 - 1) Quantity: per Drawings

2.10 AUDITORIUM PORTABLE LOUDSPEAKERS

A. Active Portable Loudspeaker

1. Provide 2-way loudspeaker with integrated amplifier, 8" low-frequency driver, detented gain control, balanced audio line input and output.
2. Provide each loudspeaker with 25-foot XLR extension cable and 25-foot power cable.
 - a. QSC K8
 - b. Yamaha DXR8
 - c. Electro-Voice ZxA1
 - 1) Quantity: 4

2.11 AUDITORIUM PRODUCTION INTERCOM SYSTEM

A. Provide a two-channel production intercom system as shown on the Drawings. Homerun circuits as enumerated to the master station in equipment rack. Connect circuits to master station output channels as shown. Connect power cable to "unswitched" receptacle in equipment rack. Provide single channel belt-packs, headsets and extension cables compatible with the production intercom systems specified below. Provide all equipment from the same manufacturer.

B. Main Station

1. Provide 2-channel production intercom master station with gooseneck microphone. Locate in main equipment rack. Provide with additional power supplies as required.
 - a. Telex MS-2002 with MCP-90-8" microphone
 - b. Clear-Com MS-702 with GM-9 microphone
 - 1) Quantity: 1

C. 1-Channel Belt-Pack Station

1. Telex BP-1002
2. Clear-Com RS-701
 - a. Quantity: 6

D. Headset

1. Telex PH-1
2. Clear-Com CC-300
 - a. Quantity: 6

E. Handset

1. Telex HS-6
2. Clear-Com HS-6
 - a. Quantity: 1

F. Intercom Extension Cable

1. Provide twenty-five foot long rubber-covered flexible microphone extension cables. Fit each flexible extension cable with black three conductor XLR microphone receptacles. Provide color-coded shrink-wrap tubing to designate these extension cables separate from the microphone extension cables.
 - a. Wireworks C25
 - b. Pro Co M25
 - c. Whirlwind Equivalent
 - 1) Quantity: 5

2.12 AUDITORIUM VIDEO SYSTEM INPUT EQUIPMENT

A. Custom Lectern

1. Provide custom lectern with all related audio, video and control equipment securely installed.
2. Provide lectern with the following features:
 - a. Standard 19-inch equipment rack mounting
 - b. Locking casters
 - c. Space for two laptops to sit on work surface
 - d. Space for cable management (specified below)
 - e. Pull-out drawer for document camera.
 - f. Reading light
 - g. Clock
 - h. Gooseneck microphone
 - i. AC power distribution
 - j. Locking storage drawer or compartment
 - k. Angled mount for touch panel.
3. Wood Species and Finish: per Architect
4. Hardware Finish: per Architect
5. Acceptable Manufacturers:
 - a. Middle Atlantic
 - b. Miller's Millwork
 - c. Marshall Furniture1) Quantity: 1

B. Lectern Equipment

1. Integrate specified equipment within lectern specified above. Coordinate installation with Owner's Designated Representative. Secure all equipment neatly within lectern. Provide a means for coiling, storing, and securing excess umbilical cabling within lectern. Provide with all required power supplies and distribution.
2. Cable Management
 - a. Provide cable management enclosure mounted in lectern. Provide with cables and cable umbilical as shown on the functional diagram. Label all cables near connector with function. Install in top of lectern as directed by Owner's Designated Representative.
 - b. Provide unit with the following:
 - 1) Two 120V AC Power Outlets
 - 2) Two powered USB outlets
 - 3) HDMI cable with retractor
 - 4) VGA/Audio cable with retractor
 - 5) UTP network cable with retractor
 - a) Extron Cable Cubby 1200 assembly
 - b) Equal
 - c) Quantity: 1
3. Gooseneck Microphone Mount
 - a. Provide gooseneck microphone mount flush-mounted in top of lectern. Provide with finish chosen from manufacturer's standard options as directed by Architect.
 - 1) FSR T3-MJ-XXX
 - 2) Equal
 - a) Quantity: 1
4. Cables
 - a. HDMI
 - 1) Extron HDMI Ultra/15
 - 2) Crestron CBL-HD-20
 - a) Quantity: 4
 - b. VGA

- 1) Extron VGA-A M-M MD/25
 - 2) Crestron CBL-VGA-AUD-20
 - a) Quantity: 2
 5. Cable Adapters
 - a. DVI to HDMI
 - 1) Extron HDMIF-DVIDM
 - 2) equal
 - a) Quantity: 2
 - b. Displayport to HDMI
 - 1) Extron DPM-HDMIF
 - 2) equal
 - a) Quantity: 2
 6. Umbilical Cord
 - a. Provide 15-foot long umbilical cord for lectern with power, data, and signal cables bundled within a flexible synthetic mesh, clearly labeled and provided with appropriate strain relief. All cables in the umbilical should be designed for hard usage and repeated handling. Use of cables designed for installation in conduit will not be accepted.
 - 1) Quantity: 1
- C. Floor Box Input Panel
 1. Provide two-gang digital transport input panel with support for HDMI, DVI, DisplayPort, RGB, component, S-Video and composite video signal formats. Provide unit with support for HDMI and analog stereo audio signal formats. Provide device which transports all video signals digitally to the A/V switcher over a single CAT5e cable. Provide with cover plate suitable for floor box.
 - a. Crestron DM-TX-200-C-2G
 - b. Extron DTP T UWP 232D
 - c. AMX Equal
 - 1) Quantity: 2
- D. Blu-ray Player
 1. Provide Blu-ray disc player with RS-232 and Ethernet control, DVD support and rack mounting kit.
 - a. Denon DN-500BD
 - b. Equal
 - 1) Quantity: 1
- E. Wireless Presentation Gateway
 1. Provide presentation gateway designed to receiver wireless audio and video signals and transmit over HDMI connector. Provide with rack-mount shelf. Coordinate networking with Owner's IT department.
 - a. Crestron AM-101
 - b. Extron ShareLink 250
 - 1) Quantity: 1

2.13 AUDITORIUM VIDEO SYSTEM PROCESSING AND CONTROL EQUIPMENT

A. Integrated Audiovisual Matrix Switcher and Controller

1. Provide audiovisual matrix switcher and integrated system control processor with the following properties:
 - a. Local HDMI inputs: 4
 - b. Local RGB inputs: 2

- c. Remote category cable digital video inputs: 2
- d. Local HDMI outputs: 2
- e. Remote category cable digital video outputs: 2
- f. Bidirectional RS-232 ports: 2
- g. Logic inputs: 4
- h. IR Outputs: 4
- i. Program audio output
- j. Ethernet support
- k. HDCP key management
- l. EDID management
- m. Fast HDMI switching
- n. CEC signal management
- o. HDBT-compatible projector output
- p. iPad control license or application credit
 - 1) Crestron DMPS3-300-C
 - 2) Extron DTP CrossPoint 84 IPCP
 - 3) AMX Equal
 - a) Quantity: 1

2.14 AUDITORIUM VIDEO SYSTEM OUTPUT EQUIPMENT

A. Video Projector

- 1. Provide video projector with 10,000 ANSI lumen output (minimum), 2500:1 contrast ratio (minimum), HDBaseT input, and a native aspect ratio of 16:9 and minimum resolution of 1920x1080. Provide projector with zoom lens and recallable zoom, focus and lens shift presets. Verify final throw distance to projection screen, screen size and geometry before ordering lens. Provide with two (2) spare lamps.
 - a. Christie D12HD-H w/ zoom lens
 - b. Equal
 - 1) Quantity: 1

B. Control Room Video Monitor

- 1. Provide 24-inch diagonal flat-panel LCD with matte screen, 16:9 aspect ratio, 1920x1080 resolution, HDCP support, and HDMI input. Provide unit from one of the following manufacturers.
 - a. Samsung
 - b. HP
 - c. NEC
 - d. LG
 - 1) Quantity: 1

2.15 AUDITORIUM CONTROL SYSTEM EQUIPMENT

A. Touch Panel

- 1. Provide 7" diagonal touch panel with 800x480 resolution. Provide touch panel that can be controlled and powered by single Category cable. Mount one touch panel in rack panel, one touch panel mounted on lectern and portable touch panel with table-top kit.
 - a. Crestron TSW-752-B-S
 - b. Extron TLP Pro 720M (for panel mount) TLP Pro 720T (portable)
 - c. AMX Equal
 - 1) Quantity: 3

B. Touch Panel Mounting Kit

- 1. Provide table-top mounting kit for 7" touch panel.

- a. Crestron TSW750-TTK-B-S
 - b. Extron Equal
 - c. AMX Equal
 - 1) Quantity: 2
- C. Cables
- 1. Provide serial interface cables, infrared emitters, and line amplifiers as required to control devices shown on the Drawings.
- 2.16 TOWN SQUARE AUDIO EQUIPMENT
- A. Handheld Wireless Microphone System
- 1. Provide all antennas, transmitters, and receivers by a single manufacturer. Provide dual digital wireless system which allows simultaneous and independent operation from other wireless systems. Provide complete with rack-mounting kit and remotely mounted ½ wave antenna mounted to WA location. Provide with handheld microphone transmitters. Provide with rechargeable batteries and charger.
 - a. Shure BLX1288/CVL
 - b. Sennheiser Equal
 - 1) Quantity: 1
- B. Digital Signal Processor
- 1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
 - a. Feedback suppression
 - b. Nine bands of parametric equalization per signal input group
 - c. Crossover
 - d. Compressor
 - e. Digital delay
 - f. Signal limiting
 - g. Digital audio signal routing
 - h. Signal flow as shown on sound system functional drawing(s)
 - i. Volume control
 - j. Dante Ethernet-based digital audio networking
 - 1) BSS London BLU
 - 2) Biamp Tesira
 - 3) Symetrix EDGE
 - a) Quantity: 1 complete system, as required
- C. Digital Signal Processor Preset Description
- 1. Provide digital signal processing settings as described below. Exact determination of digital processor settings is an iterative process and final settings should be determined and documented with careful field measurements. Configure the default mode (with no muting) when master power switch is turned on. Configure so that all inputs are routed to appropriate outputs unless complete routing/rewiring of the internal DSP software devices is required. Presets are described below as parameter changes that do not require a muting and reinitializing of the digital signal processor.
 - a. Source Selection Presets
 - 1) CD Player
 - 2) iPod
 - 3) Wall Input
 - 4) Auditorium overflow
 - 5) Gymnasium overflow

6) Act as Lobby space for Auditorium

D. Compact Disc Player

1. Provide 1U compact disc player with balanced outputs, pitch control, and IR remote control.
 - a. Tascam CD-500B
 - b. Denon DN-C635
- 1) Quantity: 1

E. Media Shelf

1. Provide rack-mounted compartment with cabling grommets designed for use with portable media players. Provide with Bluetooth Interface with line-level output and (1) pair stereo phone (RCA) connectors with 1/8-inch stereo phone plug to RCA cable for connection to other portable media players. Provide with integral power/USB outlets mounted on back panel of shelf, per Drawings.
 - a. Middle Atlantic SH-DMP-S w/ AV Plate, Analog and Logitech Bluetooth Audio Adapter
 - b. Equal Assembly
- 1) Quantity: 1

F. Large-Format Ceiling Loudspeaker (SH)

1. Provide two-way ceiling loudspeaker with 12-inch low-frequency driver and 1 inch high-frequency compression driver. Provide units with grille in color per Architect. Provide voice-matched loudspeakers with 60° x 60° and 90°x90° coverage patterns.
 - a. Community CLOUD1266T
 - b. Equal
- 1) Quantity: 4

 - c. Community CLOUD1299T
 - d. Equal

- 1) Quantity: 1

G. Ceiling Mounted Loudspeaker

1. Provide 70.7 Volt Loudspeaker/Transformer Assembly. Furnish FA97-4 enclosure to Electrical Contractor.
 - a. Atlas FA134T87 w/ FA720-4 Grill and FA97-4 loudspeaker enclosure
 - b. JBL equal
 - c. Equal
- 1) Quantity: per Drawings

H. Power Amplifier

1. Provide FOUR-channel power amplifier with balanced bridging inputs, continuously variable-speed fan(s) or convection cooled. Provide amplifier which provides at least 200 watts output (nominal) per channel into 70 volts.
 - a. Crown DCi 4|300
 - b. Equal
- 1) Quantity: 1

2.17 TOWN SQUARE ASSISTIVE LISTENING EQUIPMENT

- A. Provide wireless assistive listening system consisting of an FM transmitter, an antenna mounted as indicated on drawings, and portable battery-operated receivers with earphones and inductive couplers (the latter for use with hearing aids with "T" switches). Provide frequencies separate and free from interference with other FM systems. Provide all assistive listening system components from the same manufacturer.
- B. Transmitter

1. Listen Technologies LT800 with LA-326 rack mounting kit
 2. Williams PPA T35 with RPK 006 rack mounting kit
 - a. Quantity: 1
- C. Transmitter Antenna
1. Listen Technologies LA-123
 2. Williams equal
 - a. Quantity: 1
- 2.18 GYMNASIUM AUDIO CONTROL AND AMPLIFICATION EQUIPMENT
- A. 8-Channel Mixer
1. Provide rack-mounted mixer with at least 8 microphone/line inputs. Provide with rack-mounting kit. Mount in rolling portable equipment rack.
 - a. Shure SCM800
 - b. Equal
 - 1) Quantity: 1
- B. Four Input Audio Mixer
1. Provide 4-input stereo audio mixer with individual gain adjustment. Provide with rack mount shelf.
 - a. RDL EZ-MX4L
 - b. Equal
 - 1) Quantity: 1
- C. Uninterruptible Power Supply
1. Provide 1000VA minimum rack-mounted UPS system to provide power-surge and power-loss protection to digital signal processor system.
 - a. APC SUA1000RM2U
 - b. Powerware 5125 1000 RM
 - c. Middle Atlantic UPS-1000R
 - 1) Quantity: 1
- D. Digital Signal Processor
1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
 - a. Feedback suppression
 - b. Nine bands of parametric equalization per signal input group
 - c. Crossover
 - d. Compressor
 - e. Digital delay
 - f. Signal limiting
 - g. Digital audio signal routing
 - h. Signal flow as shown on sound system functional drawing(s)
 - i. Volume control
 - j. Dante Ethernet based digital audio networking
 - 1) BSS London BLU
 - 2) Biamp Tesira
 - 3) Symetrix EDGE
 - a) Quantity: 1 complete system, as required
- E. Digital Signal Processor Preset Description

1. Provide digital signal processing settings as described below. Exact determination of digital processor settings is an iterative process and final settings should be determined and documented with careful field measurements. Configure the default mode (with no muting) when master power switch is turned on. Configure so that all inputs are routed to appropriate outputs unless complete routing/rewiring of the internal DSP software devices is required. Presets are described below as parameter changes that do not require a muting and reinitializing of the digital signal processor.
 - a. Muting Presets:
 - 1) Auditorium Overflow on/off
 - 2) Town Square Overflow on/off
 - 3) East Court Loudspeakers on/off
 - 4) West Court Loudspeakers on/off
 - 5) Home Bleachers on/off
 - 6) Visitor Bleachers on/off
- F. Digital Signal Processor Volume Control
 1. Provide multi-station volume control compatible with Digital Signal Processor.
 - a. Symetrix ARC-K1
 - b. Biamp TEC-1s
 - c. BSS Contrio EC-V
 - 1) Quantity: 2
- G. Volume Control Protection
 1. Provide clear polycarbonate vandalism protection for Digital Signal Processor Volume Control. Provide in size as required to fit volume control. Provide with custom label, per Drawings. Provide with custom faceplate to mount Volume Control. Label color per Architect.
 - a. STI Universal Stopper
 - b. Equal
 - 1) Quantity: 2
- H. Touch Panel
 1. Provide 5 inch touch panel (minimum) mounted in rack panel to control digital signal processor functions per functional diagrams. Provide with any required power supply and connection cables required to control Digital Signal Processor.
 - a. Crestron TSW-550-B-S
 - b. AMX Equal
 - c. Extron Equal
 - 1) Quantity: 1 assembly
- I. Room Controller
 1. Provide compact control processor with Ethernet and RS-232 connections. Connect to build-wide control system. Provide with power supply. Mount to blank rack panel on rear rack rails.
 - a. Crestron RMC3
 - b. Extron Equal
 - c. AMX Equal
 - 1) Quantity: 1
- J. Ethernet Switch
 1. Provide SNMP capable, POE enabled, managed, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.

2. Provide switch with multi-mode fiber interfaces to create ring topology, per Drawings.
 3. Create VLANs per drawings.
 - a. Packedge
 - b. Netgear
 - c. Cisco
 - d. Equal1) Quantity: 1
- K. Power Amplifier
1. Provide 4-channel power amplifier with balanced bridging inputs and variable-speed fan(s). Provide amplifier which is 2-rack space units high. Provide amplifier which supplies at least 250-watts (nominal) per channel at 4-ohms and 250-watts (nominal) per channel at 8-ohms with all channels driven.
 - a. Crown DCi 4|300
 - b. Lab.gruppen C10:4X
 - c. Equal1) Quantity: 3
- 2.19 GYMNASIUM EQUIPMENT RACKS AND ACCESSORIES
- A. Main Equipment Rack
1. Provide floor-mounted equipment rack with pivoting center section, floor base, and vented, lockable front door. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide with thermostatically controlled fan kit.
 - a. Middle Atlantic SR-40-32 w/ DWR-FK32, FC-2-215-1CA
 - b. Equal1) Quantity: 1
- B. Rolling Portable Equipment Rack
1. Provide 12-rack unit rolling portable equipment case for wireless microphone system, microphone mixer, CD player, portable media player interfaces, rack drawer and power and light units. Provide complete with rack-mounted power strip and at least two (2) spare power receptacles. Provide 25-foot balanced audio cables for connecting equipment outputs to input receptacles.
 - a. SKB 1SKB-R12 w/ SKB 1SKB-1904 caster base
 - b. Equal1) Quantity: 1
- C. Rack Power Wiring
1. Furnish equipment racks with permanently-mounted 3-conductor AC power receptacles with sufficient outlets to meet system needs plus at least 4 spares per rack. Provide raceway configured with separately circuited receptacle groups as required to distribute load across multiple circuits. Provide whip for connection to power junction box as indicated on the power plan drawings.
 - a. Juice Goose CQ-PD1-4, CQ2200, CQ2000 (special order IG version)
 - b. Middle Atlantic MPR Series w/ RLM-20IG modules1) Quantity: As required
- D. System Power Control
1. Provide a relay-controlled power switching system with a master power switch and power-on indicator for the system. Connect the master power switch to control each receptacle in the rack except for one of the spare receptacles. Label unswitched receptacles "UNSWITCHED". Connect power for rack illumination to bypass the system master power

switch. Provide a means to cycle the system power amplifiers on sequentially at intervals of approximately one second whenever the power switch is activated.

- a. Middle Atlantic USC-6R
 - b. Atlas Sound SACR-191
 - c. Juice Goose CQ1520
- 1) Quantity: 1

E. Rack Work Light

1. Provide locally switched utility lighting. Connect to unswitched receptacle. Mount in back of audio equipment rack.
 - a. Atlas Sound RWL-2
 - b. Equal
- 1) Quantity: 1 (main equipment rack)

F. 2 Rack Unit Locking Storage Drawer

1. Provide 2 rack space locking rack mounted drawer.
 - a. Middle Atlantic D2-LK
 - b. Raxxess SDR-2 w/ lock
- 1) Quantity:
- a) 1 main equipment rack
 - b) 1 rolling portable equipment rack

2.20 GYMNASIUM LOUDSPEAKER COMPONENTS

A. Loudspeakers

1. Provide passive 2-way loudspeaker with 12-inch low frequency transducer, 2-inch voice coil high frequency compression driver, and rotatable waveguide. Provide with all necessary mounting hardware. Provide loudspeaker and hanging hardware in finish per Architect.
 - a. EAW VFR129i
 - b. JBL AC299
 - c. Electro-Voice EVF-S/12
- 1) Quantity: 22

B. Loudspeaker Rigging Suspension Equipment

1. Provide contractor fabricated and designed loudspeaker rigging for loudspeaker clusters and suspended loudspeakers. Suspend loudspeaker components from brackets and any necessary suspension frames to minimize total number of ceiling hanging points. Provide with a sufficient number of suspension points for field adjustment of loudspeaker aiming. Provide with color as designated by the Architect. During fabrication and installation verify that adequate clearance from all other hanging components and adequate clearance from structural steel is provided. Provide any additional rigging hardware necessary for the safe and proper installation of these loudspeakers.
2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
 - a. Ape Rigging
 - b. Polar Focus
 - c. ATM-Flyware
 - d. Approved Contractor-Fabricated Assembly (*Show evidence of successful completion of previous projects)
3. Submit all drawings of the complete final loudspeaker rigging assemblies to a certified structural engineer and obtain approval and stamped copies of the drawings. Drawings should detail all connections from attachment to building structure to loudspeaker.

2.21 GYMNASIUM AUDIO SOURCE EQUIPMENT

A. Handheld Wireless Microphone System

1. Provide all antennas, transmitters, and receivers by a single manufacturer. Provide dual-channel UHF system which allows simultaneous and independent operation from other wireless systems at the school. Provide complete with rack-mounting kit. Provide with handheld microphone transmitters.
 - a. Shure BLX288/SM58 system
 - b. Sennheiser Equal
 - 1) Quantity: 1

B. Vocal Microphone

1. Provide microphone for "close-miked" use by popular, jazz, or folk singers. Provide complete with stand adapters as necessary. Provide with flexible microphone cable as specified above.
 - a. Shure SM58-LC
 - b. Electro-Voice N/D 267
 - c. Audix OM-3xb
 - d. Sennheiser E835
 - 1) Quantity: 2

C. Microphone Floor Stand (tripod base)

1. Provide adjustable black microphone stand with 5/8-inch thread and tripod base. Provide with adjustable-length boom arm.
 - a. Atlas TL34-21XE
 - b. On-Stage MS7701TB
 - 1) Quantity: 2

D. Microphone Table Stand

1. Provide a round base stand with 5/8-inch thread, round weighted metal base with adjustable height from approximately 8" - 13". Provide stand in black finish.
 - a. Atlas DS-7E
 - b. AKG Equivalent
 - c. On-Stage DS-7200QRB
 - 1) Quantity: 2

E. Compact Disc Player

1. Provide 1U compact disc player with balanced outputs, pitch control, and IR remote control.
 - a. Tascam CD-500B
 - b. Denon DN-C635
 - 1) Quantity: 1

B. Media Shelf

1. Provide rack-mounted compartment with cabling grommets designed for use with portable media players. Provide with (1) pair stereo phone (RCA) connectors with 1/8-inch stereo phone plug to RCA cable for connection to other portable media players. Provide with integral power/USB outlets mounted on back panel of shelf, per Drawings.
 - a. Middle Atlantic SH-DMP-S w/ AV Input Plate, Analog, Logitech Bluetooth Audio Adapter
 - b. Equal Assembly
 - 1) Quantity: 1

2.22 GYMNASIUM ASSISTIVE LISTENING EQUIPMENT

- A. Provide wireless assistive listening system consisting of an FM transmitter, an antenna mounted as indicated on drawings, and portable battery-operated receivers with earphones and inductive couplers (the latter for use with hearing aids with "T" switches). Provide frequencies separate and free from interference with other FM systems. Provide all assistive listening system components from the same manufacturer.
- B. Transmitter
 - 1. Listen Technologies LT800 with LA-326 rack mounting kit
 - 2. Williams PPA T35 with RPK 006 rack mounting kit
 - a. Quantity: 2
- C. Transmitter Antenna
 - 1. Provide coaxial di-pole antenna suitable for use with FM transmitter.
 - a. Listen Technologies LA-116
 - b. Williams ANT 005 with extension cable
 - 1) Quantity: 2

2.23 MUSIC CLASSROOM ROOM SYSTEMS

- A. System below is typical. Provide one system each for each room:
 - 1. Band
 - 2. Keyboarding (no Recording Microphone)
 - 3. Music CR
- B. Recording Microphone
 - 1. Provide suspended microphone with extension cable and isolation mount. Suspend from ceiling for optimum pickup of room activities. Determine final location with Architect. Provide phantom powered condenser microphone with cardioid pickup pattern. Secure rotation with mono-filament fishing line.
 - a. Audio-Technica BP4025
 - b. Sennheiser MKE 44P w/ shock absorber and extension cable
 - 1) Quantity: 1
- C. Recording Microphone Suspension Mount
 - 1. Provide hanging accessory to allow suspended microphone to be suspended in its stand attachment using its signal cable. Secure rotation with monofilament line.
 - a. Ace Backstage Microphone Hanger Slug #42
 - b. Equal
 - 1) Quantity: 1
- D. Compact Disc Player
 - 1. Provide CD player with balanced analog audio outputs and coaxial digital output. Provide unit with pitch control. Provide unit with IR remote control.
 - a. Tascam CD-500B
 - b. Denon DN-C635
 - 1) Quantity: 1
- E. Recording Interface
 - 1. Provide 8-channel microphone preamplifier assembly with Dante Ethernet interface.
 - a. Focusrite RedNet 4
 - 1) Quantity: 1
- F. Virtual Soundcard Software

1. Provide license for Dante Virtual Soundcard. Install on Owner's Computer.
 - a. Quantity: 1
- G. Digital Audio Software
 1. Provide license for Dante Via. Install on Owner's Computer.
 - a. Quantity: 1
- H. Integrated Amplifier
 1. Provide integrated amplifier, unbalanced inputs, pre-amplifier line-level output and power amplifier with 90 watts continuous (minimum) into 8 ohms. Provide with rack mount hardware.
 2. Label unit to correspond to inputs.
 - a. NAD C375BEE
 - b. Yamaha A-S1000
 - c. Marantz PM8004
 - 1) Quantity: 1
- I. Bluetooth Audio Receiver
 1. Provide Bluetooth audio receiver. Mount in equipment rack.
 - a. Denon DN-200-BR
 - b. Equal
 - 1) Quantity: 1
- J. Equipment Rack
 1. Provide 20 rack space equipment rack with locking 3" casters, locking front door and laminate top. Finish per Architect.
 - a. Middle Atlantic MFR-2027-XX
 - b. Equal
 - 1) Quantity: 1
- K. Rack Mounted Power Strip
 1. Provide 1 rack unit 15-amp surge-protector and power strip with EMI/RFI filtering, series mode surge protection. Provide unit with remote control contact closure.
 - a. Surge-X SX1115-RT
 - b. Equal
 - 1) Quantity: 1
- L. Stereo Loudspeakers
 1. Provide two wall-mounted playback loudspeakers. Mount on wall with swivel mount as designated by Architect. Provide complete with all necessary mounting hardware. Color per Architect.
 - a. QSC AD-S8T w/ X-Mount
 - b. Equal
 - 1) Quantity: 2
- M. Assistive Listening System
 1. Provide assistive listening system complete with rack-mount transmitter, antenna, signage, belt-pack receivers, headphones and neck loops.
 - a. Listen Technologies LS-17-072
 - b. Equal by Williams
 - 1) Quantity: 1
- N. Ethernet Switch

1. Provide SNMP capable, POE enabled, managed, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.
2. Create VLANs per drawings.
 - a. Packedge
 - b. Netgear
 - c. Cisco
 - d. Equal1) Quantity: 1

2.24 WEIGHT/CARDIO ROOM SYSTEM

A. Media Shelf

1. Provide rack-mounted compartment with cabling grommets designed for use with portable media players. Provide with Bluetooth Interface with- line-level output and (1) pair stereo phone (RCA) connectors with 1/8-inch stereo phone plug to RCA cable for connection to other portable media players. Provide with integral power/USB outlets mounted on back panel of shelf, per Drawings.
 - a. Middle Atlantic SH-DMP-S w/ AV Plate, Analog and Logitech Bluetooth Audio Adapter
 - b. Equal Assembly1) Quantity: 1

B. Compact Disc Player

1. Provide 1U compact disc player with balanced outputs, pitch control, and IR remote control.
 - a. Tascam CD-500B
 - b. Denon DN-C6351) Quantity: 1

C. Digital Signal Processor

1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
 - a. Feedback suppression
 - b. Nine bands of parametric equalization per signal input group
 - c. Crossover
 - d. Compressor
 - e. Digital delay
 - f. Signal limiting
 - g. Digital audio signal routing
 - h. Signal flow as shown on sound system functional drawing(s)
 - i. Volume control
 - j. Dante Ethernet-based digital audio networking
 - 1) BSS London BLU
 - 2) Biamp Tesiraforte
 - 3) Symetrix EDGEa) Quantity: 1 complete system, as required

D. Digital Signal Processor Controller

1. Provide rack-panel mounted controller for digital signal processor capable of performing function as shown on the Drawings. Provide from same Manufacturer as digital signal processor. Provide with all required power supplied, Ethernet switches and accessories as required by specific manufacturer's control topology.

- a. BSS Contrio EC-8BV
 - b. Biamp TEC
 - c. Symetrix ARC-3
 - 1) Quantity: 1 assembly
- E. Power Amplifier
- 1. Provide four-channel power amplifier with balanced bridging inputs, continuously variable-speed fan(s) or convection cooled. Provide amplifier which provides at least 300 watts output (nominal) per channel into 70 volts.
 - a. Crown DCi 4|300
 - b. Equal
 - 1) Quantity: 1
- F. Ceiling Loudspeaker, Full-Range (SW)
- 1. Provide 70.7-volt 6-inch coaxial loudspeaker/transformer assembly with back box enclosure and grille for flush mounting in ceiling. Furnish back box enclosure to Electrical Contractor. Provide with tile mounting bridge.
 - a. JBL Control 26CT
 - b. Soundtube CM600i
 - c. Equal
- G. Ceiling Loudspeaker, Low-Frequency(SB)
- 1. Provide 70.7-volt 8-inch low frequency loudspeaker/transformer assembly with back box enclosure and grille for flush mounting in ceiling. Furnish back box enclosure to Electrical Contractor. Provide with tile mounting bridge.
 - a. JBL Control 19CST
 - b. Soundtube CM1001d-T
 - c. Equal
- H. Ethernet Switch
- 1. Provide SNMP capable, POE enabled, managed, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.
 - 2. Create VLANs per drawings.
 - a. Packedge
 - b. Netgear
 - c. Cisco
 - d. Equal
 - 1) Quantity: 1
- 2.25 SHARED ASSISTIVE LISTENING RECEIVERS
- A. Receiver
- 1. Provide belt-pack receiver capable of receiving signals in each room with an FM-based ALS system. Provide with rechargeable batteries.
 - a. Listen Technologies LR-300 w/ LA-162, batteries
 - b. Williams PPA R35-8N with EAR 014 earphones
 - 1) Quantity: 55
- B. Replacement Cushion
- 1. Listen Technologies LA-163
 - 2. Williams EAR 015-10
 - a. Quantity: 200 replacement pads

- C. Over-Ear Earphones
 - 1. Listen Technologies LA-164
 - 2. Williams EAR 008
 - a. Quantity: 55
- D. Neckloop Induction Coil
 - 1. Listen Technologies LA-166
 - 2. Williams NKL 001
 - a. Quantity: 14
- E. Portable Charging Case
 - 1. Provide portable charging cases with total capacity equal to or greater than quantity of receivers specified above.
 - a. Listen Technologies LA-311
 - b. Williams CHG 3512 PRO
 - 1) Quantity: as required

2.26 PORTABLE EQUIPMENT

- A. Digital Audio Mixer
 - 1. Provide portable, compact 40-input digital mixing console compatible with Owner's existing digital stage boxes. Provide with road case.
 - 2. Provide with 100-foot long tactical shielded Cat5e Neutrik Ethercon cable to connect console to digital stage box.
 - 3. Provide with 50-foot power extension cord and surge protection strip.
 - a. Behringer X32 Compact-TP
 - b. Equal
 - 1) Quantity: 1
- B. Loudspeaker Stand
 - 1. Provide loudspeaker stand compatible with existing portable loudspeakers. Provide stand with leveling leg and speaker adapter.
 - a. Ultimate Support TS-99BL
 - 1) Quantity: 2
- C. Microphone Cable
 - 1. Provide rubber-covered flexible microphone extension cables in lengths indicated. Fit each flexible extension cable with black three conductor XLR microphone receptacles.
 - a. Wireworks C Series
 - b. Pro Co M Series
 - c. Equal assembly
 - a) 25 foot: 5
 - b) 50 foot: 5
 - c) 100 foot: 2

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Supply and install any racks, wire, conduits, pull boxes, junction boxes and raceways required to provide a complete system, to the extent that such items are not provided by others. Unless specifically instructed to the contrary, install all system wiring in steel conduit. Do not exceed 30% fill in conduits.

- B. Use separate steel conduits for microphone-level circuits (below -20 dBm), line-level circuits (up to +30 dBm), loudspeaker circuits (above +30 dBm), control circuits, and power circuits. Use audio conduit which is spaced well away from power conduit. Insulate all conduit from the equipment rack(s); ground conduit only to power system ground. Do not splice lines in conduit. Connect each input receptacle by an individual, insulated line to the system equipment rack.
- C. Secure equipment firmly in place, including control panels, loudspeakers, conduit, amplifiers, racks, and cables. Make fasteners and supports adequate to support their loads with a safety factor of at least three.
- D. Take precautions to prevent electromagnetic and electrostatic hum. Install the equipment to provide safe operation.
- E. Use terminal strips or blocks in all audio lines entering or leaving the system equipment rack(s). Make all joints and connections with rosin-core solder or with mechanical connectors appropriate for the service. Execute all wiring in strict adherence to standard broadcast practices.
- F. Assemble and install equipment racks to permit access to connections and adjustments on the rear of rack-mounted components and to permit removal of components for servicing. For any components which, for purposes of adjustment or calibration, must be removed from an equipment rack while in use, provide adequate service loops on all connecting cables.
- G. Provide safety cables prevent individual loudspeaker components from falling in case of failure or loosening of the primary component support. Paint all exposed components as directed by the Architect.
- H. Locate microphone and line receptacles as directed by the Architect. Except for receptacles mounted in equipment cabinets or in floors or designated as surface-mounted, flush-mount other receptacles on cover plates in gang boxes recessed in vertical surfaces. Provide plate finish as approved by the Architect.
- I. Install work neatly, with boxes, equipment, etc., plumb and square. Keep the job adequately staffed at all times. Designate an employee as field supervisor to be present on the job site and in responsible charge during all phases of installation and check-out. Maintain same supervisor through completion of the work unless the designated supervisor ceases to be an employee or unless by mutual agreement with the Owner or Architect. Install the system in cooperation with other trades in order to achieve coordinated progress and satisfactory final results. Watch for conflicts with work of other trades on the job. Execute, without claim for extra payment, moderate moves or changes as are necessary to accommodate other equipment or preserve symmetry and pleasing appearance.
- J. Clearly, consistently, logically and permanently mark switches, connectors, jacks, relays, receptacles, cables, and cable terminations. Engrave and paint-fill all panel and receptacle markings, directly on the material on which controls or receptacles are mounted. Fill engraving with black or white paint, whichever contrasts best with panel finish, or as directed by the Architect. Use no hand-lettering, embossed tape (e.g. "Dymo" labels), or any adhesive- or otherwise mechanically-attached labels for any labels visible to operators or public during normal system operation. Use adhesive- or screw-attached engraved or laminated labels (e.g., "Kroy" or "Brother") on manufactured assemblies, such as amplifiers, which otherwise would require disassembly for direct engraving. Use printed adhesive cable markers to mark cables, or other labels intended for the purpose. Use "Kroy" or "Brother" or similar machine-produced laminated labels, or "letter quality" or "near letter quality" mechanically-produced lettering for patch panel labels. Insert patch panel labels into clear plastic-covered label holders.
- K. Label each receptacle with its type and a unique number; for example, "MIC 18", "FP3" "A/V Input Panel 5". Label each jack with the name of the device to which it is connected, plus "IN" for input or "OUT" for output. In addition, label horizontal rows of jacks with letters "A", "B", etc., and vertical columns with numbers "1", "2", etc.
- L. Paint or provide approved factory finishes for all system components exposed to public view as directed by Architect. Paint or otherwise remove all visible manufacturers' trademarks exposed to public view as directed by Architect.

- M. If any item of equipment includes exposed controls which are not used in system operation, and if those controls cannot be locked, capped, or concealed behind a security cover, mount said item of equipment recessed behind a blank rack panel.
- N. Save all unused products accessories and turn over to Owner at checkout.

3.2 PROTECTION AND REPAIR OF EXISTING FINISHES AND STRUCTURES

- A. Cut and patch all holes required for this installation.
- B. Make good all materials and finishes cut into or damaged during installation.
- C. On completion, remove all rubbish and unused materials from the premises, clean the premises where dirtied, and clean all equipment, removing all dirt, dust, stains, and fingerprints.

3.3 ELECTRONIC TEST EQUIPMENT

- A. Provide the following test equipment for use during tests and adjustments and during acceptance testing and final adjustment of the system.
 - 1. Continuously Variable Sine Wave Generator - 20 Hz to 20,000 Hz range within +1 dB with less than 0.5% THD at 1 volt output into 600 ohms.
 - 2. AC Voltmeter with frequency response within +1 dB from 20 to 20,000 Hz, 0.0001 volts to 100 volts, minimum input impedance 0.1 meg ohm.
 - 3. Multimeter (VOM) (may be included with AC Voltmeter)
 - 4. Oscilloscope with at least 5 MHz bandwidth and external horizontal input. Vertical sensitivity to 10 mV/division or less.
 - 5. Impedance Measuring Device, capable of measuring at 1,000 Hz and within each loudspeaker's passband (at center of passband or at least one octave removed from crossover frequency), minimum range 0 to 1,000 ohms.
 - 6. Light Meter: The meter shall be capable of measuring illuminance (foot-candles) and luminance (foot lamberts).
 - 7. NTSC Color Video Test Signal Generator: The test signal generator shall be capable of generating SMPTE color bars, multiburst, modulated ramp or stair step, and window signals.
 - 8. Video Sweep Generator: The generator shall be capable of producing sine wave frequency sweep from 30 Hz to 100 MHz, locked to horizontal sync.
 - 9. Wideband Video Distribution Amplifier: Provide a one input three output (minimum) distribution amplifier with frequency response at least -3dB at 100 MHz.
 - 10. RGB Test Signal Generator: The generator shall be capable of generating the SMPTE RP-133 test pattern and window pattern on black background over entire range of horizontal and vertical scan frequencies of the video projector(s) specified.
 - 11. Waveform Monitor and Vectorscope: The monitor(s) shall provide facilities for complete line select and simultaneous channel A and B display. The unit shall be able to make differential phase and gain measurements. Inputs shall be able to be displayed in one or two line sweeps. The vectorscope shall be able to measure SC/H phasing and color framing.
 - 12. Real Time Audio Analyzer: Shall provide a pink noise generator, a calibrated microphone and graphic representation of the audio spectrum in 1/3-octave increments.
 - 13. Connectors, Adapters, Cables, etc. to permit flexible interconnection of test equipment and convenient, reliable connection to receptacles, patch panels and amplifier terminal strips.
 - 14. Network Cable Analyzer: Certification-grade cable analyzer suitable for testing up to TIA Category 6A cable and testing cable length, bandwidth, and attenuation.
 - 15. Fiber Optic Cable Analyzer: Certification-grade optical power and fiber optic test kit suitable for testing fiber length, bandwidth, and attenuation.
 - 16. Laptop personal computer with software as provided for any computer-controlled equipment.
 - 17. Table to support test equipment at system equipment rack, minimum 30" square. (Required only during acceptance testing.)

3.4 SHOP AND FACTORY TESTING

- A. **The Audiovisual Contractor shall perform preliminary tests at their shop or factory before the system is shipped to the Owner's site.** The Owner's Authorized Representative, Owner's Project Manager, Consultant or other designated representative may be present for these tests. These tests shall include Contractor provided equipment and any Owner provided equipment (equipment that the Owner shipped to the assembly site). The tests shall include equipment provided by other Vendors, if applicable, plus all installation service and materials.

3.5 INITIAL POST-COMPLETION TESTS AND ADJUSTMENTS

- A. Perform these tests and adjustments. Furnish equipment necessary to perform these tests, and perform work required to modify the performance of the system in accordance with this specification.
1. Loudspeaker Line Impedance
 - a. Measure the resistance and impedance of each loudspeaker line leaving the system equipment rack, with the line disconnected from its normal driving source. Measure impedance within each loudspeaker's passband (at center of passband or at least one octave removed from crossover frequency). Verify that values are within +10% of the value calculated for that circuit based upon the parallel impedances/resistances of the loudspeakers connected plus the resistance of the loudspeaker line. Correct any discrepancies.
 2. Loudspeaker Phasing
 - a. Perform phasing checks of loudspeaker lines by means of a DC source at one end of each line and a voltmeter at the other end. Phase all loudspeaker lines identically with respect to color coding.
 3. Hum and Noise Level
 - a. Measure the hum and noise levels of the overall system. Adjust gain controls for optimum signal-to-noise ratio. The adjustment shall also be such that full power amplifier output would be achieved with +8 dBm input. Terminate inputs with shielded resistors of 600 ohms for these measurements. Disconnect the loudspeaker lines and terminate the power amplifier outputs with power resistors for these measurements. Use load resistors matching the rated load impedance and output power of the amplifier.
 4. Power Output and Signal Level Adjustments
 - a. Measure the electrical distortion of the overall system. Adjust gain controls as for the tests specified in the preceding paragraph. Set variable equalizers for flat response. Apply a 1,000 Hz sine-wave signal to the input tested, at a level required to produce full amplifier output. Use a distortion analyzer to measure the output level and total harmonic distortion of the amplification equipment. (In the absence of a distortion analyzer, a VTVM or transistor voltmeter may be used to measure the output level, and lack of clipping or apparent deformation of a sine-wave input signal at the power amplifier output, as seen on an oscilloscope as specified, may serve as evidence that distortion of amplification and control equipment is within acceptable limits, subject to review by the Architect.) Make all measurements with loads actually incurred in system operation. (Power amplifier loads shall be resistors equal to the nominal impedance of the output terminals used in the system.)
 5. Freedom from Parasitic Oscillation and Radio-Frequency Pick-up
 - a. Check to insure that the system is free from spurious oscillation and radio-frequency pick-up, both in the absence of any audio input signal and also when the system is driven to full output at 100 Hz. Employ an oscilloscope as specified.
 6. Freedom from Buzzes, Rattles, and Objectionable Distortion
 - a. Apply a slow sine-wave sweep from 50 to 5,000 Hz at a level of 6 dB below rated power amplifier output voltage. Listen carefully for buzzes, rattles, and objectionable

distortion. Correct any causes of these defects, unless the cause is clearly outside the sound amplification system equipment and installation, in which case bring the cause to the attention of the Architect.

7. Gain Control Settings
 - a. Establish tentative normal settings for all gain controls. Adjust all gain controls for optimum signal-to-noise ratio and signal balance.
8. Freedom from Switching Transient Noise
 - a. Eliminate audible clicks or pops produced by the operation of any controls.
9. Listening Test
 - a. Listen to normal program material to be sure that there are no remaining defects.
10. Test of Signal Routing
 - a. Verify that signal flow is as intended.
11. Digital Signal Transport System
 - a. Verify number of HDCP keys supported by each source device.
 - b. Video timing and support audio formats (if applicable) for each display device.
 - c. Video timing and supported audio formats presented in the EDID for each source. Indicate preferred video timing.
 - d. Length of installed twisted pair cables used for signal distribution and control.
12. Video Projectors
 - a. Employ an RGB test generator to produce signals with horizontal scan frequencies of 15.75 kHz, 35 kHz, 64 kHz and other frequencies as directed. Align projectors to meet manufacturer's published specifications for all such input signals. Verify that the image size specified can be achieved, and that keystone distortion is absent. Verify the absence of any other geometry errors, including bow, skew, trapezoid, linearity, and vignetting.
 - b. Verify proper registration and focus of each tube to within the performance limits of the projector. Adjust horizontal blanking to preclude the loss of image on the sides. Verify that any remaining registration errors do not prevent the projector from performing in the intended application.
13. Subjective Image Quality
 - a. Observe the image quality on various displays throughout the system, employing various sources such as workstations and videotape, and check for errors of linearity, chroma-luminance delay, signal to noise performance, blanking and gain shifts, RF interference, crosstalk, and other imperfections. Test for these errors under various operating conditions, including selecting random sources into selected projectors.
14. Control System
 - a. Verify that all devices being controlled by the master control system respond to corresponding graphic elements on touch screens. Check all screens for full functionality. Test touch panels at all connection locations.
15. Category Cabling
 - a. Verify that all jacks have been terminated properly and conform to ANSI/TIA/EIA-568-C.
 - b. Provide list of cable runs each with associated bandwidth and length information, as well as pass/fail for ANSI/TIA/EIA-568-C compliance.
16. Fiber Optic Cabling
 - a. Verify that all jacks have been terminated properly and conform to ANSI/TIA/EIA-568-C and related ANSI/TIA/EIA fiber optic standards.
 - b. Provide list of fiber runs each with associated bandwidth and length information, as well as pass/fail for ANSI/TIA/EIA-568-C compliance.
17. 75 Ohm Coax Video Cabling

- a. Verify that all jacks have been terminated properly and meet SMPTE SDI, HD-SDI, and 3G-SDI standards 259M, 274M, 292M, 296M, 344M, 327M, and 424M.
- b. Provide list of cable runs each with associated bandwidth and length information, as well as pass/fail for SMPTE SDI, HD-SDI, and 3G-SDI standards 259M, 274M, 292M, 296M, 344M, 327M, and 424M.

B. Report

1. Upon completion of above tests and adjustments submit two copies of a written report presenting test results, including numerical values and corrective actions taken, for review by the Architect and Architect prior to demonstration and acceptance testing. With this report, submit written certification that the installation conforms to the requirements stated herein, is complete in all respects, and is ready for inspection and testing by the Architect.

3.6 DEMONSTRATION AND ACCEPTANCE TESTING OF COMPLETED INSTALLATION:

- A. Upon approval of the above test report by the Architect and at a mutually agreeable time, demonstrate operation of each major component and of the complete installation. After demonstration, assist as required in acceptance tests.

B. Listening Tests

1. Tests will include subjective evaluation by observers listening at various positions under various operating conditions of the system, intended to test its operation in conformance with its functional requirements.

C. Equipment Tests

1. Perform any measurements of frequency response, distortion, noise or other characteristics and any operational tests deemed necessary by the Architect to determine conformity with these requirements.
2. If the need for adjustment or modification becomes evident during demonstration and testing, continue working until the installation operates properly.

D. Final Adjustments

1. Make control adjustments as directed by the Architect. Make a record of these control settings. Provide covers, caps, or shaft-locks for controls not used in system operation.

END OF SECTION

SECTION 280000

INTEGRATED ELECTRONIC SECURITY SYSTEM

PART 1 - GENERAL1

1.1 GENERAL PROVISIONS1

1.2 WORK TO BE PERFORMED1

1.3 RELATED SECTIONS.....2

1.4 COMMISSIONING2

1.5 DEFINITIONS3

1.6 REFERENCES3

1.7 SYSTEM DESCRIPTION.....3

1.8 PERFORMANCE REQUIREMENTS3

1.9 QUALIFICATIONS4

1.10 INTERPRETATION OF DRAWINGS.....4

1.11 MATERIAL AND EQUIPMENT STANDARDS5

1.12 WARRANTY5

1.13 MAINTENANCE.....5

1.14 CERTIFICATES OF APPROVAL.....5

1.15 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS.....6

1.16 SUBMITTALS6

1.17 QUALITY ASSURANCE7

1.18 HOISTING EQUIPMENT AND MACHINERY8

1.19 STAGING AND SCAFFOLDING.....8

PART 2 - PRODUCTS8

2.1 SYSTEM CABLING8

2.2 ELECTRONIC ACCESS CONTROL SYSTEM.....9

2.3 VIDEO MANAGEMENT SYSTEM13

2.4 HARDWARE AND PERIPHERALS21

2.5 INTRUSION ALARM SYSTEM27

2.6 INTEGRATED COMMUNICATION AND DOOR SYSTEM.....29

2.7 IESS INTEGRATION30

PART 3 - EXECUTION31

3.1 GENERAL.....31

3.2 WORK32

3.3 EQUIPMENT RACKS, CABINETS AND BRACKETS.....33

3.4 TERMINATIONS.....34

3.5 CABLE PATHWAYS34

3.6 CABLE SUPPORTS35

3.7 CABLE PROTECTION35

3.8 INSTALLATION35

3.9 GROUNDING36

3.10 SLEEVING AND BUSHINGS.....37

3.11 INTEGRATED SECURITY SYSTEM TESTING38

3.12 TRAINING.....38

3.13 ACCEPTANCE DEMONSTRATIONS39

3.14 PROJECT OWNER COORDINATION40

3.15	CLEANING UP	40
3.16	PROJECT CLOSEOUT	40

END OF INDEX

SECTION 280000

INTEGRATED ELECTRONIC SECURITY SYSTEM

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 WORK TO BE PERFORMED

- A. Work described herein shall be interpreted as work to be done by the Integrated Electronic Security System Contractor and/or the electrical contractor. Work to be performed by other trades will be referenced to a particular contractor.
- B. The work under this Section includes providing of all material, labor, equipment and supplies and the performance of all operations to provide a complete working Integrated Electronic Security System, as required by the Drawings and details as specified herein and in accordance with the Dover High School, Dover, NH. Where the Drawings, Specifications, Codes, Regulations, Laws, or the requirements of the drawings/specifications conflict, provide the higher quality and higher quantity indicated or required and follow the strictest requirement. In general, the work includes, but is not limited to, the following:
 - 1. The Integrated Electronic Safety and Security System shall include:
 - a. Software House CCure9000 Electronic Access Control System (This will be a Proprietary System as furnished by SimplexGrinnell)
 - b. Software House CCure9000 Photo ID Badging System
 - c. Exacqvision Enterprise Video Management System with required network video recorders for storage of video. (This will be a Proprietary System as furnished by SimplexGrinnell)
 - d. IP CCTV cameras by American Dynamics
 - e. Intrusion Detection System by DSC.
 - f. Integrated Communication and Door System by Aiphone (IP based).
 - g. NOTE – the systems specified are part of a wide area network presently existing in the city. Point of contact for this section of work is:
 - 1) SimplexGrinnell 35 Progress Ave, Nashua, NH. Point of contact – Michael Chames (603) 521-1154
 - h. All systems will be fully software integrated in a single package.
 - 2. Equipment Racks and Cabinets.
 - 3. Terminations.
 - 4. Conduit Systems and sleeves will be provided by the Electrical Sub-Contractor.
 - 5. 120VAC Power Requirements will be provided by Electrical Subcontractor.
 - 6. Protection of new work.
 - 7. Record Drawings and Documentation.
 - 8. Staging.

9. Operation and Maintenance Instructions and Manuals for the Section's work.
 10. Nameplates, Labels and Tags.
 11. Testing and certification.
 12. Fireproofing of Penetrations and Openings will be provided by the Electrical Sub-Contractor.
 13. Access panels and doors.
 14. Coordination with manufacturers, other trades and Owner.
 15. Core drilling and cutting will be provided by Electrical Sub-Contractor.
 16. Patching will be provided by General Contractor.
 17. Testing of all equipment installed.
 18. Training and product demonstrations
- C. Provide and maintain in safe adequate condition all staging and scaffolding required for the proper execution of the work of this Section.
- D. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.3 RELATED SECTIONS

- A. Unless otherwise indicated, the following work is not included as part of the systems integrator's responsibilities in this SECTION, except for coordination, and is to be performed by others as indicated:
1. Surface mounted metal raceway will be provided by Electrical Sub-Contractor.
 2. Empty conduits to accessible point above ceiling or below floor will be provided by Electrical Sub-Contractor.
 3. Floor boxes and poke through devices will be provided by Electrical Sub-Contractor.
 4. Standard device boxes with plaster rings for Integrated Electronic Security System will be provided by Electrical Sub-Contractor.
 5. Interface with public utilities telephone service shall be arranged by the owner's service provider, and coordinated with this systems integrator.
 6. Hardware: Section 087100 – Door Hardware
 7. The installation, operating cost and maintenance of the controlled environmental conditions, for equipment located on site, as required by the manufacturer, NFPA 70B, or as specified in these specifications shall be the responsibility of the General Contractor.
 8. All required sleeves, J-Hooks, boxes and conduits for a complete and operational system shall be provided by the Electrical Contractor.
 9. Section 019113 – Commissioning Requirements.
 10. For availability of existing school building original construction drawings refer to 003100 – AVAILABLE PROJECT INFORMATION.

1.4 COMMISSIONING

- A. Where indicated in the equipment or commissioning specifications, engage a factory-authorized service representative, to perform startup service as per functional test sheets and requirements of Section 019113 – Commissioning Requirements.
- B. Complete installation and startup checks and functional tests according to Section 019113 – Commissioning Requirements and manufacturers written instructions.
- C. Operational Test: After electrical system has been energized, start units to confirm proper unit operation. Rectify malfunctions, replace defective parts with new one and repeat the start-up procedure.

- D. Verify that equipment is installed and commissioned as per requirements of section 019113 and manufacturers written instructions/requirements.

1.5 DEFINITIONS

- A. EIA - Electronics Industries Association
- B. TIA - Telecommunications Industry Association
- C. ANSI - American National Standards Institute
- D. TSB - Technical Systems Bulletin (EIA/TIA)
- E. SP - Standards Proposal (EIA/TIA)

1.6 REFERENCES

- A. Comply with applicable requirements of the following standards and those others referenced in their Section as most recently amended.
- B. EIA/TIA Building Telecommunications Wiring Standards:
 - 1. No. 568B Series - Telecommunications Wiring Standards
 - 2. No. 569A - Telecommunications Pathways and Spaces
 - 3. No. 606 - The Administration Standard For the Telecommunications Infrastructure
 - 4. No. 607 - Grounding/Bonding
- C. Materials and workmanship of the Integrated Security System shall conform to the latest issue of all industry standards, publications, or regulations referenced in this section and with the following applicable.
 - 1. International Building Code 2009
 - 2. National Electric Code, 2014 Edition
 - 3. State Department of Public Safety
 - 4. NFPA 101 "Life Safety Code"
 - 5. NFPA 72 National Fire Alarm Code
 - 6. NFPA Standards
 - 7. Standards of the Underwriters Laboratories (UL)
 - 8. Occupational Safety and Health Act (OSHA)
 - 9. Americans with Disabilities Act (ADA)
 - 10. City of Dover

1.7 SYSTEM DESCRIPTION

- A. Provide a complete working Integrated Electronic Safety and Security System as required by the Drawings and details and as specified herein.

1.8 PERFORMANCE REQUIREMENTS

- A. Include GENERAL CONDITIONS, SUPPLEMENTARY GENERAL CONDITIONS and applicable parts of Division 01 as part of this Section.

- B. Examine all Project Specifications and Drawings for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.

1.9 QUALIFICATIONS

- A. The Systems Integrator shall be experienced in the operations they are engaged to perform..
- B. UL Compliance: The system supplied shall be listed by Underwriter's Laboratories. A copy of the UL listing card for the proposed system shall be included with the contractor's submittal.
- C. FCC Approval, the intrusion detection system shall be approved for direct interconnection to the telephone utility under Part 68 of FCC rules and regulations. Provide the FCC registration number of the system being proposed as a part of the submittal process.

1.10 INTERPRETATION OF DRAWINGS

- A. All work indicated on the Drawings is intended to be correct to scale, but figures dimensions and detailed Drawings are to be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of raceways and methods of running them are indicated, but it is not intended to show every offset and fitting, nor every structural difficulty that may be encountered.
- B. Locations indicated on the Drawings are approximate and it is intended that all equipment shall be located in accordance with the general and detail Drawings of the construction proper. Coordinate the location, mounting heights and routing of cabling work with other trade's requirements and with field conditions, city electrician and engineer.
- C. All measurements shall be taken at the building before fabrication commences.
- D. Schematic diagrams shown on the Drawings indicate the required functions. Standard diagrams of the manufacturer may be used for the functions indicated without exact adherence to the Schematic Drawings shown. Work required for such deviations shall be provided.
- E. Items referred to in singular number in Contract Drawings shall be provided in quantities necessary to complete work.
- F. The right is reserved to make changes in locations of work prior to rough-in at no additional cost.
- G. Where Drawings or Specifications conflict or are unclear, advise the Architect, in writing, before Award of Contract. Otherwise, interpretations of Contract Documents by the Architect shall be final, and no additional compensation shall be permitted due to discrepancies or unclarities resolved according to the Architect's interpretation.
- H. It is the intent of these Contract Documents to have systems and components that are fully complete and operational and fully suitable for the intended use. There may be situations in the documents where insufficient information exists to precisely describe a certain component or subsystem, or the routing of a component. In cases such as this, where the Installer has failed to notify the Architect, in writing, of the situation prior to Contract Award, the Installer shall provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in workmanlike manner either concealed or exposed per the design intent.

1.11 MATERIAL AND EQUIPMENT STANDARDS

- A. Materials shall be new, unused, of recent manufacture, not previously installed, full weight, standard, the best quality of its kind and acceptable to the Architect.
- B. Provide NRTL listed or labeled products whenever there are NRTL standards, listings or labeling available for that product category.
- C. The Specifications or notes and description following a catalog number is basically to identify the item, but may also call for accessories, options or modifications which are not indicated in the catalog number.
- D. Provide products of one manufacturer for each classification of equipment.

1.12 WARRANTY

- A. Provide one (1) year Warranty, warranty shall start at time of substantial completion. Any failure due to defective material, equipment, installation or workmanship which may develop, shall be corrected at no expense to the Owner including all materials, labor, travel, expenses, system diagnostics and damage to areas, materials and other systems resulting from such failures.
- B. Manufacturers shall provide replacement warranties for material and equipment furnished under this Section. Such warranties shall be in addition to and not in lieu of all liabilities which the Manufacturer and the Installer may have by law or by provisions of the Contract Documents.
- C. Include copies of all warranties, maintenance contracts and training contracts or performance bonds in the Operation and Maintenance Manuals.

1.13 MAINTENANCE

- A. Provide installers maintenance contract upon request for a period equal to warranty.

1.14 CERTIFICATES OF APPROVAL

- A. Upon completion of all work, and as a condition to receiving payment at Substantial Completion, furnish to the Architect the following original signed certificates and include copies of these certificates as part of the Operation and Maintenance manuals: (Provide 3 copies of O & M Manuals).
 - 1. Certification from the manufacturers authorized representative stating that authorized factory engineers have inspected and tested the operation of their respective equipment and found same to be installed in accordance with the manufacturer's requirements, all requirements for manufacturer's warranties are complied with, and equipment are within factory tolerances. This certification shall be provided for each piece of major equipment and for all complete systems. Provide certificate for additional items requested by the Architect.

2. Certificates of inspection, letters or notices from the appropriate governmental authorized inspection authorities stating that all portions of the work (indicate trade and responsibility) have been inspected and are installed in conformance with the applicable codes, laws, ordinances and referenced standards. If non-conformance notices are received, include the re-inspection certificate, letter of explanation, etc. as required to indicate complete conformance. Provide written evidence of all exceptions or variances given by the AHJ.
3. Certificate from the installing firm responsible for the work (indicate trade and responsibility) signed by an authorized Officer of the firm and the Foreman or Project Manager in charge, indicating trade license numbers and stating that to the best of the signer's knowledge and belief that the project (indicate project name and address) has been installed in compliance with the Contract Drawings, Specifications and Addenda, and all applicable codes, laws, ordinances and referenced standards. Where sub-contractors perform a portion of the work of this Section include certificates from them.

1.15 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. Give detailed instructions, prior to the Substantial Completion of the work, to the responsible personnel designated by the Owner in the operation and maintenance of all work installed under this Section. A letter with two copies containing the name of the person or persons to whom the instructions were given and the dates of the instruction period shall be submitted to the Architect at the completion of the project.
- B. Prepare three sets of Owner and Maintenance containing Manufacturer's catalogs, other similar data including the necessary photographic equipment cuts, wiring diagrams and final reviewed Shop Drawings and Product Data covering all equipment and devices furnished or installed under this Section. These manuals shall provide complete instructions for the proper operation and use of the equipment together with instructions for lubrication and periodic maintenance and for trouble shooting. Operating instructions shall be specific for each system and shall include copies of posted specific instructions. This manual shall contain only that information which specifically applies to this project and all unrelated material shall be deleted or clearly crossed out.
- C. Submit a valid certificate of completion of installation and service training on the latest up-to-date version of the manufacturer's equipment being provided from the security system (or systems) manufacturer (s) for at least two (2) present employees of the installer.
- D. Include copies of all test reports and certifications.

1.16 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.

- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Diagrams for cable management system.
 - 2. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
 - 3. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
 - a. Workstation outlets, jacks, and jack assemblies.
 - b. Patch cords.
 - c. Patch panels.
 - 4. Cable Administration Drawings: As specified in "Identification" Article.
 - 5. Battery and charger calculations for central station, workstations, and controllers.
 - 6. Network video recorder storage calculations.
 - C. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.
 - D. Other Action Submittals:
 - 1. Project planning documents as specified in Part 3.
 - E. Field quality-control reports.
 - F. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Microsoft Windows software documentation.
 - 2. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
 - 3. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
 - 4. System installation and setup guides with data forms to plan and record options and setup decisions.
- 1.17 QUALITY ASSURANCE
- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
 - 1. Cable installer must have on staff a registered communication distribution designer certified by Building Industry Consulting Service International.
 - B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.
 - C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - D. Comply with NFPA 70, "National Electrical Code."
 - E. Comply with SIA DC-01, SIA DC-03 and SIA DC-07.

1.18 HOISTING EQUIPMENT AND MACHINERY

- A. Unless otherwise specified, all hoisting and rigging equipment and machinery required for the proper and expeditious prosecution and progress of the Work of this Section shall be furnished, installed, operated and maintained in safe condition by the General Contractor, as specified under Section 015000, TEMPORARY FACILITIES AND CONTROLS.

1.19 STAGING AND SCAFFOLDING

- A. Unless otherwise specified, the General Contractor shall provide all lifts and man-lifts, and furnish, erect and maintain in safe condition, all staging and scaffolding over 8 ft. in height, including the initial 8 ft. in height, for use by the HVAC Contractor and Sub-Contractors, as needed for proper execution of the work of this Section. Staging and scaffolding shall be of adequate design, erected and removed by experienced stage builders having all accident prevention devices required by Federal, state and local laws.
1. The Electrical Contractor and subcontractors shall be responsible for his own scaffolding under 8 ft. in height, as specified under Section 015000, TEMPORARY FACILITIES AND CONTROLS.

PART 2 - PRODUCTS

2.1 SYSTEM CABLING

- A. Provide and terminate all cabling per manufacturers recommendations for a completely operational system as specified.
- B. CCTV System Cabling, provide & terminate all cabling as required for a completely operational CCTV System as required by equipment manufacturer.
1. CCTV Camera Cabling:
- a. CAT 6 cabling shall be provided for each CCTV camera location.
 - b. Provide CAT 6 patch cabling as required between patch panels and POE switches at each IDF/MDF location and at camera locations.
 - c. Power cabling for exterior devices shall be 12 gauge 2 conductor, provide applicable gauge per applicable distances.
 - d. Data/Control cabling (for PTZ pan/tilt/zoom cameras) shall be 2-pair 22 gauge with an overall shield to applicable PTZ locations as specified, Belden #9841.
 - e. Provide all line cords as required, field measured for proper length.
 - f. Provide any additional cabling as required per manufacturer's specifications.
2. Telephone Line interface; provide and terminate a Cat 6 cable between security system headend and the MDF/Demarc.
- C. Intrusion Alarm System Cabling, provide & terminate all cabling as required for a completely operational Intrusion Alarm System as required by equipment manufacturer.
- 1. Key Pad: The control station shall be connected to the control/communicator with #18 AWG, unshielded, 4-wire cable and have a maximum of 1000 feet between the control/communicator and the control station.
 - 2. The Electrical Sub-Contractor shall provide 120VAC duplex outlet at the Intrusion Alarm System Controller location.
 - 3. Multiplex Loops: Provide #18 AWG four conductor cable for loops up to 2000 feet, provide #18 AWG four conductor cable for loops up to 5000 feet. Do not use twisted pair or shielded cable for multiplex bus wiring loops. Cable shall be as required by the equipment supplier.

4. Audible Devices, provide a minimum #14 AWG four conductor cable.
 5. Telephone Line interface, provide and terminate a Cat 6 cable between the Intrusion Alarm System Controller and the MDF/Demarc.
- D. Cabling for Access Control System, provide & terminate all cabling as required for a completely operational Access Control System as required by equipment manufacturer.
1. EL = Door Lock Device; provide & terminate cabling between EL and associated Power Supply and between Power Supply and associated ACC. Electrical Sub-contractor shall confirm power supply location with installer. Electrical Sub-contractor shall provide 120VAC outlet and power supply backbox at power supply location. EL furnished and installed by door hardware, associated EL Power Supply furnished by door hardware provider, installed and wired by systems integrator. EL may be an Electronic Door Strike, Magnetic Door Lock, etc., see Architect for details.
 2. CR = Door Reader Device; provide CR, provide and terminate cabling to associated ACC. The cable requirements of the card reader shall be a minimum five (5) conductor, 22 AWG, stranded cable with overall shield (for a Wiegand protocol interface). A six (6) conductor cable is required when controlling the red and green LED individually. A seven (7) conductor cable is required when both the red and green LED's are controlled by the Host. A 22 AWG twisted pair, shielded, stranded cable is required for use of the tamper switch. The card reader shall be provided with a 10 wire pigtail connector.
 3. ALM = Alarm Line Module; provide ALM, provide & terminate cabling to associated Door Contact, and ACC. ALM mounts within J-Box at door location.
 4. DC = Door Contacts (recessed in door/frame); DC furnished, installed and wired by systems integrator, provide & terminate cabling to associated ALM (Alarm Line Module).
 5. ACC = Access Control System Controller.
 6. ACS = PC & Monitor for Access Control System.
 7. Fire Alarm System interface.
Provide and terminate cabling between applicable electronic door lock power supplies and the fire alarm system headend. Terminations to fire alarm control panel by fire alarm contractor.
Provide and terminate cabling between access control system head end and the fire alarm system head end. Terminations to fire alarm control panel by fire alarm contractor.

2.2 ELECTRONIC ACCESS CONTROL SYSTEM

- A. Manufacturer: Software House CCure9000
1. General: Submit the following according to the Conditions of Contract and Division 01 Specification Sections:
 - a. Product data sheets for system components highlighted to indicate the specific product, features, or functions required to meet this specification. Alternates shall not be considered.
 - b. Wiring diagrams from manufacturer.
 - c. Shop drawing showing system details including location of all devices and circuiting.
 - d. System operation description including method of operation.
 - e. Operation and maintenance data for inclusion in Operating and Maintenance Manual.
Include data for each type product, including all features and operation sequences, both automatic and manual. Provide the names, addresses and telephone numbers of service organizations.

- B. Contractor Responsibility:
1. All products shall be new and unused, and be provided from the manufacturer's current and standard production. Where two or more equipment items of the same kind are provided, all shall be identical and provided by the same manufacturer. Drawings and specifications shall indicate major system components, and may not show every component, connector, module, or accessory required to support the operation specified. Contractor will provide all components needed for complete and satisfactory operation.
- C. Electronic Access Control Functional Requirements
1. General:
 - a. The system infrastructure shall be a distributed architecture. Each door shall have a dedicated door controller capable of managing user access privileges, schedules, and events without the need of a centralized server.
 - b. The system shall have the ability to expand on a per-door basis, without the need for added licenses, software upgrades, or a reallocation of hardware.
 2. The access control shall execute functions related to access control, site and door surveillance.
 3. The EAC shall provide the ability to print badges, including logos, barcodes and pictures, without the need for software license upgrades.
 4. The EAC shall be composed of three hierarchy levels:
 - a. Door controllers that control supervision and command functions at the door.
 - b. An EAC control station that monitors alarms and responds in real time to all information in a user-friendly manner.
 - c. Door locking hardware and monitoring hardware, such as door strikes, readers, PIR, Door Position Switches (DPS), etc. all required for proper control of EAC controlled doors.
 5. All systems shall have the ability to do the following:
 - a. Add, modify, view, or remove information.
 - b. Provide storage of all system transactions in a retrievable file, such as a database.
 - c. Log all events by time and date.
 - d. Log on to the software by means of valid user name and password.
 - e. Make system configuration changes such as, but not limited to, door open time, door open too long, and reader names, when and where a card holder is valid, and the ability to add or modify card databases at any time.
 - f. Provide the ability to configure event display, alarms, and e-mail notification based on one or more of schedule, group, zone, event type and resulting action at the door.
 - g. Allow for configuration of rules based on incoming events that lock a zone, lockdown a zone, unlock a zone or revert to the current unlock schedule.
 - h. Provide the ability for manual operator control of system outputs. The manual functions shall include the ability to energize, de-energize, and return to original state.
 - i. Provide the ability for manual operator control of system inputs. The manual functions shall include the ability to bypass and un-bypass.
 - j. Provide the ability for manual operator control of system access services. The manual functions shall include the ability to lock, unlock, and set door to default schedule.
 - k. Provide the ability for manual operator control of system alarm services. The manual functions shall include the ability to arm, disarm, and return the alarm zone to default schedule.
 - l. Provide the ability for manual operator control of system arming services. The manual functions shall include the ability to arm, disarm, and set alarm zone to a schedule.

- m. Provide the ability for manual operator control of system equipment services. The manual functions shall include the ability to activate, deactivate, and set equipment service to default schedule.
 - n. Provide the ability to easily check status of each door including whether the controller is available or initializing, the controller configuration is current, if the door is locked or unlocked and open or closed. Variations on these statuses shall indicate if the state is normal or extraordinary, such as a lock that is overridden with lockdown preventing access through the door.
- D. EAC Premium Software Requirements
- 1. A premium version of the EAC system shall allow for additional integration into intrusion detection including:
 - a. Maps of devices on client workstations with icons representing cameras/intrusion devices/access control devices.
 - 2. A premium version of the EAC system shall allow for additional integration into 3rd party Video Management Systems including:
 - a. Exacq Video Management System
 - 3. A premium version of the EAC system shall allow for additional integration into 3rd corporate management software including:
 - a. Microsoft Active Directory
 - 4. Corporate management integration shall allow users to be created and managed in the corporate management software, and seamlessly transferred into the EAC system as defined by the user.
- E. EAC and VMS Integration Requirements
- 1. Front-End Software; System Configuration
 - a. The system shall have the ability to:
 - b. Support groups and membership of a cardholder in multiple groups
 - c. Build compound schedules for cardholders who have been granted access to specific doors or zones through their membership in multiple groups. This shall be automatic and transparent to the user.
 - 2. Time & Schedules
 - a. Schedule definitions shall include starting time, ending time, and days of the week. A schedule shall cover 24 hours by 7 days. Schedules shall allow a minimum of 3 distinct segments in one schedule. Schedules can be overridden by holiday sets and holiday schedules.
 - b. Maximum number of schedules that can be created and assigned in the system shall be unlimited.
 - c. Holiday Sets are groups of holidays. The system shall support up to 4 billion holidays and 4 billion holiday sets. Each Schedule shall support up to 7 holiday sets assigned to it for the purpose of overriding the schedule on those dates.
 - d. Each Holiday Set when assigned to a schedule can have its own 24 hour schedule.
 - e. The maximum number of holidays that can be stored on a door controller shall be 254.
 - 3. Hardware Configuration
 - a. Provide the ability to add and configure hardware modules (door controllers). A minimum of 500 door controllers shall be able to be configured per server.
 - b. Support auto-discovery on the server's default subnet or be configured to search on a different subnet. A list of controllers discovered on the subnet shall be listed when creating a door and shall be automatically removed from the discovered list once assigned with a door.
 - c. Encapsulate all key configuration elements of a controller/door in a set of user selectable templates with associated wiring diagrams available in the software.
 - d. Allow for the addition of new templates to the system as required.

4. Zones
 - a. The EAC system shall use zones, rather than door, for access privilege management.
 - b. A zone is a physical area with a set of one or more doors that provide access into and out of that area
 - c. A door shall join two zones together.
 - d. Only groups shall have access to zones.
 - e. Users will not have access to specific doors, rather, groups will have access to zones.
5. Groups
 - a. A group is a collection of people.
 - b. A person can be a member of one group or many groups.
 - c. The system shall support unlimited number of users in groups.
 - d. No additional licensing shall be required for card holders.
 - e. Groups shall have access privileges to zones.
6. Privileges
 - a. A privilege grants a group access to a zone on a schedule.
 - b. A group may have only one privilege per zone.
 - c. A group may have any number of privileges.
 - d. Privileges may only be assigned at a group to zone level.
7. Rules
 - a. The system shall have the ability to define the following Rules within the software:
 - 1) Access Privilege
 - 2) Event Management
 - 3) Hide Event
 - 4) Credential Management
 - 5) Alarm Management
 - 6) Email Event
 - 7) Lock Zone
 - 8) Lockdown Zone
 - 9) Revert Zone
 - 10) Unlock Zone
 - b. The system shall allow Rules to be configurable down to specific schedule, group, and zone.
8. Reports
 - a. The system shall not use a proprietary reporting software. Tools adequate to create, modify, generate and export reports shall be included in the system.
 - b. There shall be no license charge for any tools required to design or modify reports.
 - c. The reporting system shall allow for reports to be run from within the system and separately.
 - d. The reporting system shall be server and browser based for viewing, printing and exporting reports.
 - e. Badges shall be designed and managed in a manner similar to reporting.
 - f. Badges shall be printable directly from the edit dialog for a person, and from the reports menu. The Reports menu shall allow badges to be printed individually or severally (batch).
 - g. Barcoding in a report or on a badge of any available field shall be supported in a minimum of 8 different formats.

9. Miscellaneous Services
 - a. Database management shall be performed using the database vendor's standard toolset. The toolset shall be automatically installed on the server when the access control software is installed.
 - b. An Operator's service shall allow the user to define operator privileges that shall define the operator actions that can be performed while being logged on to the application. A minimum of three role types shall be available.
 - 1) Administrator – shall be able to perform all functions within the software
 - 2) Human Resources – shall be able to see events, run reports, view door status, and perform door specific actions such as momentary lock and unlock. The HR operator shall be able to create, edit and delete people and groups, and print badges.
 - 3) User – shall be able to view events, run reports, see people and groups, monitor door status, and perform door specific actions. The User operator shall not be able to modify any data in the system.
10. Events and History
 - a. All events shall be recorded in the database. The database shall have the capacity to store a minimum of 20 million events. The system shall include the ability to upgrade its database to a storage capacity of 4 billion events.
 - b. A History Report search shall show the event that occurred, when the event occurred, where the event occurred, and who caused the event to occur. Video attached to events shall also be available for playback from the History screen.
 - c. The administrator shall define what event will be shown on the events page. This shall include the ability to build rules based on various criteria to filter the event
 - d. Events presented as Alarms on the events page shall be fully configurable by the administrator. The administrator shall have the ability to include schedules, zones, groups and event types as criteria in determining if an event is an alarm.
 - e. The system shall have the ability to accept events from 3rd party systems. The administrator shall be able to define rules and actions based on those events.
11. Video Configuration
 - a. The AC-VMS system shall be able to add IP cameras to the system either through auto-discovery or manually.
 - b. The AC-VMS client software shall be a Microsoft Windows only application and shall be able to receive live video, live audio and alarm information.
 - c. The AC-VMS shall allow the customization of the user interface to allow software triggers to activate events through the push of a button, which could trigger recording or PTZ presets.
12. Furnish 500 proximity cards equal to HID 13.56MHz, I-Class. 2000PGGMV-S1

2.3 VIDEO MANAGEMENT SYSTEM

- A. Manufacturer: Exacqvision Enterprise
- B. The Video Management System (VMS) software shall be used to view live and recorded video from capture cards and IP devices connected to local and wide area networks. The VMS software shall have a client/server-based architecture that can be configured as a standalone VMS system with the client software running on the server hardware and/or the client running on any network-connected TCP/IP workstation. Multiple client workstations shall be capable of simultaneously viewing live and/or recorded video from one or more servers. Multiple servers shall also be able to simultaneously provide live and/or recorded video to one or more workstations. The VMS server software shall also have the ability to be installed on an IP edge device—such as an IP camera or encoder that allows for 3rd party applications—allowing the device to serve as both a server and IP video recording device.

- C. The VMS shall be certified/integrated with the access control solution.
- D. The VMS shall not charge for the number of concurrent clients.
- E. The VMS system shall utilize manufacturer built servers, commercial-off-the-shelf (COTS) computer workstations, servers, IP edge devices that allow for third-party application installation, networking devices and storage equipment.
- F. Recording of all video transmitted to the VMS shall be continuous, uninterrupted and unattended.
- G. The VMS system shall offer the capability of video motion detection recording, such that video is recorded when the NVRMS detects motion within a region of interest of the camera's view. Video prior to the detection of the motion shall also be stored with recording using the pre-recorded feature.
- H. The VMS system shall manage the video it has been configured to monitor. Loss of video signal shall be configured to annunciate on VMS client by an on-screen visual indication alerting operators of video loss.
- I. The VMS software shall have an open architecture supporting IP cameras and encoders from multiple manufacturers providing best-of-breed solutions ranging from low-cost, entry-level features to high-resolution, megapixel features.
- J. The VMS client software shall be able to view live video and audio, recorded video and audio and be able to configure the complete system all from a single application.
- K. The VMS shall continue to record video and audio at all times during the administration and configuration of any feature.
- L. The VMS client software shall have the same functionality when connected remotely as it does when it is run locally on the same computer as the server software.
- M. The VMS client software shall add and remove features based on the permissions of the user and the licensed functionality.
- N. The VMS client software shall operate on all of the following operating systems:
 - 1. Microsoft Windows Server 2003/2008
 - 2. Microsoft Windows XP (all versions)
 - 3. Microsoft Windows Vista (all versions)
 - 4. Microsoft Windows 7 (all versions)
 - 5. Linux Ubuntu 8.04/10.04 Debian Package
 - 6. Mac OSX (operating on Intel CPU)
- O. The VMS software shall allow the user to have any combination of VMS client applications running on any of the supported operating systems and be able to connect to any of the VMS servers running on any of the supported operating systems. For example, a VMS client running on Microsoft Windows 7 shall be able to simultaneously connect to four (4) different VMS servers all running on different operating systems, such as Windows Server 2003, Windows XP, Vista and Linux.
- P. The VMS software shall have the capability to run multiple client applications simultaneously on one workstation with multiple monitors. Up to 12 monitors shall be configured on a single workstation with one (1) client application running on each monitor. Because decompressing video is CPU-intensive, the PC workstation shall have multiple core processors with a recommendation of one core for each VMS client application.

- Q. The VMS shall also allow an authorized user to view video through a web client interface. The web client interface shall allow authorized users to view live video, view recorded video, control pan-tilt zoom (PTZ) cameras and activate triggers. The web client interface shall allow connections to multiple VMS servers simultaneously.
- R. The web client interface shall operate without requiring installation of any software.
- S. When using the web client interface, the VMS server shall transcode the video into a JPEG file of the size as the browser screen before sending it to the browser.
- T. The web client interface shall support the following browsers:
 - 1. Internet Explorer 6 and later
 - 2. Firefox 2 and later
 - 3. Opera 9 and later
 - 4. Safari and later
 - 5. Chrome
 - 6. The web client interface shall also connect with non-JavaScript browsers and shall be compliant with HTML 4.0 (www.w3.org).
- U. The VMS server software shall record and retrieve video, audio and alarm data and provide it to the VMS clients upon request.
- V. The VMS software shall provide at no additional charge a purpose built mobile application capable of viewing multiple simultaneous live video streams and playing a recorded video stream. Application shall be provided for both iOS and Android operating systems (including Kindle Fire).
- W. The VMS server software shall operate on any of the following operating systems:
 - 1. Microsoft Windows Server 2003/2008
 - 2. Microsoft Windows XP (all versions)
 - 3. Microsoft Windows Vista (all versions)
 - 4. Microsoft Windows 7 (all versions)
 - 5. Linux Ubuntu 8.04/10.04 Debian Package
- X. The VMS server shall not decode video for the purpose of motion detection.
- Y. The VMS server shall not decode video for the purpose of repacking it for transmission to clients.
- Z. The VMS server software shall record video based on metadata generated by an edge network device. The edge network devices shall generate the metadata and transmit it with the video stream to the VMS server software.
- AA. The VMS shall license the total number of cameras on the system. This license shall be based on the MAC address of a single network card that is present on the system. The VMS shall only require that this network card be enabled and does not require that data is actually sent through it.
- BB. The VMS shall not require the manufacturer to be contacted when a camera fails.
- CC. The VMS server software shall run as a service. The VMS shall not require any application to be running in order to operate.

- DD. The VMS shall be able to use the Active Directory or LDAP features of a network to authenticate users and determine which permissions they will have on each server.
- EE. The VMS shall allow for a user's permissions to be configured across multiple servers from a single screen.
- FF. The VMS shall allow the use of maps. The maps will be accessible to users with the appropriate permission levels and display video sources and their status.
- GG. The VMS shall allow maps to be embedded inside of maps (i.e. hierarchical or nested maps). When an event happens on a map that is embedded inside of a map, it shall transmit the alert to all parent maps and change the color of the icon on the parent map and all subsequent parent maps.
- HH. The VMS allows soft triggers to be placed, viewed and triggered from a map.
- II. The VMS shall have a single page that displays the status of all servers and cameras currently connected. This page shall display any alarms, events, MAC addresses, camera configuration, format and frame rate from each individual camera.
- JJ. The VMS shall support the use of a panoramic lens on an analog or IP camera. The VMS client shall de-warp the image on both live and recorded video.
- KK. The VMS software shall have three methods of allowing third-party integration: command line, API and web SDK. The command line shall allow for the most basic of interfaces, calling up the appropriate video when requested using command line functionality. The API shall allow for a deeper interface, allowing video to be transmitted from the VMS software into the party software interface. The web SDK shall use the web server to transcode the video and send it to the third-party software interface. The web SDK method shall use standard HTML, XML, CGI and JavaScript commands.
- LL. Video Management System Software Features
 - 1. When in live display mode, the user shall be able to view live video, live audio, point of sale (POS) data and alarm information.
 - 2. The VMS shall be able to organize the camera video view panel in the following patterns:
 - a. 1-camera (full-screen) layout
 - b. 4-camera (2x2) layout
 - c. 8-camera (3 large views and 4 small views) layout
 - d. 10-camera (2 large views and 8 small views) layout
 - e. 13-camera (1 large view and 12 small views) layout
 - f. 16-camera (4x4) layout
 - g. 8-camera (1 very large view and 7 small views) layout
 - h. 9-camera (3x3) layout
 - i. 6-camera (2x3) widescreen layout
 - j. 12-camera (4x3) widescreen layout
 - k. 20-camera (5x4) widescreen layout
 - l. 30-camera (6x5) widescreen layout
 - m. 48-camera (8x6) widescreen layout
 - 3. The VMS shall allow the customization of the user interface to allow software triggers to be shown. This shall allow them to activate events through the push of a button, which could trigger recording, PTZ presets, output triggers or email.
 - 4. The VMS shall allow the user to pick their own icon and select the software triggers to display in the client. The VMS shall also display the status of any soft triggers on connected VMS servers.

5. The VMS software shall allow control of PTZ cameras to authorized users and be used to maneuver a PTZ camera. When used on a non-PTZ camera, it shall allow you to digitally pan, tilt and zoom on any video whether in live or recorded mode.
6. The VMS shall allow following methods of controlling a PTZ camera to be available:
 - a. PTZ graphics control windows
 - b. Live graphic overlay PTZ control icons
 - c. Keyboard control (up, down, left, right arrows; page up, page down for zoom)
 - d. PTZ presets
 - e. Digital PTZ
 - f. USB joystick to control PTZ cameras
 - g. Proportional PTZ control by clicking the mouse in the center and moving it
7. The VMS software shall allow virtual matrix functionality by designating a cell to do so. This video cell shall automatically show video as it is triggered.
8. The VMS software shall have a feature for viewing logical groups of cameras. This shall allow efficient viewing of cameras in a logical order.
9. The VMS software shall have a feature to organize your cameras into preset views. Views are preconfigured arrangements of the video panels so that they may be easily recalled later. A view can save the location of the video streams, audio streams, POS data, maps and event views. These views shall be accessible in both live and recorded video modes.
10. The VMS software shall have the capability to automatically cycle through two or more saved views to create a video tour. The VMS shall allow the configuration of the dwell time and the different views it shall use.
11. The VMS client software shall be used to search for and play back recorded video, audio and events from VMS servers.
12. The VMS software shall have the capability to search for and play back video from multiple cameras simultaneously. All recorded video shall be played back and displayed in a synchronized multi-camera layout.
13. The VMS software shall support searching through recorded video based on time, date, video source and image region and have the results displayed as both a clickable timeline and a series of thumbnail images.
14. The VMS software shall allow search and play back of audio in synchronization with video.
15. The VMS software shall allow you to search on a specific area of recorded video and only display the frames where motion happened in that area.
16. The VMS software shall have the capability to export video, maps, POS data and audio files.
17. The VMS software shall provide the option of exporting the file in the following formats:
 - a. Standalone Exe (*.exe) – includes an executable player with the video and audio data
 - b. AVI File (*.avi) – a multimedia container format
 - c. PS File (*.ps) – a format for multiplexing video and audio
 - d. QuickTime File (*.mov) – native for Macintosh computers
18. The VMS standalone player shall package all of the exported video into a single executable. The VMS standalone player shall be able to authenticate that the video has not been tampered with using a keyed Hash Message Authentication Code (HMAC).
19. The VMS client software shall be able to connect to multiple systems simultaneously. Each of the systems could have individual permissions, thereby limiting the client's configuration or viewing abilities for that system, but not affecting the abilities on the other systems.
20. The VMS system shall be able to display system information about users that are currently logged into the system, plug-in file version information number and status, and a system log that contains a detailed history of the processes that occur on the system.

21. The VMS system shall have the ability to record an audit trail of when users log in that shows what changes they have made, what video they have viewed and what they have exported.
22. The VMS system shall allow the configuration of the video devices to be performed in the client and pushed out to the devices. The configuration itself is stored both on the camera and on the VMS.
23. The VMS shall allow monitoring of the inputs on both network devices and on manufacturer provided hardware. The VMS shall also allow triggering of outputs on the network devices and manufacturer provided hardware.
24. The VMS shall allow for the configuration of what drives to use for recording video. Those drives may be local drives, direct attached storage drives or iSCSI drives.
25. The VMS shall allow for the configuration of rules of how to record the video. These rules shall allow you to set a maximum number of days or minimum number of days on a per video stream basis.
26. The VMS shall not require a database when recording video.
27. The VMS shall use the operating systems native file system for recording the video. For example, if there was video that was recording on March 1, 2012 from 10:00 AM to 10:35 AM. Files for that day would be in the data drive, in the path 2012 for year, subfolder 03 for the month, with a sub folder 1st for the day, and then the 10 subfolder for the hour. So when the client sends a request to search for video, the VMS shall look in the D:\2012\03\01\10 directory. Each video stream shall be kept in 5-minute increments in a paired video and index file. The video file shall contain the data of the video, audio, and include meta data. The index file shall contain the index of the metadata from the network device. So when the VMS searches for the video, it shall gather up the information in the index files and display those results. When the client then requests to display the video, the VMS will then transmit the video file data from the server to the client.
28. The VMS shall have the ability to receive ASCII data through the COM port on the server or over the network.
29. The VMS shall have the ability to look for keywords in the ASCII data and use these to execute various events such as PTZ presets, recording video, recording audio and sending email notifications.
30. The VMS software shall be able to send a predefined email based on an event trigger. The VMS software shall also support SSL and TLS connections for transmissions of the mail.
31. The VMS software shall have a feature to export a video segment from specific cameras or audio inputs to a CD or DVD upon an input trigger or other event being activated.
32. The VMS software shall be used to connect different types of events, such as input triggers, to a desired action such as recording video or triggering an alarm. The VMS software shall recognize the following event types:
 - a. Video Motion
 - b. Video Loss
 - c. Input Trigger
 - d. POS Port
 - e. POS Profile
 - f. Health
 - g. IP Camera Connection
 - h. Software Trigger
 - i. Analytics

33. The VMS software shall be able to execute the following action types:
 - a. Record Video
 - b. Output Trigger
 - c. Output Video
 - d. Send an email
 - e. Burn a CD/DVD
 - f. Call a PTZ Preset
34. The VMS software shall have the ability to configure each video input's recording time on an hourly basis. This shall allow the user to schedule when to record on motion, when to record on event and when to not record.
35. The VMS shall use a combination of a user name and a password to authenticate the user's permission level.
36. The VMS shall allow granularity of permissions by creating custom user groups. The members of these custom user groups shall all have the same permissions.
37. The VMS client shall be able to use OpenGL and Direct 3D to decompress and render video.
38. The VMS shall allow the user to perform a visual thumbnail search. The user can select one camera to see one image per set time period. The user shall be able to play video from that image or zoom in to a time range.
39. The VMS client can be configured to automatically switch views on any trigger within the event monitoring function.

MM. VIDEO MANAGEMENT SYSTEM HARDWARE

1. Server Requirements:
 - a. The VMS server software shall operate on the following minimum requirements:
 - b. For the Dover School project – Furnish 48Terabytes of storage – RAID 5. Model IP08-48T-R2Z. Furnish 2 units.
 - 1) Rack mount 2U recorder with 8IP licenses (128 max), dual Gb NIC, HDMI, DVI-I, DisplayPort (2 max. simultaneous), RS-232/485 serial port, RAID 5, DVD. Win7 64 bit or Ubuntu 14.04 linux on 60GB SSD, redundant power supplies, keyboard and mouse, Exacqvision Enterprise Client and server software pre-installed, 3 year warranty and software updates.
 - 2) Include 1 rack mount Sliding rails kit for Z chassis, 26” mounting rails spacing.
 - 3) Include Professional IP Camera licenses for all IP cameras including software updates.
2. Client Workstation Requirements.
 - a. The VMS client software shall operate on the following minimum requirements:
 - 1) Windows platform:
 - Based on manufacturer's latest requirements as published on manufacturer's website. These requirements will be included with the submittal for verification purposes.
3. Client Workstation Requirements :
 - a. Per most recent manufacturer's published requirements for software level required. Include in submittal for validation purposes. Every client workstation shall include a 22” monitor/keyboard/mouse.
 - b. Include a 750va UPS at each workstation location.

4. Video Surveillance System Functionality
 - a. General
 - 1) The VMS shall be based on a true open architecture that shall allow for use of non-proprietary workstation and server hardware, non-proprietary network infrastructure and non-proprietary storage.
 - 2) The VMS shall offer a complete and scalable video surveillance solution which allows cameras to be added on a unit-by-unit basis.
 - 3) The VMS shall interface with analog-to-digital video encoders and IP cameras, hereafter referred to as digital video servers (DVS). The VMS shall support DVS from various manufacturers.
 - 4) All video streams supplied from analog cameras or IP cameras shall be digitally encoded in MPEG-4, MPEG-2, MJPEG, H.264, Wavelet or JPEG2000 compression formats and recorded simultaneously in real time.
 - 5) All audio streams supplied from IP video servers shall be digitally encoded in g711 (u-law), g721, g723 or AAC compression formats and recorded simultaneously in real time.
 - 6) The VMS shall support a wide range of IP Video cameras.
 - 7) The VMS shall support the following industry standards to interface to IP-based physical security products:
 - a) ONVIF
 - 8) Each camera's bit rate, frame rate and resolution will be set independently from other cameras in the system, and altering these settings will not affect the recording and display settings of other cameras.
 - 9) The VMS shall be able to use multiple CCTV keyboards to operate the entire set of cameras throughout the system, including cameras of various manufacturer's brands, including their PTZ
 - 10) The VMS shall PTZ protocols independently of the PTZ protocols supported by the video server.
 - 11) The VMS shall be able to retrieve and set the current position of PTZ cameras using XYZ coordinates.
 - 12) The VMS shall support a wide range of PTZ camera protocols. Consult with Exacqvision for current list.
 - 13) The VMS shall support a wide range of CCTV keyboard protocols. Consult with Exacqvision for current list.
 - 14) The MVS shall support wide range of joysticks. Consult with Exacqvision for current list.
 - 15) Audio and Video storage configuration for the SSM shall either be:
 - a) Internal or external IDE/SATA organized or not in a RAID configuration;
 - b) Internal or external SCSI/iSCSI/Fiber Channel organized or not in a RAID configuration;
 - c) It shall be possible to include within the overall storage system disks located on external PCs on a LAN or WAN as well as;
 - d) Network Attached Servers (NAS) on a LAN or WAN as well as;
 - e) Storage Area Networks (SAN);
 - 16) The SSM shall not limit the actual storage capacity configured per server

- b. Video Recording and Storage Parameters
 - 1) Recording and Storage parameters shall be defined as supporting all cameras/devices detailed and as shown on the drawings for:
 - a) 30 days minimum
 - b) At least 3.0 megapixel resolution for all fixed cameras
 - c) At least 2.0 megapixel resolution for all PTZ cameras
 - d) 12 frames/images per second per camera
 - e) 24 hours of activity
 - f) 50 percent motion activity
 - 2) Supply the necessary storage solution as specified. Provide calculation sheets from the IP Video system manufacture with the submittal.

2.4 HARDWARE AND PERIPHERALS

- A. Primary Network Video Directory and Archiver Servers
 - 1. Each Directory and Archiver server shall have the following specifications. Provide a UPS with battery backup for 10 minutes for each server.
 - a. Per manufacturer's most recent requirements as published on their website.
 - 2. Security Control Workstation (Client)
 - a. Provide security workstations with the following specifications. Provide a UPS with battery backup for 10 minutes for each workstation. The security control workstation shall be used for the USP. Each workstation CPU shall be rack mounted in the MDF. Provide KVM extenders as shown below for all monitors, keyboards and mice.
 - 1) Four Core Xeon 3.6 GHz or higher, 20 MB Cache
 - 2) Microsoft Windows 7
 - 3) 16GB RAM
 - 4) 200 GB of storage or more.
 - 5) NVIDIA Quadro 4000, dual mon or better. Provide with quad monitor card.
 - 6) 1280x1024 or higher screen resolution
 - 7) 10/100/1000 Ethernet Network Interface Card
 - 8) 16x DVD/RW Drive
 - b. Provide a 26 in. LED monitor with each workstation.
 - c. Provide Dell Precision T3600 series or approved equal.
 - d. Provide a minimum of one (1). Provide as shown on the drawings.
 - 3. Photo Badging Workstation
 - a. Provide a photo badging workstation for photo badge creation and printing. Provide a UPS with battery backup for 10 minutes for each workstation.
 - 1) Four Core Xeon 3.6 GHz or higher, 20 MB Cache
 - 2) Microsoft Windows 7.
 - 3) 8GB RAM
 - 4) 200 GB of storage or more.
 - 5) NVIDIA Quadro 4000 dual mon or better. Provide with quad monitor card.
 - 6) 1280x1024 or higher screen resolution
 - 7) 10/100/1000 Ethernet Network Interface Card
 - 8) 16x DVD/RW Drive
 - 9) Four (4) USB ports
 - b. Provide with 26 in. LED monitor.
 - c. Provide Dell Precision or approved equal.
 - d. Provide with a USB video camera.
 - e. Provide one (1) as shown on the drawings.

4. Photo Badge Printer
 - a. Provide a single sided color photo badge printer. Coordinate with the owner on exact location.
 - b. Print mode. Color dye sublimation, monochrome thermal printing and rewritable technology.
 - c. Printer interfaces. USB and Ethernet both fitted as standard.
 - d. Software drivers Windows 2000 Professional (SP4), XP, Windows Vista 7 and 8 (32/64 bit compatible), Windows Server 2003 R2 SP2, Server 2008) (32/64 bit compatible).
 - e. Card capacity 100-card feeder, 70-card stacker.
 - f. Power source. External power supply 100-240V 50-60Hz autoranging.
 - g. Print speed. *Color standard mode: 31 seconds, *Color fast mode: 23 seconds, *Monochrome resin: 6 seconds (*single-sided card)
 - h. Operating environment. Sheltered office environment 50 deg.F to 85 deg.F (10 deg.C to 30 deg.C).
 - i. Provide one (1) Magicard Rio Pro or equal. Provide with color ribbon and cleaning kit. Provide two (2) spare color ribbons. Provide 1 as shown on the drawings.
5. Other Workstations
 - a. As shown on plans.
6. Core and Edge Network Switch
 - a. Provide Power over Ethernet Plus (PoE+) network switch(s) for all cameras, access control panels, encoders/decoders, security workstations, video servers, and access control servers.
 - b. Each switch shall have 20 percent spare capacity per closet/IDF/MDF.
 - c. Each closet shall support 10/100mbs per port with a minimum of 1000GB on the back bone/core switch. The fiber infrastructure shall be only utilized for connectivity from each IDF to the MDF/core switch. The use of any portion of the copper back bone shall not be allowed.
 - d. Provide a core switch which shall support each IDF/remote security closet with 1000gbs bandwidth over the fiber infrastructure. In addition to the support of each closet, provide a dedicated 1000gbs for each server (access control and video). Provide 20 percent 1000gbs copper ports and 20 percent spare 1000gbs fiber ports at the core switch/head end.
 - e. Provide Uninterruptible Power Supply (UPS) for each closet/IDF/MDF to support the network PoE Switches. For closet locations requiring 24 ethernet ports or less, install a 1000VA UPS.
 - f. Each network switch shall be located in each IDF/MDF.
 - g. Provide HP, Brocade or approved equal for the core switch in MDF. Provide multimode fiber GBIC cards and module as required to support each IDF and/or security closet as shown on the drawings and riser diagram. Interconnect all switches in a star configuration using fiber GBIC modules.
 - h. Provide HP, Brocade or approved equal for each edge switch. Each switch shall include a minimum of one (1) fiber GBIC card and module.
 - i. Provide an interface to the owner's LAN as required.

7. Interior/Exterior Fixed Megapixel Vandal Dome Camera – 3 MegaPixel with IR.
 - a. Provide cameras with the following specifications for all indoor/outdoor fixed cameras as shown on the drawings. Provide exterior model for all exterior cameras.
 - 1) Image sensor: 1/3.2" progressive scan
 - 2) Lens: Vari-focal, DC iris. Provide 3 – 9mm.
 - 3) Day/Night
 - 4) Shutter time: 1/35500s to 1/6s
 - 5) Resolution: 2048x1536
 - 6) Digital PTZ functions
 - 7) Video compression: H.264 and Motion JPEG
 - 8) Frame rate per camera: 30 fps at max resolution
 - 9) Video streams: Multiple, individually configurable
 - 10) Audio streaming: Two-way
 - b. Each camera shall be able to provide 3 megapixel resolution at 20 frames per second.
 - c. The power source shall be Power over Ethernet (IEEE 802.3af).
 - d. Provide American Dynamics IPS03D2ISWIT for all interior cameras. Vandal resistant, white, smoked dome.
 - e. Provide American Dynamics IPS03D2OSWIT with IR for all exterior fixed cameras. Vandal resistant, white, smoked dome. Provide with wall/corner mount where required.
 - f. Provide corridor format for cameras mounted in corridors.
8. Exterior PTZ Megapixel Dome Camera and Housing
 - a. Provide PTZ cameras with the following specifications for all outdoor PTZ cameras as shown on the drawings.
 - 1) Image sensor: 1/3 progressive scan, 2.0 megapixels
 - 2) 30x optical zoom, 12 x digital zoom
 - 3) Day/Night
 - 4) Shutter time: 1/30000s to 1/4s
 - 5) Resolution: 1920x1080 (1080p)
 - 6) Video compression: H.264 and Motion JPEG
 - 7) Frame rate per camera: 30 fps at 1080p
 - 8) Video streams: Multiple, individually configurable
 - 9) Audio streaming: Two-way
 - b. The power source shall be high powered Power over Ethernet (IEEE 802.3af). Include a separate power supply for heater/blower at the camera location as required.
 - c. Provide American Dynamics Illustra Pro 30x vandal resistant, smoked dome. Provide with appropriate mounting bracket.
9. Exterior Camera Fiber Transceivers
 - a. Provide fiber optic transceivers for all pole mounted and remote building mounted cameras. Transceivers shall be located at the base of the pole in a NEMA rated heated enclosure.
 - b. Provide American Fibertek MX2-MM-FX or equal media converters as required for each camera. Transmitter shall be located in NEMA rated enclosure at the pole. Receiver shall be located in the security rack.
 - c. Provide Altronix T2428100WP or equal outdoor rated power supply for each camera, located at the pole. Power supply shall be located in NEMA 3R rated lockable enclosure at the pole.

10. 180-Degree Surround Video Camera Equal to Arecont Vision AV12186DN (12MP) and 360-Degree Surround Video Camera Equal to Arecont Vision AV20356DN (20MP) – as indicated on plans:
 - a. Hardware:
 - 1) The camera shall utilize four high sensitivity 3-Megapixel WDR CMOS sensors with 1/3.2" optical format, progressive scan and Active Pixel Count: 2048(H) x 1536(V) pixel array
 - 2) The camera shall integrate four 5.4mm M12 megapixel IR corrected lenses, 1/3.2", F2.0, Horizontal Field of View of 46.5°. (AV12186DN)
 - 3) The camera shall integrate four 2.6mm M12 megapixel IR corrected lenses, 1/2.5", F2.0, Horizontal Field of View of 96°. (AV12366DN)
 - 4) The camera shall have die-cast aluminum chassis with IK-10 vandal resistant dome. Entire enclosure to be rated minimum IP66 for water and dust protection.
 - 5) The camera shall have a 2-axis easily adjustable gimbal with 360° pan and 90° tilt for easy and accurate positioning.
 - b. Imaging:
 - 1) The camera shall combine four images for a 180 degree horizontal field of view. (AV12186DN)
 - 2) The camera shall have dual standard compression support with simultaneous streaming of both H.264 and MJPEG formats.
 - 3) Each sensor of the camera shall feature automatic exposure, automatic multi-matrix white balance, shutter speed control to minimize motion blur, programmable resolution, brightness, saturation, gamma, sharpness and tint.
 - 4) The camera's shutter speed shall be 1ms - 500ms.
 - 5) The camera shall feature selectable 50/60 Hz flicker control, windowing, simultaneous delivery of full-field view and zoomed images at video frame rate, instantaneous electronic zoom, pan and tilt, and electronic image rotation by 180 degrees
 - 6) The camera shall have +/-5° digital vertical alignment to adjust images. (AV12186DN)
 - 7) The camera shall have +/-7° mechanical tilt adjustment to locate each sensor angle. (AV12366DN)
 - 8) The camera shall have multi-streaming support of up to 8 non-identical concurrent streams (different frame rate, bit rate, resolution, quality, and compression format).
 - 9) The camera shall have wide dynamic range up to 100 dB and a maximum SNR of 51 dB
 - 10) The camera shall have privacy masking, the ability to select multiple regions of an arbitrary shape to block the video. The camera shall have extended motion detection grid, a higher granularity grid of 1024 distinct motion detection zones. User can select between 64 zone based motion detection and extended motion detection to provide backward compatibility with the existing Video Management System (VMS) integration. This feature shall support RTP, HTTP and TFTP protocols, as well as the on-camera web interface.
 - 11) The camera shall feature streaming of the full field of view (FOV) and simultaneous multiple regions of interest (ROI) for forensic zooming.
 - 12) The camera shall provide 21 levels of compression quality for optimal viewing and archiving.
 - 13) It shall be possible to program the camera in binning mode to output lower resolution images: i.e. 4096(H) x 768(V) pixels (1/4 full resolution) at 17 FPS.
 - 14) The camera shall provide flexible cropping (Resolution windowing down to 1x1 pixels for JPEG and 2x2 pixels for H.264)

- 15) The camera shall be able to save bandwidth & storage by running at 1/4 full resolution
 - 16) The camera shall feature MoonLight™ mode - extended exposure and noise cancellation
 - 17) The camera shall be able to support Picture-in-Picture: simultaneous delivery of full field of view and zoomed images
 - c. Video:
 - 1) Video frame rate (up to):
 - a) 5.2FPS @ 8192x1536
 - b) 17 FPS @ 2048x1536
 - 2) Video frame rate in binning mode up to:
 - a) 17 FPS @ 4096x768
 - d. Protocols:
 - 1) The camera shall have Real Time Streaming Protocol (RTSP) support allowing for compatibility with media players such as Apple QuickTime, VLC Player and others.
 - 2) The camera shall support both unicast and multicast communication protocol.
 - 3) The camera shall support RTSP, RTP over TCP, RTP over UDP (Unicast/Multicast), HTTP1.0, HTTP1.1, TFTP
 - 4) 100 Base-T Ethernet Network Interface
 - 5) Multi-streaming: 8 non-identical streams (2 active connections to each sensor)
 - e. Electrical:
 - 1) General purpose opto-coupled input and output
 - 2) Power over Ethernet (PoE): PoE 802.3af
 - 3) Auxiliary Power 12-48V DC, 24VAC
 - 4) Power consumption: PoE – Class 3; auxiliary- 14W max
 - f. Networking:
 - 1) The camera shall be equipped with a 100 Mbps LAN connector
 - g. Environmental
 - 1) Operating temperature -40°C (-40 °F) to +50°C (122 °F)
 - 2) Stable image temperature 0°C (32 °F) to +50°C (122 °F)
 - 3) Storage temperature -40°C (-40 °F) to +60°C (140 °F)
 - 4) Humidity 0% to 90% (non-condensing)
 - h. Illumination:
 - 1) Color (non-binning): 0.5 Lux @ F2.0
 - 2) Color (binning): 0.25 Lux @ F2.0
 - 3) B/W: 0 Lux, IR sensitive (with additional IR light source)
 - i. Packaging:
 - 1) Unit Dimensions (H x Dia) 4.9"H (125 mm) x 5.5" dia. (140 mm) Weight: 2.8 lbs (1.27kg)
 - 2) Packaged Dimensions (H x W x L) 6" (150mm) x 7.5" (190mm) x 8" (200mm) Weight: 3.4 lbs (1.54kg)
11. Reader and Input/Output (I/O)Control Panels
- a. General
 - 1) The control panels include but no limited to card reader modules, input modules, output modules, power supply, harnesses, and batteries. Provide quantities as required for a complete working system. Each module card shall be neatly installed in a locked wall cabinet. Enclosures shall be located in each IDF/MDF or as shown on the drawings. Each controller shall be connected to the security network switch. .

- b. Features
 - 1) Stores a complete access control and configuration database for up to 32 Reader Interfaces (up to 64 doors) and 44,000 cardholders with expansion capability up to 250,000 cardholders.
 - 2) The access control system interfaces with combinations of devices with a maximum of: 32 Door/Reader interfaces (up to 64 doors/readers) or 32 input monitor interfaces 9 (up to 512 monitor points) or 32 output control interfaces (up to 384 control relays)
 - 3) Reports supervised inputs/alarms with 255 priorities.
 - 4) Includes an HTTP API, Windows® DLL API, and direct communication API.
 - 5) Allows local connection of a laptop computer for diagnostics and configuration.
 - 6) Connects to the host and other devices on a TCP/IP network.
 - 7) Receives and processes real time commands from the host software application.
 - 8) Reports all activity to the host.
 - 9) Controls and communicates with all connected devices.
 - 10) Buffers offline transactions and uploads to the host when communication is restored.
 - 11) UL 294 and UL 1076 recognized component.
- 12. Combination Card Reader and Keypad
 - a. Provide contactless smart card readers with keypad as shown on the drawings.
 - b. Each reader shall operate on a 13.56 transmit frequency.
 - c. The reader shall have a Weigand output.
 - d. The readers shall have both an audio and visual notification for access granted and access denied.
 - e. The reader shall be suitable for indoor and outdoor applications.
 - f. The reader shall operate up to 500ft on 22AWG cable.
 - g. The reader shall be able to communicate with either 2K, 16K or 32K bit iClass cards.
 - h. Provide HID RK40 iClass readers. Standard readers shall be HID R40.
- 13. Contactless Printable Smart Cards
 - a. The smart card shall be 13.56MHZ and shall be an iClass card manufactured by HID Corporation or approved equal.
 - b. The card shall be capable of being directly printed to.
 - c. The card shall be a 2000 bit card with two application areas. One shall be for access control and the other for user customization.
 - d. The smart card shall have an operating temperature of -40 to 158 degrees Fahrenheit, and shall have an operating humidity of 5-95 percent non-condensing.
 - e. The card shall meet ISO 15693 standards for contactless communications.
 - f. Provide HID iClass Card model 2000 or approved equal.
 - g. Provide 500.
- 14. Door Contacts
 - a. Furnish and install 3/4 in. recessed magnetic door contacts as shown on the drawings.
 - b. Provide Sentrol/GE 1076C or equal unless noted below.
 - c. Provide DPDT contacts for all exterior doors which have a card reader. The second pole will be wired and connected to the intrusion alarm system. Provide Sentrol/GE model #1076-D or approved equal.

15. Request-to-exit devices
 - a. Furnish and install motion request-to-exit sensors as shown on the drawings and as required. Devices shall mount directly above the each door. Utilize doors that have hardware which have integral request-to-exit switches as required. Coordinate with door hardware.
 - b. Provide DS 150i or approved equal with trim plate unless hardware is noted to be in door crash bar per plans. Take note accordingly.
16. Auxiliary Power Supply
 - a. Provide auxiliary power supply(s) for REX sensors as required. Provide Altronix or approved equal.
17. Electric strike/magnetic locks power supply
 - a. Furnished by hardware installed and wired by Electrical Contractor. Security Interface by IESS Contractor.
 - b. Fire Alarm interface by Electrical Contractor.
 - c. Provide coordination with door hardware contractor.
 - d. Power supplies shall be interfaced to the fire alarm system as required.
18. Locking Devices (Electric strike/Magnetic locks/Electric locks/Electric Hinges locking hardware power supplies)
 - a. Furnished and installed by others. Wired by security contractor.
19. Beacons
 - a. Provide blue security beacons as shown on the drawings. The unit shall wall or ceilings mount. The unit shall be 12/24 VDC and wired to the security management system.
20. Duress Stations
 - a. Provide remote duress red mushroom push button as shown on the drawings. The device shall be designed for high security applications and shall be vandal proof. Each duress button shall be wired to the USP for camera call-up and general alarm conditions. Each button shall report and be programmed independently of one another.
 - b. Provide Sentrol 3045 or approved equal.
21. UPS Units
 - a. Furnish and install UPS units for the complete Integrated Security systems as specified herein. UPS units shall be sized to support all equipment as specified herein for a minimum of 15 minutes. Provide calculations as required.
 - b. Each UPS units shall be located in the MDF room and IDF closets.
 - c. Material
 - 1) Each UPS shall have the following specifications.
 - 2) Up to .8 power factor (in watts)
 - 3) Independent battery pack chargers
 - 4) Simultaneous RS-232, USB and SNMP communications
 - 5) Monitoring and control software capable
 - 6) Front panel display with status indicators
 - 7) Hot swappable batteries
 - d. Provide APC SMT1500 and/or 2200 series or approved equal.

2.5 INTRUSION ALARM SYSTEM

- A. Intrusion Alarm Control Panel
 1. Provide an intrusion system as required and as shown on the plans. The cost of monitoring the facility at a UL listed central station shall be included for a period of one year.
 2. The intrusion alarm panel shall be fully integrated to the USP.

3. Provide all labor, materials, equipment, and services to perform all operations required for the complete installation and related work as shown in all contract documents.
 4. All motion detectors, roof hatches and exterior doors shall report and be individually annunciated on the intrusion alarm system. For locations that are exterior access control doors, each door contact shall be double pole, double throw. One pole shall be wired to the intrusion alarm system and the other shall be wired to the access control system and programmed in accordance with the access control specification. Each exterior door shall be wired and individually reported to the intrusion alarm system.
 5. Keypads shall be able to arm and disarm the intrusion alarm system
 6. Once armed, any motion detector, door contact, glass break, etc shall both cause the audible sounder to sound and call the central station.
 7. The control panel shall be capable of supporting Dynamic Host Communication Protocol (DHCP) Internet Protocol (IP) addressing.
 8. The control panel shall be capable of two-way network communication using standard Ethernet 10BaseT in a LAN, WAN, or Internet configuration.
 9. Provide an addressable intrusion alarm control panel complete with enclosure, power supply, door lock, etc.
 10. The panel must support up to 599 addressable points.
 11. The panel must be able to support 16 independent partitions.
 12. Provide with battery back up and battery harness for a minimum of 4 hours.
 13. Provide Bosch B9512G series or approved equal. Include D9127U expansion module and B430 phone module.
 14. Include D122 battery harness and D126 12V/7AH battery.
- B. Intrusion Alarm Keypad
1. Provide multi character platinum keypad as shown on the drawings.
 2. The keypads can be used to both arm and disarm the intrusion system.
 3. Provide Bosch B920 32 character LCD keypad.
- C. PIR Motion Detectors
1. Provide motion detectors of "home run" type as shown on the drawings. Sensors shall process their signals independently and shall have coverage patterns individually adjustable.
 2. Each PIR shall be wired to the intrusion alarm system.
 3. Provide long range detectors as shown on the plans and as required.
 4. Wiring connections shall be made in equipment cabinets. Conductors other than that of detector will not be allowed at each device. Detectors shall not be wired in series or with door contacts. There shall be no exposed wiring leading to/from detectors.
 5. Catalog, model and type numbers itemized herein for motion detectors are those of DSC.
 6. Detectors shall be mounted on ceiling type wiremold box.
 7. Fields of view that are directed at heat sources such as fans, radiators and other areas that may cause false alarms shall be masked out.
Provide Bosch models ISC-PPR1-W16 with POP IT module wall or DS9360 ceiling based on location/type.
- D. Door Contacts/switches
1. Provide recessed door contacts/switches as shown on the drawings. Contacts shall be 3/4 inch and have wire leads of sufficient length for splices to be made in wiremold box or mud type box located adjacent to door. Provide GE model #1076C or approved equal for interior doors. Provide DPDT contacts for all exterior doors, GE model #1076-D or approved equal.
 2. In event that circumstances prevent the use of recessed contacts in some locations, surface contacts may be used, subsequent to approval of Architect.

3. Wiring for door contacts shall be concealed.
 4. Door contacts shall not be wired in series with exception of double doors which may be wired to panel as single door location.
 5. There shall be no splices in door frames or jambs. Door contact connections shall be made in wiremold or mud switch box located adjacent to door.
 6. Provide one (1) addressable input POP IT (D127U) module per door contact or set of door contacts.
- E. Overhead Door
1. Overhead door contact as shown on the drawings. Provide one (1) input module per device.
 2. Provide Sentrol 2200 series or approved equal.
- F. Addressable Input Module
1. Provide single input module devices for all non-addressable inputs (motions, door contacts, glass break detectors, duress button, etc).
- G. Indoor Security Siren.
1. Provide interior security siren(s) as shown on the drawings.
- H. Outdoor Security Siren:
1. Provide outdoor siren(s) as shown on the drawings. The horn shall draw 550ma at 12VDC.
 2. Provide Ademco 748LC or approved equal.
- I. Central Station Monitoring: Provide monitoring at a UL Listed central station for a period of one year.

2.6 INTEGRATED COMMUNICATION AND DOOR SYSTEM

- A. Systems Description – Based upon Aiphone IS Series IP Based (CAT-5e/CAT-6) system
1. The system is a combination audio and video intercom system. Intercom stations and intercom master stations shall be audio and video intercom system.
 - a. The system shall include indoor IS-MV master stations as shown on the plans, IS-DF outdoor wp stations as indicated on drawings. Connect to the security PoE switches furnished under this section.
 2. The purpose of the building security intercom system shall be to provide clear, two-way, remote reply intercommunication between the intercom master stations and remote intercom stations.
 3. System shall be a direct-selection type with an individual electronic push button and LCD image display, on the master consoles. Shall also include a handset for direct voice communications with outside stations. Also include PTZ and brightness control, door release button, 6 speed dial buttons.
 4. System shall include a central control unit that all master stations and remote door stations connect to via Cat-5e/6 cabling.
 5. Scope of system shall include all features and functions described herein and all equipment shown on the plans. System shall be capable of adding optional features and components listed in specifications, even if not initially included or shown on the plans.
 6. The extent, size, locations, and layout of the system shall be as shown on the plans.
 7. A complete and operational system shall be provided.

- B. Acceptable Manufacturers
 - 1. Must be equal in performance to the specified system:
 - a. Aiphone IS Series
 - b. Genetec
 - c. Or equal

2.7 IESS INTEGRATION

- A. Interface and Integration between Access Control, CCTV, Intrusion Alarm, Public Address, and Telephone System.
 - 1. Access Control System Keypads, Readers, etc. shall provide ability to Arm and Disarm the entire Intrusion Alarm System or specific zones.
 - 2. Access Control System Keypads, Readers, etc. shall provide ability to Arm and Disarm any individual areas in the Intrusion Alarm System.
 - 3. Intrusion Alarm System devices (i.e. motion sensors, door contacts, glass break detectors, etc.) shall be interfaced to the access control system via dry contacts. Any breach of the access control system will trip the intrusion system and dial out an alarm event.
 - 4. Activate alarm siren signal over(if shown) and activate Public Address speakers with pre-recorded message when Intrusion Alarm System trips.
 - 5. When Access Control System Keypads, Readers, etc. are used, provide ability to turn-on or go to full motion video, the associated CCTV Camera Recorder.
 - 6. When door release is detected on entry or exit, provide ability to turn-on or go to full motion video, the associated CCTV Camera Recorder.
 - 7. CCTV Camera devices and locations shall be graphically displayed on the Access Controls System's built-in Graphical Designer software for display on associated PC Workstation.
 - 8. When exterior door intercom station is activated, provide ability to turn-on or go to full motion video, the associated CCTV Camera Recorder.
 - 9. Access Control System Keypads, Readers, Door Lock, etc.. locations shall be graphically displayed on the Access Controls System's built-in Graphical Designer software for display on associated PC Workstation.
 - 10. Special Entry: If a person needs a one-time entry to the facility for a particular time and day, a Access Control Keypad entry code number can be given to that person that will only work for the specific time frame; in addition, the code can automatically disarm associated intrusion alarm zone or zones in the system.
 - 11. Emergency Codes can be used via Access Control System Keypad Entry, with capabilities to automatically notify authorities of a emergency situation, a hostage type entry, etc.
 - 12. Photo ID Bagging Capabilities Built-in to Access Control System, allowing owners the capability to develop their own Photo ID Badges.
 - 13. Access Control Systems can interface with LAN's & WAN's to provide seamlessly integrated solutions when additional facilities add access control solutions.
 - 14. When Exterior Door Intercom Stations are properly interfaced to the Telephone System Display Telephones for unique call-in ID and two-way communications, and the telephone system provides output closures (one for each controlled door) when "door release codes" are entered via the telephone's keypad, provide ability to interface these door release code closures to Access Control System for release of each associated door.
 - 15. The CCTV system shall provide "Recording-on-Motion" feature for every camera in the CCTV System. Only recording when the system detects motion in the view of each camera.
 - 16. Provide interface port for interfacing to Fire Alarm System.
 - 17. Provide interface port for interfacing to Elevator Door Access.

PART 3 - EXECUTION

3.1 GENERAL

- A. Verify the exact location prior to bid of all items that may be indicated and determine exact location of all electrical items that are not indicated on the Drawings.
- B. Include the cost of all work including sub-letting of any work that may be required to complete the work indicated in order to avoid work stoppages and jurisdictional disputes. The work to be sublet shall conform with precedent agreements and decisions of record. Jurisdictional assignment shall be a responsibility under this Section's contractual obligation.
- C. Do not install equipment and materials which have not been reviewed by the Architect. Equipment and materials which are installed without the Architect's review or without complying to comments issued with the review shall be removed from the project. No payment will be made for unapproved or removal if it is ordered removed. The Installer shall be responsible for any ancillary costs incurred because of its removal and the installation of the correct equipment and materials.
- D. Obtain detailed information on installation requirements from the manufacturers of all equipment to be furnished, installed or provided. At the start of construction, check all Contract Documents, including all Drawings and all Sections of the specifications for equipment requiring electrical connections and service and verify electrical characteristics of equipment prior to roughing.
- E. Equipment and systems shall not be installed without first coordinating the location and installation of equipment and systems with the General Contractor, AHJ and all other Trades.
- F. Any and all material installed or work performed in violation of above requirements shall be re-adjusted and corrected by the Installer without charge.
- G. Refer to all Drawings associated with the project, prior to the installation or roughing-in of the electrical outlets, conduit and equipment, to determine the exact location of all outlets.
- H. After installation, equipment shall be protected to prevent damage during the construction period. Openings in conduits and boxes shall be closed to prevent the entrance of foreign materials.
- I. Home runs indicated are not to be combined or reduced without written consent from the Architect.
- J. All connections to equipment shall be made as required, and in accordance with the approved submittal and setting drawings.
- K. Delivery, Storage and Handling:
 - 1. Deliver, store, protect and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.
 - 2. Deliver equipment in individual shipping splits for ease of handling, mount on shipping skids and wrap for protection.
 - 3. Inspect and report concealed damage to carrier within specified time.

4. Store in a clean, dry space. Maintain factory protection or cover with heavy canvas or plastic to keep out dirt, water, construction debris, and traffic. Heat enclosures to prevent condensation. Meet the requirements and recommendations of NFPA 70B and the Manufacturer. Location shall be protected to prevent moisture from entering enclosures and material.
5. Handle in accordance with NEMA and the Manufacturer's recommendations and instructions to avoid damaging equipment, installed devices and finish.
6. The equipment shall be kept upright at all times. When equipment has to be tilted for ease of passage through restricted areas during transportation, the Manufacturer shall be required to brace the equipment suitably to insure that the tilting does not impair the functional integrity of the equipment.

L. Site Observation:

1. Site observation visits will be performed randomly during the project by the Engineer. Reports will be generated noting observations. Deficiencies noted on the site visit reports shall be corrected. All work shall comply with the Contract Documents, applicable Codes, regulations and local Authorities whether or not a particular deficiency has been noted in a site visit report.
2. Be responsible to notify the Engineer and AHJ ten working days prior to closing in work behind walls, raised access floors, ceilings, etc., so that installed work can be observed prior to being concealed.
3. Work concealed prior to observation and correction of deficiencies shall be made accessible for review at the discretion of the Architect. Bear all costs for allowing worked to be reviewed.
4. Areas shall stay accessible until deficiencies are corrected and accepted. Notify the Architect when all deficiencies are corrected. Return reports with items indicated as corrected prior to re-observation by the Architect.

M. Project Open House:

1. If the Owner elects to have an open house at the end of the project, provide assistance to the Owner. Cooperate and provide manpower to operate and demonstrate systems during the open house as requested by the Owner. Coordinate open house with superintendent of schools.

N. Change Orders, Modifications, Revisions and Directives:

1. When change orders, modifications, revisions or Architect's Directives are issued or authorized, provide the required additional material, equipment, personnel and workers to prevent delays in the work, and to complete the work within the time limit of the Contract unless a specific time extension is requested with the change and accepted. Include costs for expediting deliveries where required.
2. Requests for additional compensation shall be submitted broken down and associated by item, tasks and Drawing or sketch number with material and labor costs, so quantities can be easily verified.
3. Requests shall be properly and adequately identified so the scope of work can be clearly determined. Indicate who originated change in work.
4. Submit on all credits broken down as requested for adds. Credits shall be separately identified and accounted for. Do not indicate as net changes with adds.
5. Unit costs for labor and material shall be equal for adds, deletes and credits.

3.2 WORK

- A. Loose materials shall not be stored on-site. A "gang box" is acceptable to be placed in a location agreeable to the Owner and the General Contractor. The Installer is responsible for all equipment and materials and for their delivery until the system is accepted by the Owner.

- B. A trailer may be used for the storage of materials to be located on the Owner's property at a location designated by the Owner and the General Contractor. Such on-site storage shall be kept locked by the Installer. Security for the trailer and its contents shall be strictly the responsibility of the Installer.
- C. Protect existing in spaces where work is being performed to protect it from damage and from the accumulation of dirt.
- D. Any ceilings, walls, floors, furniture, equipment, furnishings, etc., damaged by the work of this Section shall be replaced, or at the Owner's option, repaired with similar materials, workmanship and quality.
- E. This contractor is responsible for coring through any existing firestopping where using sleeves that have been firestopped to run new wiring. Provide new firestopping where firestopping was removed for new wiring.
- F. Work includes field survey of existing conditions, systems, equipment and tracing of existing circuits in order to determine scope of work.
- G. Clean and touch up all equipment, materials and work sites at the completion of work in each area.
- H. Certain portions of the work area may be occupied during construction. Determine which areas and schedule work accordingly and include necessary premium time.
- I. Make sure necessary provisions to provide continuous service of all existing systems throughout all occupied areas.

3.3 EQUIPMENT RACKS, CABINETS AND BRACKETS

- A. Securely mount equipment racks, cabinets and wall mounted relay brackets to the building structure. Proper supports such as 3/8 in. lag screws and expansion anchors shall be used. Proper quantity of supports shall be utilized. Dry wall screws and other types of supports not specifically approved to support equipment are specifically prohibited. Submit mounting supports for approval before installation.
- B. Position racks, cabinets, and wall mounted relay brackets in order to have minimum 3 foot clearance for easy access. Equipment racks, cabinets and relay brackets mounted on or against walls shall have 3 foot clearance in front of deepest component. Free standing equipment racks and cabinets shall have 3 foot clearance in front and rear of deepest components. Provide 3 foot clearance between free standing equipment racks or cabinets and any other obstruction to allow access from front to rear of rack or cabinet for maintenance.
- C. The Electrical Subcontractor shall provide cable tray over each rack and cabinet as required to facilitate a neat and orderly installation of cables and to secure the top of the racks to the structure. Cables shall drop straight down to equipment racks. Cable trays shall be secured at both ends to the structure and connected together as required for a complete contiguous installation. Utilize listed supports to support the cable tray to the building structure as well as the equipment rack and cabinet. Submit mounting supports for approval by Engineer and AHJ before installation.
- D. Install terminating components such as patch panels (UTP, Fiber optic); cable management, etc. into the racks, cabinets and wall mounted relay brackets.

- E. Patch Panels: Mount patch panels onto the rack(s) in top-to-bottom fashion with the first patch panel mounted at the top of the rack. Uniquely label each patch panel according to the numbering convention outlined in the SECTION on labeling. Each port shall also have color coded identifiers. Refer to details on the Drawings.
- F. Cable Management: All cables shall enter the wiring closet to within the equipment racks and/or brackets. Secure the bundle(s) to the rack strain relief and wire management behind the patch panels and cross connect block panels. Install horizontal and side-mounted vertical cable management panels and brackets for routing and management of patch cables. Maintain EIA/TIA and BICSI standards on bundling, supporting and bend radii.
- G. Once the cabling system has been installed and terminated, install all active components and surge protected power strips into the racks, cabinets and wall mounted relay brackets.
- H. Surge Protected Outlet Strips: Mount UPS and surge protected outlet strips per Manufacturer's directions. Refer to details on the Drawings for mounting location.

3.4 TERMINATIONS

- A. All copper or fiber conductors of every cable shall be completely terminated at both ends.

3.5 CABLE PATHWAYS

- A. Provide all equipment and cabling for a complete installed operating system. In general, pathways, outlet boxes and grounding are provided by the Electrical Subcontractor. CAT 6 Ethernet cables for all CCTV locations are provided by the I.T. Sub-Contractor.
- B. All pathways provided under this Section shall comply with fill capacities as per Code, EIA/TIA 569A and BICSI.
- C. Cable bending radius shall not be less than minimum required by EIA/TIA and BICSI.
- D. Cabling installed concealed shall be supported from the building structure (e.g. cable trays, snake tray) hook and loop (velcro).
- E. Cables shall be installed no closer than 12 inches (305mm) to electrical equipment and wiring. When cables are required to cross power wiring, they shall only do so perpendicular to the power wiring. Telecommunications cabling and power wiring shall only cross each other the minimal number of times as required due to building design limitations.
- F. Clearances: Clearances between cabling and other building systems as required by EIA/TIA 569A and BICSI shall be maintained throughout the building.
- G. All cables shall be installed in a neat and workman-like manner. Cables shall be installed parallel and perpendicular to building elements.
- H. Provide expansion fittings and adequate cable slack at all building expansion joints.
- I. Fire/smoke seal all conduits, raceways, sleeves, slots etc. where cables pass from one location to another, provided by electrical subcontractor.

3.6 CABLE SUPPORTS

- A. Provide strain relief hardware for backbone cables at each floor level as they pass from one floor to the next.
- B. Provide hook and loop (Velcro) cable wraps at all panels, equipment racks and cabinets. Cable ties are specifically prohibited.
- C. Hook and loop (Velcro) cable wraps shall be used. Cable-ties are specifically prohibited for fiber optic cables.
- D. When pathways are not provided or specified, provide hook and loop (velcro) supports from the building structure as required for cable runs to the cable drop location. Maximum distance between supports shall be three feet. Maximum number of cables per support shall be thirty. Provide additional supports as required when cable quantities exceeds thirty and to maintain required bending radius of cables. Cables installed exposed or in areas subject to abuse (below 10 feet (3m) above finished floor) or in accessible areas shall be installed in conduit.
- E. All cables shall be supported directly from building structure. Under no circumstance shall cable be installed using cross bracing, plumbing/sprinkler pipes, ceiling systems or any other system that is not a specifically approved method to independently support cables. Cables shall not be allowed to rest on ceiling tiles, duct work, piping, etc. Supports shall be provided as required in order for cables to avoid contact with any other building system. Bundle cables in groups by room and floor.

3.7 CABLE PROTECTION

- A. Provide bushings in all metal studs and the like where cables will pass through. Bushings shall be of two (2) piece construction with one piece inserted through the opening and the second piece locking it into place. Single piece bushings with locking tabs or friction fit are specifically prohibited.
- B. Cables to be installed in existing enclosed open bays or furred spaces where conduit stubs are not provided shall be protected from chafing or any damage. The Installer shall verify that the warranty shall not be violated before installing any cabling in these locations.
- C. Provide cutting, coring, sleeves and bushings and seal as required at all penetrations.
- D. Cables damaged during installation or construction shall not be repaired. They shall be completely replaced with new cable.

3.8 INSTALLATION

- A. All cabling shall be installed in conduit where indicated on plans, or shall be installed open using other methods, approved by city electrician and engineer, such as cable tray & snake tray.
 - 1. Install wiring, per manufacturers recommendations.
 - 2. All wiring shall be new, concealed in pipe where exposed.
 - 3. Install wiring for detection and signal circuit as specified. Make wiring connections to new or existing door hardware devices as required.
- B. All conduits, raceways, innerduct, etc. shall have pull strings remaining after cable is pulled.

- C. Impedance and Level Matching:
 - 1. Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

- D. Control Circuit Wiring:
 - 1. Install control circuits in accordance with NFPA 70 and as indicated. Provide number of conductors as recommended by system manufacturer to provide control functions indicated or specified.
 - 2. All housings are to be located as specified and shown on drawings.
 - 3. Make installation in strict accordance with approved manufacturer's drawings and instructions.
 - 4. The Installer shall provide necessary transient protection on the AC power feed, all station lines leaving or entering the building, and all central office trunks. All protection shall be as recommended by the equipment supplier and referenced to earth ground.

- E. Splices, Taps, and Terminations:
 - 1. Make splices, taps and terminations on numbered terminal punch blocks in junction, pull, and outlet boxes, terminal cabinets and equipment enclosures.
 - 2. Identification of Conductors and Cables:
 - a. Use color coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams.

- F. Weatherproofing:
 - 1. Provide weatherproof enclosures for items to be mounted outdoors or exposed to weather.

3.9 GROUNDING

- A. General:
 - 1. The Telecommunications systems comprising of cable tray, snake tray, equipment cabinets, racks and non-current carrying metallic parts shall be grounded according to the National Electrical Code.
 - 2. In general, the grounding shall be as specified, as indicated on the Drawings and as required by the Electrical Code.

- B. Methods:
 - 1. Provide equipment grounding connections for integrated sound, voice and video systems as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.
 - 2. Ground equipment, conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.
 - 3. The installer shall provide all necessary transient protection on the AC power feed and on all station lines leaving or entering the building.
 - 4. The installer shall note in his system drawings, the type and location of these protection devices as well as all wiring information.
 - 5. The installer shall furnish and install a dedicated, isolated earth ground from the central equipment rack and bond to the incoming electrical service ground buss bar.

- C. Telecommunications Grounding
 - 1. Raceways including wireways, conduits, cable trays, snake tray, etc. installed for low voltage or fiber optic cabling shall be made electrically continuous for grounding purposes. Provide hollow braided copper jumpers between sections equal to Belden No. 8669 (60A Ampacity). Provide equal impedance conductor for aluminum raceway.
 - 2. Bond raceways to the ground bus located in the equipment cabinet. Bond raceways in each room they terminate in.

- D. Telecommunications Equipment Bonding & Grounding
 - 1. Provide grounding and bonding as required by EIA/TIA-607 standards, codes and the equipment manufacturers.
 - 2. Make final grounding conductor connection to cabinet around bus.
 - 3. Each individual piece of equipment shall have an individual grounding conductor to the ground bus within the cabinet.
 - 4. All equipment shall have bonding jumpers between them (i.e. between cable tray, snake tray and equipment rack, etc.).
 - 5. Equipment integral to an equipment rack (i.e. shelves, panels, cable management, etc.) shall be considered bonded.
 - 6. Equipment that is not integral to an equipment rack (i.e. shelf mounted electronic equipment, cable tray, snake tray, etc.) require individual bonding jumpers between the equipment and the rack.
 - 7. Properly clean and prepare all surfaces for a complete bonding and grounding termination.
 - 8. Install grounding bus in all equipment racks and cabinets.

3.10 SLEEVING AND BUSHINGS

- A. Raceways and openings shall be laid out in advance to permit their provision in the work. Sleeves and raceway shall be set before new masonry is constructed. Any extra work required where sleeves or raceways have been omitted or improperly placed shall be performed at the expense of the Installer which made the error or omission, including coring.
 - 1. Existing Construction: Where raceways and cable pathways must pass vertically through existing construction, coring shall be located as per the guidelines shown on the drawings.

- B. Provide sleeves for raceways, busways, snake trays and cable trays penetrating floors, fire walls, or smoke partitions. Install approved material to provide for fire stop.

- C. Provide waterproof seals inside and outside raceway when penetrating from the exterior or underground.

- D. Except where specified otherwise sleeves shall be made of galvanized metal to finish flush with building finish lines.

- E. Provide acoustic sealer in sleeves between occupied spaces.

- F. Sleeves installed in floors shall extend ten inches above the finished floor unless specifically indicated otherwise. Sleeves for busways shall extend four inches (100mm) above the floor.

- G. Provide sleeves in masonry construction and in full height (slab to slab) walls.

- H. Provide sleeves for any openings requiring fireproofing.

- I. Bushings in all conduits shall be provided by the Electrical Subcontractor in all metal studs and other openings where cables will pass through. Bushings shall be of two piece construction with one piece inserted through the opening and the second piece locking it into place. Single piece bushings with locking tabs or friction fit are specifically prohibited.

3.11 INTEGRATED SECURITY SYSTEM TESTING

- A. Security Management System
 1. Test in accordance with manufacturer's security management systems testing procedures.

3.12 TRAINING

- A. As a minimum training sessions shall consist of the following:
 1. General project information and review shall be by the General Foreman or Superintendent of the Trade.
 2. Specific system training shall be by a Factory Trained Representative.
 3. Provide a complete review of the project and systems including, but not limited to, the following:
 - a. In a classroom environment review each Record Drawing (use of typical is acceptable).
 - b. Note equipment layouts, locations and control points.
 - c. Review each system.
 - d. Review system design operation and philosophy.
 - e. Review alarms and necessary responses.
 - f. Review standard troubleshooting techniques for each system.
 - g. Review areas served by equipment.
 - h. Identify color codes used.
 - i. Review features and special functions.
 - j. Review maintenance requirements.
 - k. Review operation and maintenance manuals.
 - l. Respond to questions (record questions and answers).
 4. After classroom training, walk the entire project, review each equipment room and typical locations. Explain equipment and proper operation.
- B. During the instruction period the Owner and Maintenance Manual shall be used and explained.
- C. The Owner and Maintenance Manual material shall be bound in 3-ring binders and indexed. On the edge of the binder provide a clear see-through plastic holder with a typed card indicating the Project name, the Architect's name, the installer's name and the Volume number (e.g., Vol. No. 1 of 2).
- D. Provide name, address and telephone number of the manufacturer's representative and service company for all items supplied so that the source of replacement parts and service can be readily obtained.
- E. Include copies of manufacturers and installer's warranties and maintenance contracts and performance bonds properly executed and signed by an authorized representative.
- F. Include copies of all test reports and certifications.

- G. Providers of the IESS System shall provide training as part of their package. This comprehensive training plan shall address the following areas:
 - 1. Training, providers of the IESS System shall provide (80) hours of training as part of their package, this comprehensive training plan shall address the following areas:
 - a. System Orientation for all involved staff members.
 - b. Small group hands-on training sessions for all media center staff focusing on system-wide hardware and troubleshooting.
 - c. Small group hands-on software training sessions for all media center staff.
 - d. Small group hands-on sessions covering classroom media control equipment for all instructional staff.
 - e. Small group hands-on software training sessions for all instructional staff.
 - f. Follow-up training for media center staff.
 - g. Follow-up training for all instructional staff.
 - h. System Orientation for all Involved Staff Members, providers of the Media Management System shall provide a eight-hour orientation session for the entire school community prior to the system turnover date. This orientation session shall include a full demonstration of the systems working capabilities. The demonstration shall only include those features and functions that were specified. The equipment demonstrated shall be exactly the equipment installed at the facility.
- H. The Security Management System Integrator shall coordinate with the System Administrators for two 8 hour Operator training sessions on the Operational System to be conducted on-site on the actual running system. Include city electrician and director of public services and engineering.
- I. Contractor shall be required to video tape training sessions with Owners staff and provide one copy to the school dept. and one copy to the DPW.

3.13 ACCEPTANCE DEMONSTRATIONS

- A. Systems installed under this Section shall be demonstrated to the Owner and Architect. Demonstrations are in addition to necessary testing and training sessions. Notify all parties at least 7 days prior to the scheduled demonstration. Schedule demonstrations in cooperation with and at times convenient to all parties and so as to not disturb ongoing activities.
- B. Systems shall be tested prior to the demonstrations and each system shall be fully operational and tested prior to arranging the Acceptance Demonstration. Final payments will be withheld until a satisfactory demonstration is provided for all systems indicated or requested.
- C. If the demonstration is not totally complete, performing all functions, features and connections or interfaces with other systems, or if there is a failure during the demonstration, additional demonstrations shall be arranged. Provide and pay for all costs, labor and expenses incurred for all attendees for each additional demonstration required for acceptance and demonstration of complete system operation.
- D. Demonstrations shall be scheduled in ample time to complete all activities prior to final acceptance and Owner occupancy. Demonstrations shall take place at least 45 days prior to the scheduled project completion date and 45 days prior to owner's use and occupancy.
- E. The city electrician shall be trained and factory certified to operate the systems.

- F. As a minimum, provide demonstrations for systems indicated under "Work Included" under Part One of the Specifications. Provide demonstrations of additional systems as requested by the Owner, or City Electrician.

3.14 PROJECT OWNER COORDINATION

- A. Prior to Substantial Completion of the project and in ample time to address and resolve any coordination issues, request and arrange meetings between the Owner, Owner's Vendors and Consultants, Architect and General Contractor to discuss the Scope of Work for each system being provided and the interface required for a fully functional and operational system upon project completion. Initial meetings shall be scheduled three months prior to the scheduled Substantial Completion date or as soon as Submittals are submitted and reviewed for projects with shorter schedules.
- B. At these meetings the required interface with the Owner shall be reviewed, requests for information required to complete programming or for coordination shall be presented and system operation and philosophy shall be discussed.
- C. Additional meetings shall be held as requested by any party so that all issues are resolved and with the goal and intent being that all systems are fully operational and functional upon project Substantial Completion and that the responsibility for all components required is clearly established.

3.15 CLEANING UP

- A. Upon completion of all work, and testing, thoroughly inspect all exposed portions of the installation and completely remove all exposed labels, markings, and foreign material.
- B. The interior of all boxes and cabinets shall be left clean; exposed surfaces shall be cleaned and plated surfaces polished.
- C. Repair damage to finish surfaces resulting from work under this Section.
- D. Remove material and equipment from areas of work and storage areas.
- E. All equipment shall be clean from dirt, dust, and fingerprints prior to final acceptance.
- F. Touch up all damaged pre-finished equipment using materials and methods recommended by the Manufacturer.

3.16 PROJECT CLOSEOUT

- A. Provide close out submittals as required herein and in SECTION 017700 - PROJECT CLOSEOUT including but not limited to the following close out submittals.
 - 1. Operation and Maintenance Manuals
 - 2. Record Drawings.
 - 3. Test Reports.
 - 4. Extra Materials.
- B. Obtain written receipts of acceptance close out submittals submitted. Receipts shall specifically detail what is being delivered (description, quantity and specification section) and shall be dated and signed by firm delivering materials and by the Owner.

- C. All sketches, drawings, and charts herein are for the purpose of providing for specifications in a simplified format. Errors and omissions in such does not relive the Contractor of the responsibility for providing a fully complete, secure and properly operating IESS suitable for the intended use. Bidders must obtain a complete set of Project Drawings and Specifications to determine the full scope of work. In case of conflict the Project Drawings and Specifications shall prevail.

END OF SECTION

SECTION 311000

SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Site preparation, including obtaining and paying for all construction permits necessary for execution of the Work.
2. Protecting existing vegetation to remain.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing existing above and below-grade site features.
6. Removing existing bituminous pavement, curbing, and gravel within limits of work.
7. Disconnecting, removing, capping or sealing existing site utilities.
8. Temporary erosion and sedimentation control measures.

1.2 MATERIAL OWNERSHIP

- ###### A.
- Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.3 QUALITY ASSURANCE

- ###### A.
- Regulatory Requirements: Comply with applicable requirements of federal, state and local laws, regulations and codes having jurisdiction at the project site.
- ###### B.
- Comply with City of Dover Construction Standards, latest Edition.
- ###### C.
- Comply with City of Dover Fugitive Dust Ordinance.
- ###### D.
- Comply with the City of Dover Site Plan Permit Conditions. In the event that the Permit Conditions are in conflict with technical specifications, the more stringent requirement shall prevail.

1.4 PROJECT CONDITIONS

A. Inspection

1. Examine areas for conditions under which work is performed. Report in writing to OWNER'S Representative all conditions contrary to those shown on the Drawings or specified herein and all other conditions that will affect satisfactory execution of work such as improperly constructed substrates or adjoining work. Do not proceed with work until unsatisfactory conditions have been corrected.

2. Starting work constitutes acceptance of conditions under which work is to be performed. After such acceptance, CONTRACTOR shall, at the CONTRACTOR's expense, be responsible for correcting all unsatisfactory and defective work resulting from such unsatisfactory conditions.
- B. Nuisances: Keep dirt, dust, noise, and other objectionable nuisances to a minimum. Use temporary enclosures, calcium chloride, coverings, and sprinkling, or combinations thereof, as necessary to limit dust to lowest practicable levels. Do not use water to the extent that it causes flooding, contaminated runoff, or icing. Submit dust control and street sweeping plan or air ventilation plan as indicated. Comply with work hours stipulated by the Town of Northfield.
- C. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner's Representative and authorities having jurisdiction.
 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner's Representative or authorities having jurisdiction.
- D. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises at location identified on Contract Drawings.
- E. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.
- F. Protections:
 1. Protect bench marks from displacement.
 2. Maintain access to site at all times.
 3. At active school sites, during demolition, maintain access to emergency egresses from existing buildings as indicated on the Contract Drawings.
- G. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place in accordance with the Contract Drawings.
- H. The following practices are prohibited outside limits of work identified on Contract Drawings, unless otherwise indicated/approved by the Owner's Representative:
 1. Stockpiling or storage of construction materials, debris, or excavated material.
 2. Parking vehicles or equipment.
 3. Erection of temporary sheds or storage structures.
 4. Impoundment of water.
 5. Excavation or other digging.
 6. Attachment of signs to, or wrapping materials around, trees or plants.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Division 31 Section "Earth Moving."

1. Obtain approved borrow soil material from off-site when satisfactory soil material is not available on-site.
- B. Mulch Material: Shall conform to Section 645 of NHDOT Specifications.
- C. Hay or Straw: Shall be dry, free of mold and weed seeds.
- D. Matting: Shall conform to Section 645 of NHDOT Specifications.
- E. Mulch Anchoring: When mulch must be held in place, mulch anchoring materials shall be used, consisting of mulch netting (paper, twine, plastic, or plastic and wood fiber).
- F. Fertilizer: Complete fertilizer 12-25-12 (standard product)
- G. Lime: Ground limestone containing not less than 85% total carbonates (calcium or magnesium).
- H. Filter Fabric: Shall be 4oz. non-woven geotextile with the following properties:

PROPERTY	TEST	VALUE
Weight	ASTM D3776	4.0 oz/yd ²
Thickness	ASTM D1777	50 mils
Apparent Opening Size	ASTM D4751	70 US std sieve
Grab Tensile	ASTM D4632	100 lbs.
Puncture Resistance	ASTM D4833	50 lbs.
Mullen Burst	ASTM D3787	170 psi
Water flow rate	ASTM D4491	150gpm/ft ² (min.)

Products that meet these minimum requirements include but are not limited to: Mirafi 140N, Amoco 4504, and Trevira 1114.

The geotextile shall be produced as to be free of tears, or any sign of contamination by foreign matter, and shall be of uniform thickness throughout the roll.

- I. Silt Fence: Shall conform to Section 645 of NHDOT Specifications.
- J. Existing Catch Basin Protection: Shall be protected with 4oz. non-woven geotextile and 1½" stone as shown on the Contract Drawings or using alternative pre-manufactured controls, approved by the Owner's Representative.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Verify that survey benchmark and intended elevations for the work are as indicated on Drawings. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Coordinate notification of parties outlined in Permit Conditions prior to construction start-up.
- C. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated.

1. Layout, using grade stakes or flagging, limits of clearing prior to the start of construction for review by Owner's Representative.
- D. Protect existing site features and improvements to remain from damage during construction.
1. Restore damaged improvements to their original condition, as acceptable to Owner's Representative.
- 3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL
- A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to Contract Drawings and requirements of authorities having jurisdiction.
- B. Install temporary erosion and sedimentation control measures prior to the start of construction activities on-site.
- C. Verify that flows of water redirected from construction areas or generated by construction activity do not directly enter City of Dover's closed drainage system along Alumni Drive, Bellamy Road, Durham Road and the connector road to the Dover Middle School.
- D. Divert stormwater runoff away from open excavations to construct site improvements in dry conditions.
- E. Excavation dewatering shall be conducted in accordance with all local and state regulations. Groundwater from excavations shall be pumped to "Dandy Sacks", or approved equal, prior to discharge. Open surface discharges or discharges directly to the existing stormwater drainage system on-site will not be permitted.
- F. Inspect, maintain, and repair erosion and sedimentation control measures, as shown on the Contract Drawings, during construction until permanent vegetation has been established and/or base course of bituminous pavement has been placed.
1. Monitor stormwater discharge for turbidity and adjust erosion and sediment control measures as needed to permit only clean water to enter existing stormwater drainage system.
 2. Maintain clean paved surfaces outside work area to minimize dust and tracking of sediment onto roadways.
- G. Seeding and Mulching: All pre-excavation grassy areas which will remain open shall be seeded and mulched within three days of being backfilled and graded.
- H. Matting: Shall be installed and maintained to the Standards of NHDOT Specifications, Section 645.
- I. Silt Fence: Shall be installed and maintained to the Standards of NHDOT Specifications, Section 645.
- J. Dandy Sack: Shall be installed and maintained in accordance with the Contract Drawings and the manufacturers specifications.
- K. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

- A. General: Protect trees and plants remaining on-site to the fullest extent possible throughout the duration of the project.
- B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by Owner's Representative.

3.4 EXISTING UTILITIES

- A. Notify Dig-Safe at least 72 hours prior to the start of work.
- B. Locate and identify utilities indicated to remain in place.
 - 1. Notify Owner's Representative and applicable utility company immediately if there is a conflict between existing utilities to remain in place and proposed utilities.
 - 2. Contractor is responsible and liable for all damages to utilities.
- C. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Owner's Representative and applicable utility company not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Owner's Representative and applicable utility company written permission.
- D. Verify that utilities which are to be removed, capped or abandoned by others are turned off, disconnected, or rerouted to new locations before starting demolition.

3.5 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
 - 1. Completely remove stumps and roots, obstructions, and debris within the limits of work shown on the Contract Drawings, and as needed to permit installation of new construction.
- B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
 - 1. Place fill material in horizontal layers not exceeding a loose depth of 12 inches, and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

- A. Remove sod and grass before stripping topsoil.

- B. Strip topsoil in a manner to prevent intermingling with underlying subsoil or other waste materials.
- C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water.

3.7 SITE IMPROVEMENTS

- A. Remove existing above and below grade site features as indicated and necessary to facilitate new construction.
- B. Remove existing bituminous pavement within the limits of work. At the edges of bituminous pavement, the pavement shall be saw cut to provide a clean vertical face.
- C. Notify the Owner's Representative and other Contractors working on-site at least 24-hours prior to starting site improvements.

3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.
- B. Remove excavated asphalt to off-site receptor and provide documentation as to destination.
- C. Clean-up windblown litter from project site and adjacent properties and dispose of properly.
- D. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 311000

SECTION 31 13 00

SELECTIVE TREE AND PLANT MATERIAL REMOVAL

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 SUMMARY

- A. The Work of this Section includes, but is not limited to, the following:
 - 1. Protection of existing improvements to remain.
 - 2. Tree and plant material removal and disposal.
 - 3. Post construction clean-up.

1.3 RELATED WORK

- A. Related work includes, but is not limited to, the following work covered in other sections:
 - 1. SECTION 01 56 39 – TEMPORARY TREE AND PLANT MATERIAL PROTECTION
 - 2. SECTION 02 41 19 – SELECTIVE DEMOLITION
 - 3. SECTION 31 20 00 – EARTH MOVING

1.4 REFERENCES

- A. Comply with applicable requirements of:
 - 1. State of New Hampshire, Standard Specification for Roads and Bridge Construction, Department of Transportation, latest edition.
 - 2. City of Dover, of the State of New Hampshire, and of other authorities having jurisdiction. Provide labor, materials, equipment and services to comply with requirements.
 - 2. ASTM: American Society for Testing and Materials.
 - 3. AASHTO: American Association of State Highway and Transportation Officials.
 - 4. AAN: American Association of Nurserymen.
 - 5. ISA: International Society of Arboriculture.
 - 6. ANSI: American National Standards Institute.

1.5 QUALITY ASSURANCE

- A. Tree and shrub removal shall be performed by a certified landscape contractor with a minimum of five years of related work experience and under full time supervision of a qualified supervisor.
- B. Conform to provisions of SECTION 01 40 00 QUALITY REQUIREMENTS.

1.6 SUBMITTALS

- A. Prepare and submit in accordance with SECTION 01 33 00 – SUBMITTAL PROCEDURES.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Deliver and store all products in unopened original manufacturer's packaging. Store all materials in strict accordance with manufacturer's instructions and recommendations. Protect materials from all damage.

1.8 WARRANTY

- A. In addition to the guarantee/warranty requirements of the Contract and General Conditions, the Contractor shall obtain in the name of the Owner the standard manufacturer's guarantee of all materials furnished under this Section where such guarantees are offered in the manufacturer's published product data. These guarantees are in addition to, and not in lieu of, other liabilities which the Contractor may have by law or other provisions of the Contract Documents.

1.9 PROJECT CONDITIONS

- A. General: The Contractor shall visit and accept the site as he/ she finds it, and shall inform him/herself of the character and the type of plant material items to be removed. The Contractor shall walk the site with the Owner's Representative prior to commencing work to determine the full scope of plant materials to be removed and plant materials to remain.
- B. Damage or loss to site improvements shall be at the risk of the Contractor from and after the date of Contract execution, and no such damage or loss shall relieve the Contractor from any obligation under the Contract.
- C. Disposal: Dispose of cleared and grubbed plant material off the site. Burning of materials on the job site will not be permitted.
- D. Traffic: Adjacent building areas, site areas and streets will continue to be used throughout the construction process. Contractor shall use extreme care to protect the safety and welfare of pedestrians and occupants of these areas. Submit pedestrian access plan prior to beginning work.
- E. Conduct operations and removal of debris to ensure minimum interference with the normal use of streets, public ways, and other adjacent facilities. Do not close or obstruct adjacent buildings, loading docks, traffic ways, corridors, streets, walks or other used facilities without the written permission of the Owner and authorities having jurisdiction.
- F. Protection: Existing buildings and traffic ways adjacent to the work site will be occupied during demolition and construction operations. Ensure the safe passage of vehicles and persons in and around the work areas during and after demolition. Prevent injury to persons and damage to property. Immediately repair damaged property to its condition before being damaged.

- G. Protection of Existing Landscaping to Remain: Prior to beginning any work of the Contract on site, take effective action to protect all existing landscaping indicated to remain. Refer to requirements specified herein.
- H. Dust and Noise Control: Take effective measures to prevent windblown dust and to control noise to avoid creating a nuisance. Obtain Owner's Representative and Owner's approval of means, methods and techniques used to control dust and noise. Chemicals deleterious to plant growth may not be used on sub-grades of areas that will be sodded, seeded, or planted. Avoid creating ice hazards in freezing weather.
- I. Utilities: Maintain all utilities except those requiring removal or relocation. Keep utilities in service and protect from damage. Do not interrupt utilities serving used areas without first obtaining permission from the utility company and the Owner. Provide temporary services as required and review interim utility service plan with the Owner and Owner's Representative prior to interruption of service.

1.10 LOCATION OF UTILITIES

- A. The Contractor must verify the location of all utilities in the limit of work before starting work, including but not limited to gas, electric, telephone, storm drainage, sanitary drainage, fiber optic, telecommunication, cable, and water services.

1.11 EXAMINATION OF SITE AND DOCUMENTS

- A. The Contractor shall carefully study the Contract Documents and shall fully inform him/herself of existing conditions of the site before submitting his/ her bid and before starting work. The Contractor shall at once report to the Owner's Representative any errors, inconsistencies or omissions he/ she may discover. The Contractor shall be fully liable to the Owner for any damage resulting from such errors, inconsistencies or omissions in the Contract Documents.
- B. The Contractor shall be fully responsible for carrying out all site work required to fully and properly execute the work of the Contract, regardless of the conditions encountered in actual work. Plans, surveys, measurements and dimensions under which the work is performed are believed to be correct to the best of the Owner's knowledge, but the Contractor shall have examined them for him/herself during the bidding period, as no allowance will be made for any errors or inaccuracies that may be found therein.
- C. On all Project Drawings, figures take precedence over measurements by scale. The Owner's Representative shall decide on questions that may arise regarding the meaning and intent of the Project Drawings and Project Specifications. If any Project Drawings or figures that are necessary for a clear understanding of the Work are omitted, or if any error appears in either Project Drawings or Specifications, or if discrepancies are found between the Project Drawings and Project Specifications, it shall be the duty of the Contractor to notify the Owner's Representative of such omissions, errors or discrepancies, and in no case proceed in uncertainty. If any mistakes arise in consequence of such neglect on the part of the Contractor to notify the Owner's Representative, the Contractor must correct the work at his/ her own expense.
- D. The Contractor shall perform no portion of the Work at any time without the Contract Documents or, where required, Product Data, Samples, or other Submittals for such portion of the Work. No claim for extra compensation or extension of time will be allowed on account of actual conditions inconsistent with those assumed, except those conditions described in the GENERAL CONDITIONS.

1.12 EXISTING UTILITIES

- A. The Contractor shall locate and mark underground utilities to remain in service before beginning work. Markings shall remain throughout the length of the project.
- B. Protect all existing utilities to remain during operations. In work on or around the utilities, follow all rules and regulations of the respective utility. Do not interrupt existing utilities except as authorized by authorities having jurisdiction. Provide not less than 72 hours written notice to Owner if shut down of utility service is required.
- C. Active utilities shall be adequately protected from damage and removed only as indicated on Drawings or as directed by the Owner's Representative. Where active utilities are encountered but not shown on the Drawings, the Contractor shall notify the Owner's Representative immediately in writing. The Contractor shall protect and maintain these utilities until written instructions are received from the Owner's Representative.
- D. Inactive and abandoned utilities and drains encountered in plant material removal operations shall be reported to the Owner's Representative immediately.

1.13 PROTECTION

- A. All local rules and regulations governing the works shall be observed by the Contractor in executing all work under this section.
- B. All work shall be executed in a manner to prevent any damage to existing buildings, streets, pavings, vegetation designated to remain, service utility lines, structures, existing improvements, adjoining property and existing improvements on adjoining property. Protect from damage all utilities that are to remain.
- C. Items to remain and existing improvements that are damaged shall be restored to their original condition that is acceptable to the Owner's Representative and parties having jurisdiction. Restoration work shall be at no cost to the Owner and parties having jurisdiction.
- D. All work shall be executed using all precautions necessary to assure safety.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide all materials, equipment, and supplies as required to completely perform the work specified herein and as shown on the Drawings.

2.2 PROTECTION OF DRAINAGE

- A. Refer to SECTION 02 41 19 – SELECTIVE DEMOLITION.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Inspect all parts and conditions of the area under which SELECTIVE TREE AND PLANT MATERIAL REMOVAL AND TRIMMING must be performed. Report in writing to the Contractor, with a copy to the Owner's Representative, any conditions which might adversely affect the

installation. Do not proceed with the installation until defects have been corrected and conditions are satisfactory.

3.2 PROTECTION OF EXISTING PLANT MATERIAL TO REMAIN

- A. Do not commence SELECTIVE TREE AND PLANT MATERIAL REMOVAL, SELECTIVE DEMOLITION or any other construction activity until tree and plant material protection fencing has been installed as specified in SECTION 01 56 39 – TEMPORARY TREE AND PLANT MATERIAL PROTECTION.
- B. Refer to SECTION 01 56 39 – TEMPORARY TREE AND PLANT MATERIAL PROTECTION for requirements of tree protection including but not limited to tree protection, fertilization, watering compaction and replacement criteria.
- C. Temporary access within tree protection areas is permitted to perform tree and plant material removal as described on the Drawings. All work within tree protection areas shall be performed by hand or with small equipment that will not damage or threaten damage to trees. All tree protection fencing shall be restored at the end of each day's operation.

3.3 PROTECTION OF EXISTING IMPROVEMENTS

- A. The Contractor shall provide protections necessary to prevent damage to existing improvements indicated to remain in place and newly constructed improvements on Owner's property.
- B. The Contractor shall protect existing improvements on adjoining properties from any damage.
- C. The Contractor shall restore damaged improvements to their original condition, as acceptable to the Owner's Representative and parties having jurisdiction, at no cost to the Owner and parties having jurisdiction.

3.4 SELECTIVE TREE PRUNING

- A. Prune existing trees to compensate for root loss or damage anticipated or caused by construction activities, whether or not those activities were required to complete the work of this contract. Confer with Owner's Representative prior to start of construction to determine if pruning of any existing trees is necessary. Do not prune vegetation without the written approval of the Owner's Representative. If the Owner's Representative deems pruning necessary, it shall be done in a manner compliant with the American Association of Nurserymen, Horticultural Standards to preserve the natural character of the plant. Remove broken or badly bruised branches with a clean saw cut. All pruning shall be done by skilled, certified arborists in accordance with best horticultural practice, appropriate to the type of plant and to its special or individual requirements. Pruning work that is performed to compensate for root loss or damaged branches, that is not necessary to complete the work of this contract, shall not indemnify the Contractor to take other specified measures to correct and/or compensate the owner for the injury or death of plants.
- B. The Contractor shall repair in a manner acceptable to the Owner's Representative trees and vegetation indicated to remain that is damaged by construction operations.
 - 1. The Owner's Representative shall select a qualified Arborist to inspect the damaged trees and to make a determination on damage, sustainability, and remediation procedures.
 - 2. The Contractor shall strictly adhere to the Arborist's recommendations.
 - 3. The total cost of tree repair, including the cost of the Arborist, shall be borne by the Contractor.

3.5 TREE AND PLANT MATERIAL REMOVAL AND DISPOSAL

- A. Remove and dispose of all trees and plants indicated on the Drawings. Remove stumps and roots completely by grinding or removing in areas indicated to be improved to the limits listed below.

Lawn Areas: 2'-0" minimum below grade
Shrub Beds: 3'-0" minimum below grade
Trees: 4'-0" minimum below grade
Paving: 3'-0" minimum below grade

- B. The Contractor may encounter tree stumps buried below grade. These stumps shall be removed to the limits listed in Paragraph B, above.
- C. All depressions resulting from demolition and removal, if not subject to further earthwork and construction, shall be filled with soil in layers 5" thick compacted to a density equal to adjacent grade to a depth within 6" of finish grade. Loam shall be placed up to finish grade.

3.6 PATCHING AND REPAIRS

- A. Promptly patch and repair holes and damaged surfaces caused to adjacent construction by tree and plant material removal and soil stockpiling operations.
- B. Where repairs to existing surfaces are required, patch to produce surfaces suitable for new materials.
- C. Restore exposed finishes of patched areas and extend finish restoration into adjoining construction to remain in a manner that eliminates evidence of patching and refinishing.
- D. Patch and repair surfaces in the new areas where demolished surfaces extend one finished area into another. Provide a flush and even surface of uniform color and appearance.
1. Closely match texture and finish of existing adjacent surface.
 2. Patch with durable seams that are as invisible as possible. Comply with specified tolerances.
 3. Inspect and test patched areas to demonstrate integrity of the installation, where feasible.
 4. Also refer to SECTION 01 73 29 CUTTING AND PATCHING.

3.7 DISPOSAL OF WASTE MATERIAL

- A. Burning will not be permitted on the Owner's property.
- B. The Contractor shall remove waste materials, unsuitable and excess materials from the Owner's property and legally dispose of off-site.
- C. The Contractor shall submit the dumpsite owner's name and location of dumpsite to the Owner for approval prior to waste removal from project site.

3.8 POST CONSTRUCTION CLEAN-UP

- A. The Contractor shall completely remove all signs of stockpiles of excess or waste materials, or any other vestiges of construction. Disturbed areas shall be graded and filled with approved soil

to a depth of 5" lower than the original contour or new contour as shown on the Drawings. The top layer of soil over the entire area shall be loam 6" thick. The entire area shall be seeded with a lawn seed mix approved by the Owner's Representative.

END OF SECTION

SECTION 312000

EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Preparing subgrades for structures, utilities, pavements, asphalt and concrete walks, turf and grasses, synthetic turf, and plants.
2. Excavating for buildings, structures, utilities, and pavements.
3. Excavating rocks, boulders, solid rubble masonry, and concrete that is less than one cubic yard or more in volume for trench work, and two cubic yards or more in open excavation.
4. Drainage course for concrete structures and slabs.
5. Subbase course and base course for bituminous (asphalt) paving.
6. Backfilling for buildings, structures, utility trenches, and pavements.
7. Replacing excavated or unsuitable material with select fill material, common fill material, or base course material.
8. Complying with compaction requirements.
9. Rough grading.

1.2 DEFINITIONS

A. Backfill: Soil material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the concrete slabs and structures that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Owner's Representative. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.

2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Owner's Representative. Unauthorized excavation, as well as remedial work directed by Owner's Representative, shall be without additional compensation.
- G. Fill: Soil materials used to raise existing grades.
 - H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, precast concrete drainage structures, high density polyethylene drainage structures, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
 - I. Subbase Course: Aggregate layer placed between the subgrade and a cement concrete or hot-mix asphalt surface.
 - J. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
 - K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.
 - L. Topsoil: Friable, fertile, natural, free-draining loam typical of the locality placed over subgrade in vegetated (grassed) areas.
- 1.3 QUALITY ASSURANCE
- A. Preexcavation Conferences: Conduct a conference at the Project site during preconstruction/kickoff meeting.
- 1.4 PROJECT CONDITIONS
- A. Utility Locator Service: Notify utility locator service for area where Project is located before beginning earth moving operations.
- 1.5 SUBMITTALS
- A. Submit 25-lb. samples as requested by Owner's Representative of each type of imported fill material in containers to Engineer.
 - B. Testing and analysis results for backfill and fill materials.
 - C. Source information for backfill and fill materials.
 - D. Provide records of utility locations to Owner's Representative prior to Substantial Completion.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations, as determined by Owner's Representative.
- B. All fill material shall be subject to the approval of the Owner's Representative.
- C. Contaminated soil or fill material to be transported off-site shall not be removed prior to notification and consent of the Owner's Representative.
- D. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 6-inches in any dimension, debris, concrete or other rubble, waste, organic matter, muck, peat, frozen materials, vegetation, and other deleterious matter.
- E. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.
 - 1. Fills: Topsoil; frozen materials; construction materials and materials subject to decomposition; debris; concrete or other rubble; clods of clay and stones larger than 6-inches; organic material, including silts, which are unstable; and inorganic materials, including silts, too wet to be stable and any material with a liquid limit and plasticity index exceeding 40 and 15 respectively.
 - 2. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction, as defined by ASTM D 1557.
 - 3. Existing Subgrade (Except Footing Subgrade): Same materials as 2.1.E.1, that are not capable of direct support of slabs, pavement, and similar items with possible exception of improvement by compaction, proofrolling, or similar methods.
 - 4. Existing Subgrade (Footings Only): Same as 2.1.E.1, but no fill or backfill.
- F. Subbase Material: (Clean Bank Run Gravel)
 - 1. Gravel shall meet the standards of NHDOT 304.2, as listed below:

<u>U.S. Sieve Size</u>	<u>% passing (by weight)</u>
6-inch	100
No. 4	25-70
No. 200	0-12*

*Based on the fraction passing the No. 4 sieve

G. Base Course: (Clean Crushed Gravel)

1. Crushed Gravel shall meet the standards of NHDOT 304.3, as listed below:

<u>U.S. Sieve Size</u>	<u>% passing (by weight)</u>
3-inch	100
2-inch	95-100
1-inch	55-85
No. 4	27-52
No. 200	0-12*

*Based on the fraction passing the No. 4 sieve

H. Compacted Free-Draining Crushed Stone:

1. Compacted Free-Draining Crushed Stone shall meet the standards of NHDOT 304.4, as listed below:

<u>U.S. Sieve Size</u>	<u>% passing (by weight)</u>
2 1/2-inch	100
2-inch	85-100
3/4-inch	45-75
No. 4	10-45
No. 200	0-5

I. Free Draining Sand-Gravel – Crushed Gravel for Structural Fill:

1. Free Draining Sand-Gravel – Crushed Gravel for Structural Fill shall meet the standards of NHDOT Item 508 Free Draining Sand-Gravel – Crushed Gravel for Structural Fill, as listed below:

<u>U.S. Sieve Size</u>	<u>% passing (by weight)</u>
3-inch	100
2-inch	95-100
1-inch	55-85
No. 4	27-52
No. 200	0-12*

*Based on the fraction passing the No. 4 sieve

J. Structural Fill – Bank-run Gravel for Structural Fill:

1. Structural Fill – Bank-run Gravel for Structural Fill shall meet the standards of NHDOT Item 508 Bank-Run Gravel for Structural Fill, as listed below:

<u>U.S. Sieve Size</u>	<u>% passing (by weight)</u>
3-inch	100
No. 4	25-70
No. 200	0-15*

*Based on the fraction passing the No. 4 sieve

K. Bedding Course: (Bedding Sand)

1. Bedding sand shall be clean medium to coarse textured sand and shall meet the standards of NHDOT 304.1, as listed below:

<u>U.S. Sieve Size</u>	<u>% passing (by weight)</u>
1/2 inch	100
No. 4	70-100
No. 200	0-12*

*Based on the fraction passing the No. 4 sieve

L. Drainage Course: (3/4-Inch Crushed Stone)

1. Use NHDOT Section 702 Table 1E Coarse Aggregate Standard Stone #67. Stone shall consist of clean, washed, hard, durable stone free from sand, loam, clay, excess fines and deleterious materials, and shall have particle size limits as follows:

<u>U.S. Sieve Size</u>	<u>% passing (by weight)</u>
1 inch	100
3/4 inch	90-100
3/8 inch	20-55
No. 4	0-10
No. 8	0-5

M. 3/4-Inch Washed Stone

1. Washed stone shall consist of clean, washed, hard, durable stone free from sand, loam, clay, excess fines and deleterious materials, and shall have particle size limits as follows:

<u>U.S. Sieve Size</u>	<u>% passing (by weight)</u>
1 inch	100
3/4 inch	95-100
1/2 inch	35-70
3/8 inch	0-25

N. 1½-Inch Washed Stone

1. Use NHDOT Section 702 Table 1E Coarse Aggregate Standard Stone #467. Coarse aggregate shall consist of crushed stone, gravel, or other approved inert materials with similar characteristics or combinations thereof, having hard, strong, durable particles, free from surface coating and injurious amounts of soft, friable, or laminated pieces, and free of alkaline, organic, or other harmful matter. Material passing the No. 200 (0.075 mm) sieve as determined by AASHTO T 11 shall not exceed 1.0 percent by weight. Thin or elongated particles shall not exceed 10 percent by number as determined by ASTM D 4791, on a 3 to 1 ratio and a minimum of 100 particles. The percent of wear shall not exceed 40 as determined by AASHTO T 96. 1½-Inch Washed Stone shall have particle size limits as follows:

<u>U.S. Sieve Size</u>	<u>% passing (by weight)</u>
2 inch	100
1 1/2 inch	95-100
3/4 inch	35-70
3/8 inch	10-30
No. 4	0-5

O. 3/8-Inch Washed Stone

1. Use NHDOT Section 702 Table 1E Coarse Aggregate Standard Stone #89. Coarse aggregate shall consist of crushed stone, gravel, or other approved inert materials with similar characteristics or combinations thereof, having hard, strong, durable particles, free from surface coating and injurious amounts of soft, friable, or laminated pieces, and free of alkaline, organic, or other harmful matter. Material passing the No. 200 (0.075 mm) sieve as determined by AASHTO T 11 shall not exceed 1.0 percent by weight. Thin or elongated particles shall not exceed 10 percent by number as determined by ASTM D 4791, on a 3 to 1 ratio and a minimum of 100 particles. The percent of wear shall not exceed 40 as determined by AASHTO T 96. 3/8-Inch Washed Stone shall have particle size limits as follows:

<u>U.S. Sieve Size</u>	<u>% passing (by weight)</u>
1/2 inch	100
3/8 inch	90-100
No. 4	20-55
No. 8	5-30
No. 16	0-10
No. 50	0-5

P. Filter Course Material: (Modified Bank Run Gravel)

1. Filter Course Material (under porous asphalt and pervious concrete) shall meet the standards of Modified NHDOT 304.1, as listed below:

<u>U.S. Sieve Size</u>	<u>% passing (by weight)</u>
6-inch	100
No. 4	70-100
No. 200	0-6*

*Preferably less than 4% fines

Q. Washed Stone Dust: (AASHTO #10)

1. Finish surface stone under synthetic turf and shot put landing area shall meet AASHTO #10 gradation. Material shall be washed to remove fines and comply as listed below.

<u>U.S. Sieve Size</u>	<u>% passing (by weight)</u>
3/8"	100
No. 4	85-100
No. 200	0-10*

*Preferably less than 5% fines

R. Other Material:

1. All other material, not specifically described but required for proper completion of the work, shall be selected by the CONTRACTOR and submitted to the ENGINEER for review.

2.2 ACCESSORIES

- A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility; colored to comply with local practice or requirements of authorities having jurisdiction.
- B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored to comply with local practice or requirements of authorities having jurisdiction.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.
- B. Protect and maintain erosion and sedimentation controls during earth moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.
- D. Remove all water, snow, ice and debris from areas to be backfilled.
- E. Comply fully with Dust Control Plan per City of Dover Fugitive Dust Ordinance.
- F. A stockpiling area shall be prepared prior to excavation, for possible storage of clean soils. The stockpiling area should be prepared according to the following guidelines.
 1. Determine the dimensions and location of the stockpile area; the area should be selected so that the estimated volume of overlying clean soil can be placed in a stockpile whose sides do not exceed a 2.5H:1V slope.
 2. The actual length and width dimensions of the area may be adjusted as necessary to accommodate the available workspace.
 3. The stockpile area should be constructed so that there is an overall slope towards one corner (approximately 0.5% grade) so that accumulated groundwater runoff can be treated.
 4. Prepare the area by removing any loose material and grading the existing soil to provide the 0.5% grade needed to facilitate runoff.

5. Place sandbags along the outside perimeter of the trough to act as a berm which will help to contain runoff, as needed.
6. At the lowest elevation corner of the stockpile area dig a sump area which shall collect any runoff. The sump area should be approximately 4 feet in diameter and approximately 2 feet deep.

3.2 EXCAVATION, GENERAL

- A. **Unclassified Excavation:** Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, boulders, soil materials, and obstructions up to one cubic yard or more in volume for trench excavations and up to two cubic yards or more in volume for open excavations. When removal of rock, boulders, soil materials, and obstructions greater than one cubic yard or more in volume for trench excavations and up to two cubic yards or more in volume for open excavations is required, the Contractor shall be reimbursed for the volume removed in accordance with the unit prices provided in Division 012201 (Unit Prices). Changes in the Contract Sum and the Contract Time will be authorized for rock excavation and/or removal of obstructions greater than one cubic yard or more in volume for trench excavations and up to two cubic yards or more in volume for open excavations.
 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.3 EXCAVATION FOR STRUCTURES

- A. Excavate areas for new structures to the indicated lines, elevations, and subgrades provided on the Contract Drawings and as needed to complete work. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
 1. **Excavations for Footings and Foundations:** Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

3.4 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, elevations, and subgrades provided on Contract Drawings and as needed to complete work.

3.5 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
- B. Excavate trenches to uniform widths to provide clearance on each side of pipe and/or conduit as shown on the Contract Drawings. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.
- C. **Trench Bottoms:** Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material, and as shown on Contract Drawings elsewhere, to allow for bedding course.

D. Trenches near Trees and Plants to be Protected:

1. Excavate to indicated lines, elevations, and subgrades. Protect existing trees and roots along limits of clearing to the fullest extent possible during excavation activities. Do not break, tear, or chop exposed roots.
2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.

3.6 SUBGRADE INSPECTION

- A. Proof-roll all subgrade areas with a pneumatic-tired roller, or vibratory plate compactor, using a minimum of 6 passes to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 1. Protect subgrades from softening, undermining, washout, or damage by rain or water accumulation. Reroute surface water runoff from excavated areas and not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches. When subgrade for foundations has been disturbed by water, remove disturbed material to firm undisturbed material after water is brought under control.
- B. All subgrades shall be reviewed by the Owner's Representative prior to proceeding with work. Sufficient time must be allowed for the Owner's Representative to observe and perform any necessary tests on the subgrade.
- C. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Owner's Representative, without additional compensation.

3.7 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by Owner's Representative.
 1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Owner's Representative.

3.8 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials, excavated satisfactory soil materials, and excavated unsatisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees or existing buildings.

3.9 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course (sand or crushed stone as indicated on Contract Drawings) on trench bottoms and where indicated on the Contract Drawings. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Division 03 Section "Cast-in-Place Concrete."
- D. Trenches under Asphalt Parking and Walkways, and Concrete Walkways: Provide 4-inch thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase course. Concrete is specified in Division 03 Section "Cast-in-Place Concrete."
- E. Place and compact initial backfill of select material as shown on the Contract Drawings, to the height shown on the Contract Drawings over the pipe or conduit.
 - 1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
- F. Place and compact final backfill of satisfactory soil to final subgrade elevation.
- G. Install warning tape directly above utilities as shown on the Contract Drawings. Where no information is provided on the Contract Drawings, install warning tape 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers to required elevations as follows:
 - 1. Under grass and planted areas, use satisfactory soil (common fill) material.
 - 2. Under sidewalks and pavements, use crushed gravel (base course) and bank run gravel (subbase material).
 - 3. Under steps and ramps, use crushed gravel (base course) and bank run gravel (subbase material).
 - 4. Under track and D-zone areas, use crushed gravel (base course) and bank run gravel (subbase material)
 - 5. Under turf field, use course aggregate stone #467, course aggregate stone #89, and washed stone dust #10.
 - 6. Under storm drainage and sanitary structures, use ¾-inch crushed stone (drainage course).
 - 7. Around storm and sewer service pipes, use ¾-inch crushed stone (drainage course) and bedding sand.
 - 8. Around underground conduit and water/fire service pipes, use bedding sand.
 - 9. Around the underdrain use ¾-inch washed stone.

3.11 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
 - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.12 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 12-inches in loose depth for material compacted by heavy compaction equipment, and not more than 8-inches in loose depth for material compacted by hand-operated tampers or walk behind vibratory plate compactors.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D1557 (Modified Proctor Method):
 - 1. Under natural turf or unpaved areas, scarify and recompact top 8 inches below subgrade and compact each layer of backfill or fill soil material at 88 percent of maximum dry density.
 - 2. Under walkways, pavements and synthetic turf, scarify and recompact top 8 inches below subgrade and compact each layer of backfill or fill soil material at 95 percent of maximum dry density.
 - 3. Under steps and ramps, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent of maximum dry density.
 - 4. Under building slabs and exterior concrete slabs, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent of maximum dry density.
 - 5. Under footings, scarify and recompact top 12 inches below subgrade and compact each layer of backfill or fill soil material at 95 percent of maximum dry density.
 - 6. Around foundation wall, in landscaped areas, scarify and recompact top 12 inches below subgrade and compact each layer of backfill or fill soil material at 90 percent of maximum dry density.
 - 7. Under storm drainage and sanitary structures, compact using 4 passes of walk behind vibratory plate compactor.
 - 8. For utility trenches, compact each layer of initial and final backfill soil material at 95 percent of maximum dry density.

3.13 COMPACTION TESTING FREQUENCY

- A. Compaction testing for existing subgrade and each layer (lift) of backfill or fill soil material will be conducted using the following frequency:
 - 1. Under natural turf or unpaved areas: 1 test per 2,000 SF or less of continuous area. Minimum of two tests per area.

2. Under walkway, pavements and synthetic turf: 1 test per 2,000 SF or less of continuous area. Minimum of two tests per area.
3. Under steps and ramps: 1 test per area.
4. Under building slabs and exterior concrete slabs: 1 test per 2,000 SF or less of continuous area. Minimum of two tests per area.
5. Under footings: 1 test per 100 LF or less of footing length. Minimum of two tests per footing length.
6. Around foundation walls: 1 test per 100 LF or less of wall length. Minimum of two tests per wall length.
7. Under storm drainage and sanitary structures: Visually inspect crushed stone has been compacted with vibratory plate compactor.
8. For utility trenches: 1 test per 100 LF or less of trench length. Minimum of two tests per wall length.

3.14 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to lines and elevations indicated.
- B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
 1. Turf or Unpaved Areas: Plus or minus 1 inch.
 2. Walks: Plus or minus 1 inch.
 3. Pavements: Plus or minus 1/2 inch.
 4. Artificial Turf: Plus or minus 1/2 inch.
- C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.
- D. Final grading areas to be covered with topsoil and seeded:
 1. Excavate to grades shown on the Drawings or as required for landscaping and amenities. Backfill and compact all over-excavated areas at no additional cost to the OWNER. Remove all material, including rocks and boulders to a point at least 4 inches below the finished grade of landscaped areas to be covered with topsoil and seeded.
 2. Remove all ruts, hummocks and other uneven surfaces by surface grading prior to placement of fill. Do not place, spread or compact any fill material during unfavorable weather conditions and do not conduct further fill operations until compaction tests indicate acceptable results in previous layers. Do not use frozen materials or place a successive layer of fill on frozen material. Use only approved fill material, free of stumps, trees, trash, organic or other unsuitable material.
- E. Final Grading of areas to be covered with synthetic turf
 1. After subgrade is established at tolerances listed in 3.14.B.4, the stone base of #467 stone shall be installed per the plans to a surface tolerance not to exceed 1/2" over 10 feet and 1/2" from design grade. Upon completion of base stone, the choker layer of stone (#89) shall be placed to a surface tolerance not to exceed 1/2" over 10 feet and 1/2" from design grade. The final finish stone (washed stone dust-AASHTO #10) shall be installed upon the completed and accepted choker layer. The finish stone shall be placed to a surface tolerance not to exceed 1/4" over 10 feet and 1/2" from design grade.

3.15 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place subbase course and base course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase course and base course under pavements and walks as follows:
 - 1. Shape subbase course and base course to required crown elevations and cross-slope grades.
 - 2. Place subbase course and base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
 - 3. Aggregate base courses shall be constructed in accordance with NHDOT Standard Specifications, Section 304, except as herein modified.
 - 4. Compact subbase course and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.16 DRAINAGE COURSE UNDER STORM DRAINAGE AND SANITARY STRUCTURES, AND AS SHOWN ON CONTRACT DRAWINGS

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs and as shown on the Contract Drawings, as follows:
 - 1. Place drainage course in maximum 12" loose lifts.

3.17 FIELD QUALITY CONTROL

- A. Testing Agency: Owner's Representative will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- B. Contractor is responsible for scheduling all backfill field compaction testing.
- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- D. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained. The Contractor shall be responsible for cost associated with re-testing if the initial testing results fail.

3.18 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.19 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 312000

SECTION 312001

BUILDING EARTHWORK

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the work of this trade.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 DESCRIPTION OF WORK

- A. The work of this Section consists of all earthwork and related items as indicated on the Drawings and/or as specified herein and includes, but is not necessarily limited to, the following:
 - 1. General excavation.
 - 2. Trench excavation.
 - 3. Installation of sheeting, shoring and bracing and protection of existing structures, utilities and structures as may be required.
 - 4. Legal off-site disposal of excess and/or unsuitable excavated material, and debris.
 - 5. Providing, placing and compacting all fill materials as required.
 - 6. Placing and compacting Structural Fill for the support of spread footings and slab-on-grade.
 - 7. Performing overexcavation of all fill and unsuitable materials to the surface of the natural bearing surface consisting of either undisturbed marine clay or glacial till deposits and the subsequent replacement with compacted Structural Fill within the northwest corner of the building footprint west of the retaining wall extending from column lines BE.3-B7 to BG.5-B10 and north of column lines AK and BH for preparation of slab-on-grade and footing subgrades as indicated on Drawing GEO.1.
 - 8. Performing overexcavation of all fill and unsuitable materials to the surface of the natural undisturbed bearing surface consisting of marine clay or glacial till deposits to a depth of up to about 3 feet below the existing bottom of footings and the subsequent replacement with either lean concrete or Structural Fill at footing locations to the limits described herein south of column line AK and west of column line A4 and within the northeastern building quadrant as indicated by the contours presented on Drawing GEO.1.
 - 9. Performing overexcavation below footings to the invert elevation of the sewer line traversing the site between approximately column lines A14 and A15 and the subsequent replacement with lean concrete fill.
 - 10. Preparation of subgrade for footings, slabs, pavements and landscaping.
 - 11. On-site reuse of excavated soils.
 - 12. Restoration of existing surfaces
 - 13. Removal, off-site disposal and/or relocation of utilities.

14. Drainage, pumping and other dewatering procedures necessary to maintain excavated areas free of water from any source whatsoever and to avoid disturbance of subgrade.
15. Providing adequate protection of stockpiles consisting of excavated fill material against increases in moisture content.
16. Preparation of the work area to facilitate the installation of Ground Improvement consisting of aggregate piers (APs) located within the southeastern quadrant of the building footprint to the extent shown on Drawing GEO.1 and defined in Specification Section 316630, Aggregate Piers.
17. Installation and performance of an as-built of the underslab and perimeter drainage system.
18. Frost protection.
19. Rough grading.
20. Dust control.

1.3 RELATED WORK

- A. Carefully examine all of the Contract Documents for requirements which affect the work of this section. Other specifications sections which directly relate to the work of this section include, but are not limited to, the following:
1. Section 03 30 00, Cast-In-Place Concrete
 2. Section 31 66 30, Aggregate Piers

1.4 STANDARDS AND DEFINITIONS

- A. The following standards and definitions are applicable to the work of this Section to the extent referenced herein:
1. ASTM: American Society for Testing and Materials
 2. AASHTO: American Association of State Highway and Transportation Officials
 3. CODE: Building Code: Current edition of the International Building Code.
 4. OSHA: Occupational Safety and Health Administration
 5. ACI: American Concrete Institute
 6. Trench Excavation: Excavations of any length where the width is less than twice the depth and where the shortest distance between payment lines does not exceed ten (10') feet.
 7. Open Excavation: All excavations not conforming to the definition of Trench Excavation shall be defined as Open Excavation.
 8. Boulders: For pay purposes, boulders shall be defined as individual rock measuring greater than 1 cubic yard and 3 cubic yards in volume in trench and open excavations, respectively.
 9. Invert or Invert Elevation: The elevation at the inside bottom surface of the pipe or channel.
 10. Bottom of pipe: The base of the pipe at its outer surface.
 11. Unsuitable Material: Soils which, due to their consolidation properties, degree of saturation, gradation or other deleterious characteristics and frozen soils which, in the opinion of the geotechnical engineer, will not provide a stable subgrade, cannot be used as backfill, or do not conform to the requirements of these specifications, shall be considered unsuitable material.
 12. Bedding Course: Course placed over the excavated subgrade in a trench before laying pipe.
 13. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

14. Structures: Footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
15. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill or topsoil materials.
16. Utilities: On-site underground pipes, conduits, ducts and cables, as well as underground services within buildings.

1.5 PERMITS, CODES, AND SAFETY REQUIREMENTS

- A. Comply with all rules, regulations, laws and ordinances of the City of Dover, State of New Hampshire, and Federal entities, and all other authorities having jurisdiction over the project site. The Contractor shall provide all labor, materials, equipment, and services necessary to make the work comply with such requirements without additional cost to the Owner.
- B. Comply with the provisions of the Manual for Accident Prevention in Construction of the Associated General Contractors of America, Inc., and the requirements of the Occupational Safety and Health Administration, United States Department of Labor.
- C. The Contractor shall procure and pay for all permits and licenses required for the complete work specified herein and shown on the Drawings.
- D. The Contractor shall not close or obstruct any street, sidewalk or passageway without written permission from authorities having jurisdiction. The Contractor shall so conduct his operations as to interfere as little as possible with the use ordinarily made of roads, driveways, or other facilities near enough to the work to be affected thereby.

1.6 SUBMITTALS

- A. Provide samples of approximately 50 pounds of each fill material from the proposed source of supply, including on-site sources. The Contractor shall identify the name and address of the source of all materials. Allow a minimum of one-week for testing and evaluation of results before material is needed.
- B. Submit shop drawings, engineering calculations, and design assumptions for determination of loads and stresses acting in the excavation lateral support systems, including interim soil berms, during intermediate construction stages as well as final conditions and all other information for the temporary earth support systems a minimum of three (3) weeks prior to the start of installation.

1.7 LAYOUT AND GRADES

- A. The Contractor shall maintain and/or re-establish benchmarks and survey monuments shown on the Drawings, or found to exist on the site, to provide a base reference for the construction. Replace any which may become destroyed or disturbed. The Contractor shall employ and pay all costs for a registered Civil Engineer or Surveyor who is licensed within the jurisdiction of the project site to lay out all lines and grades in accordance with the Drawings and Specifications, and as necessary or required for the construction. The selection of the registered Civil Engineer or Surveyor shall be subject to the Architect's approval.
- B. Submit to the Architect a written confirmation of locations of all lines, and any discrepancies between conditions and locations as they actually exist and those indicated on the Contract Drawings. Such confirmation shall bear the Civil Engineer's registration stamp.

- C. The General Contractor shall not commence any excavation or construction work until the Engineer's verification has been received and approved by the Architect.
- D. The words "finished grades" as used herein shall mean final grade elevations indicated on the Drawings. Spot elevations shall govern over proposed contours. Where not otherwise indicated, project site areas shall be given uniform slope between points for which finished grades are indicated or between such points and existing established grades. Under this Section of the Contract, the Contractor is required to bring all areas to the grade elevations as indicated unless otherwise indicated on the Drawings and as specified herein.
- E. Finished grades, contours, and elevations indicated on the Drawings describe final surface elevations for completed construction. The Contractor shall review the Drawing details and Specifications carefully to ascertain specific work limits and requirements for this Contract.
- F. The word "subgrade" as used herein, means the required surface of natural soil or acceptable existing fill or approved compacted fill. This surface is immediately beneath any improvements, specially dimensioned fill, drainage installations or other surfacing material.
- G. "Rough grading" shall mean excavating or filling to elevations indicated, and to the required depths described herein. The permissible tolerance of rough grading within an area 100 feet square, shall not exceed plus or minus 2 inches. The cost of placing fill material to refill areas having rough grades lower than designed shall be borne by the Contractor.

1.8 PROTECTION OF EXISTING CONDITIONS

- A. All rules and regulations governing the respective utilities shall be observed by the Contractor in executing work under this Section. All work shall be executed in such manner as to prevent any damage to the Owner's and any other property and existing improvements, such as, but not limited to, streets, curbs, paving, service utility lines, and other public or private property. Protect existing improvements from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.
- B. Locate and mark underground utilities to remain in service before beginning the work. Protect all existing utilities to remain. Do not interrupt existing utilities except when authorized in writing by authorities having jurisdiction. Existing utilities have been shown on the plans for the Contractor's convenience. It is the Contractor's responsibility to verify all existing utility locations either shown or not shown on the plans. Should uncharted or incorrectly charted existing utilities be encountered during excavation, consult the Architect immediately for directions as to procedure. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of Utility Owner.
- C. The Contractor is hereby notified of the presence of an active sewer line which traverses the proposed building footprint at the location shown on Drawing C-4.2 approximately located between column lines A14 and A15. The Contractor shall perform all work for the project in such a manner as to protect and maintain the operation of the sewer line.
- D. When an active utility line is exposed during construction, its location and elevation shall be plotted on the Record Drawing by the Contractor and both the Architect and the Utility Owner notified in writing. Active utilities existing on the site shall be carefully protected from damage and relocated or removed as required by the work. Active utility lines damaged in the course of construction operations shall be repaired or replaced as determined by the Architect without additional cost to the Owner.

- E. Conduct earthwork operations to ensure minimum interference with the Owner's operations and the normal operation of streets, sidewalks, and other adjacent properties. Do not close or obstruct streets, walks, etc. without written permission from authorities having jurisdiction. Provide barricades, fences, lights, signs, and all other safety devices required for the protection of the public. Operate warning lights from dusk to dawn every day.
- F. Inactive or abandoned utilities encountered during construction operations shall be removed, plugged or capped. The locations of such utilities shall be noted on the Record Drawings and reported in writing to the Architect.
- G. In case of any damage or injury caused in the performance of work the Contractor shall, at his own expense make good such damage or injury to the satisfaction of, and without cost to, the Owner. Existing streets, sidewalks and curbs damaged during the project work shall be repaired or replaced to their condition prior to commencement of earthwork operations.

1.9 SUBSURFACE CONDITIONS

- A. It is the obligation of the Contractor to examine the site, to verify all dimensions in the field, review logs of the borings, examine the soil samples and to employ all other means at his disposal to familiarize himself completely with conditions existing at the site. At his own expense, the Contractor may take whatever additional borings or explorations he deems necessary upon notification to the Owner of his intention to do so.
- B. Foundation Engineering Reports dated May 14, 2015 and November 2, 2015, and a letter entitled "Revised Foundation Engineering Recommendations" dated March 21, 2016 which include the logs of borings, has been prepared for this project by McPhail Associates, LLC and is available at the office of the Architect. The reports and updated recommendations are provided solely as information to bidders.
- C. The aforementioned borings logs were prepared for purposes of foundation design only. These data are offered for general information only. Interpretation of this data for purposes of construction is the responsibility of the Contractor. It is the Contractor's sole responsibility to make interpretations and draw conclusions with respect to the character of the materials to be encountered and their impact upon his work based on his expert knowledge. Neither the Owner nor the Architect assumes responsibility for the accuracy of the data.

1.10 DEWATERING

- A. The Contractor shall control the grading in areas under construction on the site so that the surface of the ground will properly slope to prevent accumulation of water in excavated areas and adjacent properties.
- B. The presence of groundwater in soil will not constitute a condition for which an increase in the contract price may be made. Under no circumstances place concrete, fill, lay piping or install appurtenances in excavations containing free water.
- C. The Contractor shall furnish and operate pumps and related equipment, including standby equipment, and all necessary piping to keep all excavations clear of surface, rain or groundwater during the operations, and shall be responsible for any damage to the subgrade, completed work or adjacent properties from such water. All piping exposed above surface for this use shall be properly covered to allow traffic to pass without obstruction.

- D. The Contractor is responsible for correcting any disturbance of natural bearing soils, compacted fills or structures caused by an inadequate dewatering system or by interruption of the continuous operation of the dewatering system as specified.
- E. The Contractor shall provide adequate dewatering methods, such as pumping from sumps, drainage ditches, deep wells or wellpoints in order to keep the excavation free of standing water, to provide stable support for construction equipment and to preserve the undisturbed condition of foundation bearing surfaces.
- F. Keep excavations free from water until backfilling has been completed.
- G. Submit to the Architect, prior to the start of excavation, complete plans and description of the overall dewatering system proposed for use. The submittal shall include the location and installation details of all dewatering elements, drainage lines, sedimentation tanks and filter system.
- H. Discharge water on-site into temporary trenches. Prevent erosion and siltation of surrounding areas.

1.11 FROST PROTECTION

- A. Make no excavations to full depth indicated when freezing temperature may be expected unless intended improvements can be accomplished immediately after the excavations have been completed. Protect the subgrade of in-place footings and slabs from frost.
- B. No work shall be installed on frozen ground.
- C. Should protection fail, remove frozen materials and replace with Structural Fill as directed by the Architect at no cost to the Owner.

1.12 SHEETING, SHORING AND BRACING

- A. The Contractor shall provide all earth support systems as necessary to retain the sides of the excavations and to protect adjacent structures, roadways, utilities and property during the construction period.
- B. Provide sheeting, shoring and/or bracing at excavations, as required, to assure complete safety against collapse of earth at side of excavations. See also disposition of existing utilities for protection of same.
- C. Comply with local safety regulations or in the absence thereof, with the provisions of the Manual of Accident Prevention in Construction of the Associated General Contractors of America, Inc.
- D. Shoring or sheeting shall not constitute a condition for which an increase may be made in the Contract Price.
- E. All temporary earth support systems shall be designed and stamped by a Professional Engineer Registered in the State of New Hampshire employed by the Contractor and submitted in accordance with Paragraph 1.6. B.
- F. Install and limit the movement of the excavation lateral earth support systems to minimize settlement of the ground and facilities adjacent to excavations.

- G. Acceptance of the Contractor's plans, design calculations and methods of construction by the Architect shall not relieve the Contractor of the responsibility for the adequacy of the excavation lateral support system, preventing damage to structures, utilities and streets adjacent to excavations, and the safety of persons working within excavated areas and the public at large.
- H. All submittals shall be made to the Architect. The time period(s) for submittals are the minimum required by the Architect to review, evaluate and respond to the Contractor. If, after review, the Architect requires re-submission for any reason, the specified time period(s) shall commence upon the date of receipt of the re-submittals. The Contractor is responsible for scheduling specified submittals and re-submittals so as to prevent delays in the work.

1.13 DISPOSAL

- A. Materials not suitable for reuse within the building area or as backfill around structures and under pavements, shall be legally disposed of off-site.
- B. No soil shall be removed from the site without approval from the Owner, Architect, or the Project Environmental Consultant.

1.14 MEASUREMENT AND PAYMENT

- A. The base bid lump sum price shall include all costs of whatever nature associated with the content of this specification section including, but not limited to, excavation, removal and backfilling of existing below-grade abandoned and active utility pipes and structures, excavation and removal of existing surface treatments, segregating of all topsoil, fill, marine and glacial till deposits at all times, stockpiling, handling and reuse of excavated materials, placing and compacting fill materials to the limits defined herein or shown on the drawings, construction dewatering in and accordance with the provisions documented herein, frost protection, shoring and bracing, placement and compaction of the specified fill materials, and off-site disposal of excess fill and natural soil and solid waste in accordance with the procedures documented herein and dust control.
- B. If any part of the excavation is carried through error beyond the depth and the dimensions indicated on the Drawings, or called for in the Specifications, the Contractor, at his own expense, shall furnish and install compacted Structural Fill or with other material as directed by the Architect.
- C. Payment Lines: The following payment lines shall be used for purposes of Contract Price adjustment to determine volume of materials to be excavated, removed or backfilled.
 - 1. Footings: A vertical line twelve inches from the toe of the footings. The depth shall be measured to six inches below the bottom of concrete elevations for footings.
 - 2. Depth of Overexcavation: To the contour lines provided on Drawing GEO.1.
 - 3. Slabs: The depth shall be measured to nine inches below the bottom of concrete for floor slabs as shown on the drawings.
 - 4. Surface areas outside the building: Twelve inches below required subgrade as shown on the details.
 - 5. Utility structures: Twelve inches outside of the walls and twelve inches below the bottom of the structures.
 - 6. Utility trenches: Width shall be the outside diameter of the pipe plus two feet. Maximum depth shall not exceed one foot below the bottom of the pipes, etc. Banks of trenches shall be vertical.

- D. The Contractor shall include in his Base Bid all costs associated with handling, loading, trucking and the legal off-site disposal of all excess soil.
- E. The Contractor may consider the reuse of excess excavated on-site fill as Ordinary Fill when the fill meets the requirements for reuse specified herein, however, if the material for any reason becomes unsuitable for reuse or is unable to be properly compacted, the unsuitable fill shall be legally disposed off-site at an unlined landfill by the Contractor under his Base Bid at no additional cost to the Owner.
- F. All footings for support of the proposed building shall be supported on natural marine or glacial till deposits, or on compacted Structural Fill placed over the marine or glacial till deposits where overexcavation is required, or ground improved with Aggregate Piers.
- G. Compensation for all work required under this Section shall be included in the Contract Lump Sum Price. For purposes of adjusting the scope of the earthworks, the Unit Price Schedule shall include Unit Prices for the following:
 - 1. Open Soil Excavation per Cubic Yard
 - 2. Trench Soil Excavation per Cubic Yard
 - 3. Crushed Stone, Compacted In-Place, from Off-Site Source per Cubic Yard
 - 4. Gravel Borrow, Compacted In-Place, from Off-Site Source per Cubic Yard
 - 5. Ordinary Fill, Compacted In-Place, from Off-Site Source per Cubic Yard
 - 6. Ordinary Fill, Compacted In-Place, from On-Site Source per Cubic Yard
 - 7. Structural Fill, Compacted In-Place, from Off-Site Source per Cubic Yard
 - 8. Sand Blanket (Pipe Backfill)
 - 9. Loading, Trucking and Disposal of Solid Waste per Ton

1.15 TESTING

- A. The Owner will retain the Geotechnical Engineer to perform on-site observation and testing during the construction operations. The Contractor shall coordinate the Geotechnical Engineers required presence on the site with the Geotechnical Engineer and the construction activities. The services of the Geotechnical Engineer shall include, but shall not be limited to the following:
 - 1. Monitoring the excavated foundation bearing surfaces for conformance with the design requirements.
 - 2. Monitoring the preparation of slab subgrades.
 - 3. Monitoring the installation of the underslab and perimeter drainage system.
 - 4. Installation of Aggregate Piers.
 - 5. Laboratory testing and analysis of fill materials specified, as required.
- B. The Geotechnical Engineer's presence does not include supervision or direction of the actual work by the Contractor, his employees, or agents. Neither the presence of the Geotechnical Engineer nor any observations and testing performed by him, nor any notice or failure to give notice, shall excuse the Contractor from defects discovered in the Work.
- C. The Contractor shall provide a 50 pound sample of each fill material from each proposed source of supply. Allow sufficient time for testing and evaluation of results before materials are needed.
- D. Architect shall be sole and final judge of suitability of all material.
- E. The Geotechnical Engineer will determine the maximum modified dry density and optimum water content of fill materials in accordance with ASTM D1557, Method D, and the in-place density in accordance with ASTM D1556 or ASTM D2167.

- F. Tests of materials as delivered may be made from time to time. Materials in question shall not be used pending test results. The Contractor shall remove and legally dispose of off-site all rejected materials and replace with new, whether in stockpiles or in-place

PART 2 - PRODUCTS

2.1 FILL MATERIALS

- A. Fill materials shall conform to the following material descriptions. Gradation requirements shall be determined by ASTM D422 unless otherwise specified.
- B. ¾-Inch Crushed Stone: Inert angular material derived from a stone quarry that is hard, durable, washed stone, and free of deleterious materials. Gradation shall conform to the following:

<u>U.S. Sieve No.</u>	<u>Percent Passing By Weight</u>
1"	100
¾"	90 – 100
½"	10 – 50
⅜"	0 – 20
#4	0 – 5

- C. Gravel Borrow: Suitable well-graded, off-site gravel, sandy gravel, or gravelly sand, obtained from a natural, bank-run source, free of organic material, loam, trash, snow, ice, frozen soil and other objectionable material and well-graded within the following limits:

<u>U.S. Sieve No.</u>	<u>Percent Passing By Weight</u>
4"	100
1"	60 – 100
#4	25 – 85
#20	10 – 55
#40	8 – 35
#200	0 – 8

Gravel Borrow shall have a modified Proctor dry density of at least 130 pounds per cubic-foot.

- D. Structural Fill: Well-graded, natural inorganic soil approved by the Architect and meeting the following requirements:
 - 1. Structural Fill shall be Gravel Borrow.
- E. Ordinary Borrow may consist of excavated on-site fill or natural soil, having a maximum particle size of four (4) inches.
 - 1. Crushing, screening or other means may be required to properly "cull-out" oversized material in order to produce material having a maximum particle size of four (4) inches. All costs associated with crushing, screening, additional material handling, and protection of stockpiled on-site fill from freezing or wet environments shall be included in the lump sum price.
 - 2. It shall be substantially free of organic or other weak or compressible materials, and of frozen materials.
 - 3. It shall be of such nature and character that it can be compacted to the specified density in a reasonable length of time.

4. It shall be free of highly plastic clays, of all materials subject to decay, decomposition or dissolution, and of cinders or other materials that will corrode piping or other metal.
5. The Contractor shall take precautions to maintain suitability of excavated on-site soil for re-use, particularly in regard to moisture maintenance and freezing prevention.

F. Sand Blanket (Pipe Backfill)

1. The material shall consist of clean sand free of organic, frozen or other deleterious materials, and conform to the following gradation:

<u>Sieve Size</u>	<u>Percentage Passing By Weight</u>
1/2"	90 – 100
#200	0 – 15

G. Unsuitable Material:

1. Material containing organic matter, frozen materials, debris, materials subject to decomposition, silts too wet to be stabilized and existing fill that, in the opinion of the Architect, does not satisfy the design requirements, shall be unsuitable material.
2. Unsuitable material shall be legally disposed of off-site as directed by the Architect.

H. Lean Concrete:

1. Lean concrete shall have a minimum compressive strength of 1,000 psi.

2.2 USES OF FILL MATERIALS

- A. Fill materials listed above shall be utilized as follows and as otherwise indicated on the drawings, specified or directed.

B. Crushed Stone:

1. For a minimum 3-inch thickness to cover footing bearing surfaces as soon the bearing surface is exposed and observed by the Geotechnical Engineer.
2. For a minimum 6-inch thickness surrounding all perimeter foundation drain pipes.
3. For a minimum 9-inch thickness below slab-on-grade for underslab foundation drainage system.
4. Elsewhere as shown on the drawings or specified herein.

C. Gravel Borrow:

1. For a minimum 6-inch thickness below slabs-on-grade where underslab drainage is not required.
2. For use as Structural Fill for backfilling within the building footprint.
3. For use as Structural Fill to backfill overexcavation below slabs-on-grade or foundations.
4. For use as backfill in areas where Aggregate Piers have been installed.
5. Elsewhere as shown on the drawings or specified herein.

D. Ordinary Borrow:

1. For general site fill outside the building area.
2. For backfilling to achieve the proposed footing subgrade level in areas where Aggregate Piers will be installed.

- E. Sand Blanket (Pipe Backfill)
 - 1. Bedding material for water pipe installation.
 - 2. Elsewhere as shown on the drawings or specified herein.
- F. Lean Concrete
 - 1. For backfill of overexcavation below foundations.
 - 2. Elsewhere as shown on the drawings or specified herein.

2.3 OTHER MATERIALS

- A. Filter Fabric
 - 1. Filter Fabric shall consist of Mirafi 140 N or approved equivalent.
 - 2. Place filter fabric around the Crushed Stone surrounding the perimeter drain pipes and below crushed stone for the underslab drainage system.
 - 3. Use Filter Fabric elsewhere as shown on the Drawings or specified herein.
- B. Underslab and Perimeter Drain Pipe
 - 1. Perimeter and underslab drain pipes shall be 4-inch diameter perforated PVC pipe.
 - 2. Perimeter drains shall be as shown on the Contract Drawings and as approved by the Architect.
- C. Prefabricated Drainage Board
 - 1. Prefabricated Drainage Board shall consist of Miradrain 6000, or approved equivalent.
 - 2. Prefabricated Drainage Board shall be used in conjunction with the perimeter drainage system, to be applied to the exterior below-grade walls, as shown on the drawings, beginning from finished grade and terminating within the crushed stone surrounding the perimeter drainage pipe.

2.4 EQUIPMENT

- A. Provide sufficient equipment units of suitable types to spread, level, and compact fills promptly upon delivery of materials.
- B. Contractor may use any compaction equipment or device that he finds convenient or economical, but the Architect retains the right to disapprove equipment, which, in his opinion, is of inadequate capacity or unsuited to the character of material being compacted.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. All excavation is unclassified general excavation and the cost thereof shall be included in the Bid Price except as otherwise provided herein.
- B. Excavation shall include all supplementary items normal to excavation work including off-site disposal of all excess material.

- C. "Disposal" shall mean safe and legal disposal off the site in a manner as required to comply with all applicable statutes and regulations.
- D. Monitoring of all earthwork operations will be performed by the Owner's Geotechnical Engineer. No earthworks shall be performed unless they are completed in the presence of the Owner's Geotechnical Engineer.
- E. The Drawings indicate, in general, alignments, grade elevations and invert elevations. Establish the lines and grades in conformity with the Drawings. The Architect, however, may make such adjustments in the field in grades and alignments as are found necessary in order to avoid interference with any special conditions encountered. Grading between indicated final grades shall be smooth, even surfaces, except as otherwise required.
- F. Establish and maintain suitable stakes over all areas to be graded as directed, specified or as required by the Architect. Maintain sufficient reference points at all times during construction to properly perform the contract installation.
- G. Mucky, soft, spongy, organic soils shall be considered unsuitable for construction purposes and shall be removed from the site at no additional cost to the Owner.
- H. Any excess excavation which has been carried, through error, beyond specified depths or dimensions shall be backfilled by the Contractor at his own expense with compacted Structural Fill or with other material as directed by the Architect.
- I. No excavated materials shall be deposited or stockpiled at any time so as to endanger portions of new or existing structures, either by direct pressure or indirectly by overloading banks contiguous to the operation. Material, if stockpiled, shall be stored so as not to interfere with the established sequence of construction. If there is not sufficient area available for stockpiling within the limits of the project, the Contractor will be required to furnish his own area for stockpiling at no additional cost to the Owner. Contractor shall also be responsible for moving of such material from the stockpile area to the location the material is to be used for construction purposes, at no additional cost to the Owner.
- J. When the plans require excavation in areas in close proximity to existing buildings, roads, structures and utilities it shall be the responsibility of the Contractor, at his expense, to use satisfactory means and methods to protect and maintain the stability of such roads, structures and utilities located immediately adjacent to, but outside the limits of excavation.
- K. Excavate and fill all materials to the elevations, dimensions, and forms as shown on the Drawings and as specified for the construction of drainage structures, utilities, lawn and site improvements necessary for the completion of the utilities and site work.
- L. After completion of the excavation and prior to commencement of foundation concrete, pavements and foundation construction, the excavation will be observed by the Architect to determine that subgrade surfaces have been reached and properly prepared.
- M. The Contractor shall keep the operations under this Contract free and clear of accumulation of snow within the Limit of Contract lines as required to carry out the work at no additional cost to the Owner. It shall be the responsibility of the Contractor to remove and dispose of all accumulations of snow as part of this contract.

3.2 GENERAL EXCAVATION

- A. All excavation is unclassified. All materials required to be excavated to permit construction of the proposed structures and associated site improvements, unless otherwise indicated, shall be included in the Contract Price.
- B. All existing construction shall be removed in its entirety wherever it interferes with new construction.
- C. Payment for removal of all building remnants, rubble, and other obstructions, aside from reinforced concrete, which interfere with the proposed building foundations or other portions of the new construction shall be included in the Base Proposal.
- D. Perform all excavations "in the dry". The ground adjacent to all excavation shall be graded or shall have a bituminous concrete berm to prevent surface water from running into the excavation. Keep excavations free from water. No claims for additional cost will be allowed for pumping and draining required for excavations.
- E. Excavation and dewatering shall be accomplished by methods that preserve the undisturbed state of subgrade soils. Subgrade soils which become soft, loose or otherwise unsatisfactory for support of structures and utilities as a result of inadequate or improper excavation, dewatering or other construction methods, shall be removed and replaced with Structural Fill or Crushed Stone as directed by the Architect at the Contractor's expense.
- F. When excavations have reached the prescribed depths, the Architect shall be notified and will make an inspection of the conditions. After inspection, the Contractor will receive approval to proceed if conditions meet design requirements.
- G. No excavation will be permitted below a line drawn downwards at 2 horizontal to 1 vertical from the underside of the closest edge of any proposed or in-place footing or utility at a higher elevation without providing adequate sheeting and bracing or underpinning to prevent loss of support of the footing or utility.
- H. Bottom of foundation elevations as indicated on the structural foundation drawings are approximate. All footings for the proposed building shall be supported on the natural marine or glacial till deposits, or on compacted Structural Fill placed over the surface of the natural marine or glacial till deposits and soil improved with Aggregate Piers.
- I. All soil bearing surfaces for footings shall be carefully hand-cleaned of all loose soil. The final excavation for all foundation bearing surfaces shall be made with a smooth cutting edge (i.e. a backhoe bucket having a plate welded over the teeth) to preserve the undisturbed state of the bearing soils. All bearing soils which become soft, loose or otherwise unsatisfactory for support of the structure as a result of inadequate or improper excavation, dewatering or other construction methods, shall be removed and replaced with Structural Fill or other material as directed by the Architect at the Contractor's expense.
- J. All foundation bearing surfaces shall receive a 3-inch thickness of 3/4-inch Crushed Stone to protect the bearing surface from disturbance.
- K. It is anticipated that the subgrade may become disturbed as a result of the excavation activities. The Contractor is required to maintain the trafficability of the subgrade at all times in order to perform all required construction activities, including Ground Improvement installation, at no additional cost to the Owner.

3.3 PROOFROLLING

- A. The exposed fill subgrade soils of the building slabs-on-grade, and the roadway shall be proofrolled with at least four (4) passes of a minimum 10-ton vibratory drum roller.
- B. Proofrolling shall be observed by the Geotechnical Engineer.
- C. All soft and spongy spots identified during proofrolling shall be overexcavated and replaced with compacted Structural Fill.

3.4 PRE- EXCAVATION TO REMOVE OBSTRUCTIONS

- A. Pre-excavate all Ground Improvement locations on an as-needed basis through the fill material and remove obstructions to installation. Backfill excavations with on-site soil placed in two (2) foot lifts with each lift compacted with the backhoe bucket. Obstructions which in the opinion of the Architect, which are unable to be removed shall be reported such that alternate foundation designs may be generated. The Contractor's proposed means and methods of pre-excavating shall be submitted for review.

3.5 OVEREXCAVATION

- A. Within the northwest quadrant of the building footprint as defined on Drawing GEO.1 and at footing locations within the northeastern and southwestern quadrants where fill is present at the design bottom of footing elevation, overexcavate all fill material and unsuitable materials to the surface of the natural undisturbed marine clay or glacial till deposit.
- B. For overexcavation and replacement with Structural Fill, the width of overexcavation at the natural bearing stratum shall extend beyond the plan limits of the footing a minimum of two feet plus the height of overexcavation in all directions from the footing.
- C. For overexcavation and replacement with Lean Concrete, the width of overexcavation at the natural bearing stratum shall extend beyond the plan limits of the footing a minimum of 6 inches in all plan directions.
- D. Footings located along and between column lines A14 and A15 which are located above an influence zone drawn at a rate of 2 horizontal to 1 vertical extending up and outward from the invert elevation of the existing active sewer line indicated on Drawing C-4.2 shall be overexcavated below the influence zone and the overexcavation backfilled with lean concrete fill up to the design bottom of footing.

3.6 TRENCH EXCAVATION

- A. Excavate as necessary for all drainage pipes, utilities and related structures and appurtenances, and for any other trenching necessary to complete the work.
- B. Definitions:
 - 1. Trench shall be defined as an excavation of any length where the width is less than twice the depth and where the shortest distance between payment lines does not exceed ten (10') feet. All other excavations shall be defined as open excavation.
 - 2. The words "invert" or "invert elevation" as used herein mean the elevation at the inside bottom surface of a pipe or channel.
 - 3. The words "bottom of pipe" as used herein mean the elevation at the base of the pipe at its outer surface.

- C. In general, machine excavation of trenches will be permitted with the exception of preparation of pipe beds which will be by hand work. Excavate by hand or machine methods to at least six (6") inches below the bottom of pipe or as shown on the Drawings. Excavation to final grade shall be made in such a manner as to maintain the undisturbed bearing character of the soils exposed at the excavation level.
- D. Utilities or piping shall not be laid directly on boulders, cobbles, or other hard material. This material shall be removed to a minimum of six (6") inches below the bottom of pipe at all points or as shown on plans, and backfilled or compacted as specified. Excavate nine (9") inches below pipes which are 42 inches in diameter or larger.
- E. In general, the width of trenches shall be kept to a minimum and in the case of piping shall not exceed the sum of the pipe's outside diameter plus 3 feet 0 inches to at least 12 inches above the pipe.
- F. If the material at or below the elevation of the bottom of the pipe or related structure is muck, peat, peaty sand or other unsuitable material to support the pipe or related structure, this material shall be excavated to the satisfaction of the Architect so that backfill can be placed 1 foot or greater on all sides of pipes or related structures and slope downward at a rate of 1 foot vertical to 1 foot horizontal to its intersection with natural undisturbed bearing soil.
- G. Provide shoring, sheeting, and/or bracing at excavations, as required, to assure complete safety against collapse of earth at the side of excavations. Provide shoring of public utility lines where exposed in excavations in accordance with rules and regulations of the local authorities, at no additional cost to the Owner.
- H. If there are any conflicts between the written specification and the plan details, the plan details shall govern, or as directed by the engineer

3.7 FILLING, BACKFILLING AND COMPACTION

- A. Provide material conforming to these specifications and referenced Standards for all additional required fill at no additional cost to the Owner if sufficient quality or quantity of suitable material is not available on site.
- B. Finished grades not otherwise indicated shall be uniform levels or slopes between points where levels are given or between such points and existing finished grades.
- C. All areas to be filled or backfilled shall be free of construction debris, refuse, compressible or decayable materials and standing water. Do not place fill when materials or material below it are frozen. No fill material containing ice or frozen lumps shall be used.
- D. Material shall be placed in evenly distributed layers over entire area, spread and compacted as specified.
 - 1. Remove all debris, organic materials or otherwise unsuitable materials from areas to be backfilled or filled.
 - 2. Deposit fill and backfill in successive layers having a compacted thickness of not more than 6 inches and shall be moistened and thoroughly compacted by roller, pneumatic tamper, or other approved method.
 - 3. Moisture-density determinations shall be performed on representative soil samples in accordance with ASTM D1557, Method D.
 - 4. Field density tests shall be taken in accordance with ASTM D1556.

- E. All fill within the building area shall be placed and compacted under continuous monitoring by the Geotechnical Engineer.
 - 1. Place Crushed Stone in uniform lifts not exceeding 6 inches (compacted thickness) and compact with a minimum of four (4) passes of a vibratory plate or roller type compactor.
 - 2. Place Structural Fill in uniform lifts not exceeding 6 inches (compacted thickness) and compact to 95 percent of maximum Proctor dry density.
 - 3. Place Gravel Borrow in uniform lifts not exceeding 6 inches (compacted thickness) and compact to 95 percent of maximum Proctor dry density.
 - 4. Place Ordinary Borrow in uniform lifts not exceeding 6 inches (compacted thickness) and compact to 92 percent of its maximum Proctor dry density.
- F. Filling shall be done only after the area to be filled has been observed by the Architect. The Contractor shall notify the Architect when excavation is ready for formal inspection.
- G. The Architect reserves the right to disapprove of compaction equipment being used for compacting if he deems the equipment in use to be unsuited or inadequate to compact materials to the specified densities within a reasonable length of time.
- H. All fill is to be placed "in the dry" to which end, dewatering may be required. The Contractor shall dewater excavated areas as required to perform the work and in such a manner as to preserve the undisturbed condition of the excavated subgrade.
- I. In freezing weather, a layer of fill shall not be left in an uncompacted state at the close of a days operations. Prior to terminating the operations for the day, the final layer of fill, after compaction, shall be rolled with a steel-wheeled roller to eliminate ridges of soil left by compaction equipment.
- J. Before filling against walls, the permanent structure must be completed and sufficiently aged to attain strength required to resist fill pressures without damage. Correct any damage to structure caused by filling operations at no cost to the Owner. Place no stones over 4 inches in diameter closer than 18 inches to wall surfaces.
- K. The Contractor shall notify the Architect 3 days in advance when the rough grades are established and ready for formal inspection.

3.8 BACKFILLING OF TRENCHES AND STRUCTURES

- A. All requirements for placement, compaction, and spreading of fill materials as specified herein shall be applicable to backfilling operations.
- B. Compacted backfill materials as specified herein shall be used as bedding and backfill around drainage pipes, around structures and for other uses as illustrated on the Drawings.
- C. Backfilling of trenches shall not commence until construction below the finished grade has been approved, the excavation cleaned of trash and debris, and the final excavation level is firm and undisturbed.
- D. Do not commence backfilling operations for trenches and structures until all piping, etc., has been installed, tested and approved, and the locations of all pipe and appurtenances have been recorded. Backfill carefully by hand around pipe to a depth of one foot above the top of pipe using material specified herein, and tamping firmly in layers not exceeding six inches in thickness, compacting with hand rammers or mechanical tampers. When a manufacturer suggests backfill materials or methods other than those specified herein, such requirements

shall govern, providing the finished work equals or exceeds the result obtained by the materials and methods obtained herein.

- E. Backfill as specified shall be placed to the full width of the trench as indicated on the Drawings. After a pipe is bedded, the trench shall be backfilled to the centerline of the pipe with fill as specified except at the joint. After the joint is inspected, that portion shall be filled in. Material under and around the pipe shall be carefully and thoroughly compacted to the densities specified herein.
- F. Compacted drainage fill as specified herein will be required below all pipe unless otherwise shown on the Drawings or specified herein. Compacted drainage fill is required under utility structures and shall be placed to the full width of drain pipe trenches. After a pipe is bedded, the trench shall be filled to the centerline of the pipe with crushed gravel except at the joint. After the joint is inspected, that portion shall be filled. Material under and around the pipe shall be carefully and thoroughly compacted to the densities specified herein.
- G. From the centerline of the pipe to a point twelve inches above the top of the pipe the backfill shall be placed by hand and compacted with mechanical tampers to not less than 95% of maximum modified Proctor dry density at optimum moisture content of the material. Above this point, backfill shall be compacted common fill and may be placed by machine in layers six (6") inches deep and compacted to the densities specified herein. This backfill shall be extended as shown on the Detail Drawings. Backfill simultaneously on all sides of pipe or structure.

3.9 ROUGH GRADING

- A. Rough grading shall include the shaping, trimming, rolling, and refinishing of all surfaces of the subbase and the preparation of grades as shown on the Drawings.
- B. Wherever streets, lawns, sidewalks or other items contained within or outside the Limit of Contract lines have been excavated in fulfilling the work required under this Contract, the Contractor shall furnish and install all materials necessary to bring finished surfaces level with the existing adjacent surfaces. All work shall be installed to match the existing conditions in accordance with the governing authority. Notify the proper authorities prior to restoring surfaces outside the Contract Limit lines.
- C. Do all other cutting, filling and grading to the lines and grades indicated on the Drawings. Grade evenly to within the dimensions required for grades shown on the drawings and as specified herein. No stones larger than two inches in largest dimension shall be left or placed in upper six inches of the subgrade. Fill shall be left in a compacted state at the end of the work day and sloped to drain.

3.10 DUST CONTROL

- A. The Contractor shall employ dust control methods and materials at all times using sprinklered water or other approved means. Do not use oil or similar penetrants. The Contractor shall provide dust control on a daily basis as required and when directed by the Architect.

3.11 RESTORATION OF EXISTING SURFACES

- A. Wherever streets, lawns, or sidewalks within or outside the Limit of Contract Lines have been excavated in fulfilling the work required under this Contract, this trade shall furnish and install all material necessary to bring finish surfaces level with the existing adjacent surfaces. All work

shall be installed to match the existing conditions in accordance with the governing authority. Notify the proper authorities prior to restoring surfaces outside the Limit of Contract Line.

3.12 CLEAN-UP

- A. All areas within the site shall be raked clean of all trash and other debris upon completion of the work specified herein, spoil piles leveled and excess materials disposed of as acceptable to the Architect. This work supplements the requirements of the General and Supplementary Conditions.

END OF SECTION

SECTION 31 22 19

FINE GRADING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Coordinate with such trades to assure the steady progress of all work under the Contract.

1.2 SUMMARY

- A. The Work of this Section includes, but is not limited to, the following:
 - 1. Fine Grading.

1.3 RELATED SECTIONS

- A. Related Sections include the following:
 - 1. SECTION 31 20 00 – EARTH MOVING
 - 2. SECTION 32 19 14 – PLANTING SOILS
 - 3. SECTION 32 90 00 – PLANTING
 - 4. SECTION 32 92 00 – LAWNS
 - 5. SECTION 32 93 53 – PLANTING MAINTENANCE

1.4 REFERENCES

- A. Comply with applicable requirements of:
 - 1. State of New Hampshire, Standard Specification for Roads and Bridge Construction, Department of Transportation, latest edition.
 - 2. City of Dover, of the State of New Hampshire, and of other authorities having jurisdiction. Provide labor, materials, equipment and services to comply with requirements.

1.5 QUALITY ASSURANCE

- A. Qualifications: Contractor shall have minimum five years experience in fine grading.

B. Pre-Installation Conference: Contractor shall convene a meeting with Owner's Representative present prior to start of fine grading.

C. Conform to provisions of SECTION 01 40 00 QUALITY REQUIREMENTS.

1.6 PROJECT/ SITE CONDITIONS

A. Environmental Requirements: do not deliver, handle or place soils when dry, wet, or frozen.

1. Field Test

- a. Form soil in palm of hand, if soil retains shape and crumbles upon touching, soil may be worked.
- b. If the soil will not retain shape it is too dry and should not be worked.
- c. If the soil retains shape and will not crumble, it is too wet and should not be worked.

1.7 SEQUENCING AND SCHEDULING

A. Fine Grading

1. Finish grade after soil preparation is accepted and prior to planting and seeding.

PART 2 - MATERIALS

2.1 PLANTING SOILS

A. See SECTION 32 19 14 – PLANTING SOILS.

2.2 EQUIPMENT

A. Fine Grading: Grading Tractor or other approved equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: in the event field conditions are not in conformance with the Contract Documents, notify Owner's Representative in writing.

1. Spot and Invert Elevations: verify field elevations of site improvements such as drainage and utility fixtures, pavements, curbs, and subsurface piping conform to Drawings.

3.2 PREPARATION

A. Protection:

1. Prior to fine grading operations, field locate and protect from damage site improvements such as drainage and utility fixtures, pavements, site furnishings, and curbs.
2. Dust Control: upon acceptance of soil preparation provide dust control.
3. Agricultural Chemicals: protect site improvements from contact with agricultural chemicals, soil amendments, and fertilizers.
4. Protect benchmarks.

3.3 FINISH GRADING

- A. Subgrade: top of subgrade to be parallel to finish grade and of uniform depth with the finish grade.
- B. Positive Drainage: provide free and uninterrupted flow of surface waters without erosion.
- C. Gradients: finish grade between spot elevations and between contours shall be constant. Eliminate mounds and depressions.
- D. Slope: finish grade shall be smooth with gradual transitions between top and tow of slopes.
- E. Tolerances: +0.05' to -0.05' of grades shown on the drawings.
- F. Contours: follow contours shown on drawings to shape and trim the soil surface.
- G. Maintain levels, profiles, and contours of rough grades.
- H. Removal: clear stones, roots, weeds, and debris while grading landscape soil materials. Rake surface clean of stones 1" or larger and debris.

3.4 FIELD QUALITY CONTROL

- A. Notify Owner's Representative upon completion of fine grading. Owner's Representative shall review the work for conformance to Contract Documents and if the work is approved, subsequent lawn and planting work shall proceed.
- B. Soil compaction at moisture content near field capacity based on measurements with a CL 700 pocket penetrometer shall not exceed 2.5 tons per square foot.

3.5 ADJUSTING

- A. Repair and re-establish grades in settled, eroded, and damaged areas.
- B. Where completed areas are disturbed by construction operations or adverse weather, and regrade.

3.6 CLEANING

- A. Clean up debris generated under work of this section.

B. Site Improvements

1. Wash and sweep clean site improvements such as drainage and utility fixtures, pavements, existing plantings, and site furnishings.

3.7 PROTECTION

- A. Protect work of this section until Final Acceptance.
- B. Protect prepared soils from compaction by construction traffic and from contamination by construction materials.

END OF SECTION

SECTION 312319

DEWATERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Temporary construction dewatering.

1.2 PERFORMANCE REQUIREMENTS

- A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

1.3 SUBMITTALS

- A. Shop Drawings: For dewatering system. Show arrangement, locations, and details of wells and well points; pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with governing EPA and NHDES notification regulations before beginning dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.
- B. Direct discharge of dewatering operation into the City storm sewer system is not permitted. Contractor must pre-treat water from dewatering operation and obtain approval from the City prior to discharging to City storm sewer system. Contractor is also responsible for obtaining necessary State and/or Federal permits for disposal of water.
- C. Dispose of water pumped or drained from the construction site in a suitable manner to avoid public nuisance, injury to public health, damage to public and private property, and damage to the work completed or in progress.
- D. All damage resulting from the dewatering operations, or the failure of the CONTRACTOR to maintain the work in a suitable dry condition shall be repaired by the Contractor, at no additional cost to the Owner.

1.5 PROJECT CONDITIONS

- A. Perform dewatering work as necessary at no additional cost to the Owner.

- B. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
 - 1. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Owner's Representative if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
 - 1. Prevent surface water and subsurface or groundwater from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
 - 2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- B. Install dewatering system to ensure minimum interference with roads, streets, walks, parking areas, and other adjacent occupied and used facilities.
 - 1. Do not close or obstruct drives, walks, parking areas, or other adjacent occupied or used facilities without permission from Owner's Representative and the City of Dover. Provide alternate routes around closed or obstructed traffic ways if required by the Owner's Representative or City of Dover.

3.2 INSTALLATION

- A. Provide temporary grading to facilitate dewatering and control of surface water.
- B. Monitor dewatering systems continuously.
- C. Protect and maintain temporary erosion and sedimentation controls, which are specified in Division 31 Section "Site Clearing" during dewatering operations.
- D. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.
 - 1. Space well points or wells at intervals required to provide sufficient dewatering.
 - 2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.
 - 3. Use "Dandy Sack", or approved equal, at discharge end of dewatering system to prevent fine sands and silts from being discharged across exposed surface areas on-site.

- E. Before excavating below ground-water level, place system into operation to lower water to 24 inches below surface of excavation. Operate system continuously until drainage and sewer pipe, water service, conduits, and other structures have been constructed and fill materials have been placed or until dewatering is no longer required.
- F. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drainage and other piping trenches, and other excavations.
 - 1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
- G. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drainage and sewer pipe, water service, conduits, and other excavations.
 - 1. Maintain piezometric water level a minimum of 24 inches below surface of excavation.
- H. Provide standby equipment on site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to Owner.
 - 1. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.

3.3 FIELD QUALITY CONTROL

- A. All subgrades must be inspected and approved by the ENGINEER prior to proceeding with work. Sufficient time must be allowed for the ENGINEER to observe and perform any necessary tests on the subgrade.

3.4 DAMAGES

- A. Promptly repair damages to adjacent facilities caused by dewatering operations.

END OF SECTION 312319

SECTION 312500

STORM WATER POLLUTION PREVENTION PLAN

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Requirements for the project Storm Water Pollution Prevention Plan.

1.2 ABBREVIATIONS AND DEFINITIONS

A. USEPA – United States Environmental Protection Agency

B. NPDES – National Pollutant Discharge Elimination System

C. NHDOT – New Hampshire Department of Transportation

D. NHDES – New Hampshire Department of Environmental Services

E. NOI – Notice of Intent

F. NOT – Notice of Termination

G. SWPPP – Storm Water Pollution Prevention Plan

H. Qualified Products List – Products appearing on this list have been approved for general use. The list is available from the NHDOT Bureau of Materials & Research or at <http://www.nh.gov/dot/org/projectdevelopment/materials/research/documents/qpl.pdf>.

I. General Permit – USEPA NPDES General Permit for Storm Water Discharges from Construction Activities effective July, 2008 and any subsequent revisions.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with applicable requirements of federal, state, and local laws, regulations, and codes having jurisdiction at the project site.

B. Comply with the requirements included, and referenced, below.

C. In the event that applicable regulations are in conflict with each other, or the technical specifications, the more stringent requirement shall prevail.

1.4 PROJECT CONDITIONS

- A. Under no circumstances shall work involving the disturbance of land begin until the Plan is approved by the Owner's Representative, an NOI is submitted by the Contractor, an NOI is submitted by the Owner, and both NOI's are acknowledged and accepted by the USEPA.
- B. Do not commence disturbance of land until all temporary erosion and sedimentation control measures are in place in accordance with the approved Plan and the Contract Drawings.

1.5 SUBMITTALS

- A. Contractor shall be responsible for submitting the items noted in the technical specifications, the Contract Documents, and any other items as may be required by any/all applicable regulations, to the specified appropriate parties.

1.6 DESCRIPTION

A. Permanent Control:

- 1. This work shall consist of furnishing and placing hay mulch, bark mulch, wood, straw or coconut fiber mat, synthetic mat, paper mat, jute mesh or other material as a soil stabilization product for erosion control on slopes or ditches for protection to hold the ground and/or cover material (sod, seed, etc.) in place, at locations shown on the Plan, Contract Drawings, or where ordered.
- 2. Slope stabilization shall meet the requirements of the Qualified Products List for either slope greater than or less than 2:1.
- 3. Channel stabilization shall meet the requirements of the Qualified Products List for either low velocity (less than 9 feet/sec) or high velocity (greater than 9 feet/sec).
- 4. Permanent stabilization shall be permanent material installed on slopes or in channels.

B. Temporary Control:

- 1. When the use of hay bales is required, this work shall consist of furnishing and placing hay bales as a temporary erosion and pollution control device at locations shown on the Plan, Contract Drawings, or where ordered.
- 2. When seeding is required, this work shall consist of furnishing, and sowing seed specified as directed.
- 3. When silt fence is required, this work shall consist of furnishing, installing, maintaining and removing silt fence as shown on the Plan, Contract Drawings, or where ordered.
- 4. When temporary mulch is required this work shall consist of furnishing and placing at locations shown on the Plan, Contract Drawings, or where ordered.
- 5. When erosion stone is required this work shall consist of furnishing, stockpiling, placing and removal if required at locations shown on the Plan, Contract Drawings, or where ordered.

C. General Permit:

- 1. This project constitutes construction activity that disturbs one or more acres of land and requires a General Permit from the USEPA.
- 2. The Contractor shall be responsible for:

- a. Notice of Intent: The Contractor shall submit an NOI to the USEPA in order to be covered by the General Permit. Construction activity shall include any activities that expose soil such as clearing, grading, excavation, landscaping, demolition, building renovation and building construction. The forms, the permit requirements and guidance are available from:
 - 1) EPA New England Region 1, 1 Congress Street, Suite 1100, Boston, MA 02114-2023, or
 - 2) EPA Storm Water Processing Center at 866-352-7755, or
 - 3) <http://www.epa.gov/npdes/stormwater/cgp>
 - b. Notice of Termination: This work shall include the Contractor's preparation and submission of a NOT to the USEPA at the completion of the project in accordance with the General Permit.
 - c. Storm Water Pollution Prevention Plan: This work shall consist of the required submittal(s) and the preparation of the submittal to obtain final approval of a Storm Water Pollution Prevention Plan, hereinafter called the "Plan", for this project. The Plan shall be a part of the necessary documentation in accordance with the General Permit and this specification. This work shall also include the subsequent monitoring and proper execution of the approved Plan and its temporary and permanent controls during construction.
3. The approved Plan shall be adopted by the Owner for the purposes of submitting a separate NOI, however, the Owner assumes no liability for implementing the Plan nor subsequent monitoring as described under the Plan and these specifications.
 4. The Owner's Representative will furnish the following data, as available, to the Contractor:
 - a. Specific reproducible plan sheets of the project, as requested,
 - b. Drainage calculations and plans (drainage area size and characteristics; runoff volume; type, size, and slope of pipes; invert elevations; and outlet velocity), as available,
 - c. Geotechnical Report including soil boring logs, soil types, and test pit data, as available,
 - d. Other applicable permits obtained for the project, and
 - e. A list of environmental commitments, as appropriate.
 5. Recommended guides for the preparation and execution of the Plan include:
 - a. *The NHDOT Guidelines for Temporary Erosion and Sediment Control and Stormwater Management* available from the New Hampshire Department of Transportation, 1 Hazen Drive, PO Box 483, Concord, NH 03302-0483.
 - b. *The Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire* and the *Innovative Stormwater Treatment Technologies BMP Manual*, both available from the New Hampshire Department of Environmental Services (NHDES) Public Information and Permitting Office, PO Box 95, 6 Hazen Drive, Concord, NH 03302-0095 and
 - c. *Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices* by the USEPA (EPA 832-R-92-005) which is available from the National Technical Information Service (NTIS Order No. PB 922 359 51) at (703) 487-4650 or at <http://www.epa.gov/npdes/stormwater>

D. Other Attentions:

1. The Contractor's attention is called to RSA 72-B, Excavation Tax and Excavation Activity Tax and related administrative rules of the NH Department of Revenue Administration, which among other provisions, levies a tax on earth and excavations as defined in RSA 155-E.

PART 2 - PRODUCTS

2.1 MULCH

- A. Hay mulch shall consist of cured hay, free from weeds and rough or woody materials.
- B. Bark mulch shall be a bark chipping graded to be approximately 3/8 to 2 inch wide. The chippings shall not have been stored so long and under such conditions that the material has decomposed sufficiently so that it has lost its fibrous texture. Bark mulch must be approved as to grading and condition prior to its use.
- C. Temporary mulches may be hay, straw, fiber mats, netting, wood cellulose, bark, chips or other acceptable material and shall be reasonably clean and free of noxious weeds and materials toxic to plant growth.
- D. Other types of mulch, as included on the Qualified Products List available from the NHDOT Bureau of Materials & Research, may be used.

2.2 SOIL STABILIZATION

- A. Stabilization material of the type specified shall be a product as included on the Qualified Products List. The material furnished for use shall be of sufficient construction and strength to hold the processed ground and/or cover material (sod, seed, etc.) in place until an acceptable growth of natural or planted material is established.
- B. Staples for soil stabilization material matting shall be those as specified by the manufacturer.

2.3 SEED

- A. Seed for temporary control shall be shall be a quick growing species suitable to the area, such as annual or perennial ryegrass, providing a temporary cover which will not compete with the grasses subsequently sown for permanent cover.

2.4 HAY BALES

- A. Hay bales for erosion control shall consist of rectangular shaped bales of hay or straw weighing at least 40 pounds per bale. They shall be free from weed seeds and rough or woody materials.

2.5 TACKIFIERS

- A. Tackifiers for ground coverings shall be as included on the Qualified Products List available from the NHDOT Bureau of Materials & Research.

2.6 SILT FENCE

- A. Geotextile filter fabric for silt fence shall be made from polypropylene, polyester, or other approved polymeric chemically stable material and shall be resistant to ultraviolet radiation

degradation for at least 12 months. Silt retention capacity shall be no less than 75 percent of silt and suspended solids. The fabric shall meet the following requirements:

Fabric Property	Test Method	Property Requirement*
Grab Tensile Strength (lbs)	ASTM D 4632	100 Minimum
Grab Tensile Elongation (%)	ASTM D 4632	25 Maximum
Puncture Strength (lbs)	ASTM D 4833	60 Minimum
Mullen Burst Strength (psi)	ASTM D 3786	210 Minimum
Trapezoid Tear Strength (lbs)	ASTM D 4533	60 Minimum

*All properties are minimum or maximum average roll values (i.e. the test results for any sampled roll in a lot shall meet or exceed the minimum values or be less than or meet the maximum value in the table.)

- B. Posts for silt fence shall be either wood or steel. Wood posts shall be sound quality hardwood with a minimum cross sectional area of 3 square inches. Steel post shall be standard "T" or "U" section weighing not less than 1 pound per linear foot with projections for fastening wire to the fence. Maximum post spacing shall be 10 feet.
- C. Support fence for silt fence, if required, shall be a minimum of 14.5 gauge woven wire with a maximum 6-inch mesh.

2.7 EROSION STONE

- A. Erosion stone shall meet the following gradation for a nominal size stone of 1 ½" to No. 4:

Sieve Size	% By Weight Passing
2"	100
1 ½"	95-100
1"	
¾ "	35-70
½ "	
⅜ "	10-30
No. 4	0-5

PART 3 - EXECUTION

3.1 GENERAL

- A. Prior to the start of construction requiring erosion and sediment control, the Contractor shall submit four sets of the Plan to the Owner's Representative for approval. Review time shall be proportional to the complexity of the Plan and will be within approximately 15 working days from time of submittal. Names of designated personnel to perform field monitoring shall be included in the submittal. The Plan may be submitted in phases or for specific construction areas. Only work within areas covered by an approved Plan will be allowed.
- B. No work requiring land disturbance shall commence until the Plan has been approved by the Owner's Representative and all NOI's are submitted and accepted.

- C. Permanent erosion control features shall be incorporated into the project at the earliest practicable time, as specified in the Contract Documents and Drawings, and as outlined in the approved Plan. Temporary pollution control measures shall be used to correct conditions that develop during construction to temporarily control erosion not associated with permanent control features.
- D. When erosion is likely to be a problem, operations shall be so scheduled and performed that grading operations and permanent erosion control features can follow immediately thereafter.
- E. The Contractor will limit the area of land disturbance commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding and permanent pollution control measures concurrent with operations and in accordance with the accepted Plan.
- F. Earth excavation and embankment slopes shall be permanently treated for stabilization before the time the slant height of exposed slopes reaches 30 feet, unless otherwise ordered. Where construction activities are complete within the growing season, all exposed soil areas shall be permanently treated for stabilization within 14 days. Where construction activities are temporarily suspended, all exposed soil areas shall be treated for stabilization within 14 days.
- G. As work progresses, patch seeding and mulching shall be done as required on areas previously treated to maintain or establish protective cover.
- H. Drainage pipes and ditches shall be constructed in a sequence from outlet to inlet in order to stabilize outlet areas and ditches before water is directed to the new installation or any portion thereof unless conditions unique to the location warrant written approval of an alternative method.
- I. Channel and ditch work, including erosion protection items, shall be completed before diversion of the drainage is accomplished.
- J. In the event of conflict between these requirements and pollution control laws, rules or regulations of other Federal, State or local agencies, the more restrictive laws, rules or regulations shall apply.

3.2 NOTICE OF INTENT

- A. The Contractor shall prepare and submit a General Permit NOI. A copy of the Contractor's NOI shall be given to the Owner's Representative.
- B. Following the approval and adoption of the Plan, the Owner shall prepare and submit a separate General Permit NOI as required. A copy of the Owner's NOI shall be given to the Contractor.
- C. Submission of an NOI to the USEPA by the Contractor or the Owner does not release the Contractor of fulfilling the requirements of the submission and approval process of the Plan as described below.
- D. Under no circumstances shall work involving the disturbance of land begin until the Plan is approved by the Owner's Representative, an NOI is submitted by the Contractor, an NOI is submitted by the Owner, and until after 14 calendar days after acknowledgement of receipt of the completed NOI's are posted on EPA's NPDES website.

3.3 STORM WATER POLLUTION PREVENTION PLAN

- A. The Plan shall be prepared, stamped and signed by a Licensed Professional Engineer registered in the State of New Hampshire qualified to prepare erosion and sediment control plans, hereinafter called the "Preparer". Collaboration with other professionals such as soil scientists, geologists and environmentalists may be required as appropriate.
1. Qualifications for preparation of the Plan shall include a minimum of 5 years experience or knowledge of methods of construction and demonstrated knowledge of erosion and sediment control and storm water management measures. The preparer shall have previously submitted plans to NHDES under RSA 485-A:17 Terrain Alteration, to NHDOT under Section 645 Erosion Control – Erosion and Sediment Control and Stormwater Management Plan, or have prepared plans previously under the General Permit and shall have attended workshops on erosion and sediment control and storm water management.
 2. The Contractor shall submit the name and qualifications of the person or firm proposed to prepare the Plan to the Owner's Representative for approval prior to preparing the Plan. Submittal of the name and qualifications will be accepted after the opening of bids.
- B. The Plan shall be developed using a combination of structural, non-structural and vegetative Best Management Practices (BMP's) to adequately control erosion and sedimentation and manage storm water in accordance with required and recommended guidelines described previously unless otherwise specified in the contract documents.
- C. The Plan shall include but not be limited to the following information:
1. Specific information describing existing site(s) conditions, description of the project, soils, and sensitive areas, storm water flow directions and areas where soil will be disturbed.
 2. The location and extent of surface waters that are included or adjacent to the site within one mile. Surface waters shall include lakes, rivers, streams (both perennial and intermittent), tributaries and wetlands.
 3. A description of construction materials and wastes associated with the project (litter, debris, chemicals, fuels, etc.), how their exposure to storm water will be minimized, and how spills will be prevented, contained and cleaned up.
 4. A description of how off-site tracking of sediments and dust by vehicles and storm water pollution from off-site material storage areas used for the project, such as soil stockpiles and borrow areas, will be minimized.
 5. A description of how sources of non-storm water generated, such as vehicle wash water, building and pavement wash water, water line flushing, dewatering, and exposed ground water will be prevented from contributing to runoff pollution. (Discharge of wash water contaminated with detergents or other chemicals is not allowed under the General Permit.)
 6. Information on any endangered or threatened species on or near the site.
 7. The name and location of the body of water (e.g., stream, creek, brook, wetland, river, lake, bay, ocean) that will receive the runoff from the construction site or, if the receiving water is a tributary, the name of the ultimate receiving body of water.
 8. Estimates of the total site area, which represents the size of the parcel of property or right of way on which the construction is occurring, and the total area that will be disturbed.
 9. A description of the measures to be used for erosion and sediment controls throughout the construction project including stabilization measures for disturbed areas and structural controls to divert runoff and remove sediment. The measures must be shown on the Plan including the location of each measure.

10. A description and schedule of phasing and discussion of the various erosion and sediment controls and stabilization methods as they relate to the construction schedule.
11. A description and schedule for monitoring and maintaining the pollution prevention measures.
12. Contract Drawings, as available, will show the construction site(s) conditions prior to and after construction by including property lines, right-of-way lines, easements, existing and new structures, drainage, flood plains, wetlands, limits of clearing and grading, proposed final drainage, detours, permanent erosion and sediment control measures, and other critical items. The Contractor's Plan drawings shall show temporary drainage and erosion and sediment control measures for the construction site(s) on the Contract Drawings provided by the Owner's Representative.
13. Additionally the Contractor shall provide plans showing all of the above items for proposed areas related to the construction site(s) not shown on the Contract Drawings, including but not limited to, access and haul roads, equipment and material storage sites, material pits, material processing sites, and disposal areas, except municipally authorized landfill areas and commercial sites. Waste materials are quite often materials unsuitable for embankment construction and generally very susceptible to erosion; therefore, the Contractor shall pay close attention to controlling erosion of these materials.
14. Additional design typicals illustrating practices for erosion and sediment control not shown on the Contract Drawings and Specifications shall be included in the Plan. Calculations shall be included to verify all erosion and sediment control and storm water management practices such as, but not limited to, sediment retention and detention basins, energy dissipaters, diversions, waterways, and control of runoff.
15. Specific requirements for General Permit NHR100000: State of New Hampshire to be addressed in the Plan, if applicable, can be obtained at <http://www.epa.gov/npdes/stormwater/cgp>.
16. The Preparer or the Preparer's designated representative shall assist the Contractor in implementing the Plan and recommend modifications to the Plan for changing operations or inadequate erosion and sediment control and storm water management measures. The Preparer shall make modifications to the Plan as necessary and resubmit for review and approval. Review time of modifications will be within approximately 10 working days of submittal.
17. The Owner's Representative may order modifications to the Plan for changing operations or for inadequate erosion and sediment control and storm water management measures.
18. The Preparer of the Plan shall be available for on-site consultations with the Owner's Representative within 24 hours of a request.
19. A copy of the Plan and any changes to the plan shall be kept at the construction site from the time construction begins until the site is permanently stabilized. The documents must be made available upon request by the Owner's Representative or any other Federal, State or local agency that has jurisdiction over such matters.
20. Upon completion of the project, a copy of the Plan, complete with all revisions, deficiencies and corrective measures employed during the course of the work shall be given to the Owner's Representative and Owner.

3.4 MONITORING THE PLAN

- A. The monitoring of the erosion and sediment controls in relation to the Plan shall be the responsibility of the Contractor. The person(s) in charge of the monitoring of the Plan shall be hereinafter referred to as the "Reviewer". The Reviewer shall be identified to all parties at the preconstruction conference and be noted within the Plan.

- B. Inspection of erosion and sediment controls by the Reviewer does not relieve the Contractor from conducting periodical reviews of the erosion and sediment controls and making repairs.
- C. The Reviewer shall keep records on when major grading activities occur, when activities temporarily or permanently cease and when stabilization occurs.
- D. Monitoring of the erosion and sediment controls shall include on-site inspections by the Reviewer. Inspections shall be conducted on either of two schedules, 1) weekly, or 2) bi-weekly and within 24 hours after any storm event greater than 0.5 in of rain per 24-hour period. The inspection shall encompass all disturbed areas, material storage areas, structural controls, vehicle entry/exit locations and storm water discharge locations.
- E. If the area of project disturbance is entirely stabilized, monitoring of the erosion and sediment controls may occur monthly or not at all if the earth is frozen long-term up until 1 month before thaw as long as there is no earth disturbance.
- F. A monitoring report prepared by Reviewer stating the date of review and describing the erosion and sediment control and storm water management measures reviewed, the effectiveness of their operation, any deficiencies, and corrective actions to be undertaken shall be prepared after each review. A copy of the monitoring report shall be provided to the Owner's Representative, Owner and Contractor within two days of each review.
- G. The Contractor shall correct damage or deficiencies identified by the Reviewer as soon as practicable after each site review and report but in no case later than 7 days after the damage or deficiency was noted. Any changes that may be required to correct deficiencies in the Plan shall be noted on the Plan and also be made within 7 days after the noted deficiency. A copy of any changes to the Plan shall be provided to the Owner's Representative for review and approval.
- H. All monitoring reports and records of major grading activities shall be kept at the construction site from the time construction begins until the site is permanently stabilized. The documents must be made available upon request by the Owner's Representative or any other Federal, State or local agency that has jurisdiction over such matters. Upon completion of the project, a copy of all records pertaining to this section shall be given to the Owner's Representative, Owner and Contractor.

3.5 SUSPENSION OF WORK

- A. Project work may be suspended, wholly or in part, with no extension of time or additional compensation for failure to submit, implement and maintain the approved Plan, including modifications.

3.6 MULCH

- A. Mulching shall be done immediately after each area has been properly prepared. When seed for erosion control is sown prior to placing the mulch, the mulch shall be placed on the seeded areas within 48 hours after seeding. Hay that has been thoroughly fluffed shall be applied at approximately, but not to exceed 3 tons per acre unless otherwise ordered. Blowing chopped hay mulch will be permitted provided the Contractor controls the mulching operation so as not to infringe on property owners or the traveling public. Blown hay mulch shall be applied in such a manner resulting in a minimum amount of matting that would retard the growth of plants. Hay mulch should cover the ground enough to shade it, but the

mulch should not be so thick that a person standing cannot see ground through the mulch. Matted mulch or bunches shall be removed or otherwise remedied.

- B. In order to prevent mulch from being blown away, a light covering of loose branches or approved tackifier shall be employed. Unless otherwise ordered, loose branches shall be removed prior to completion of the work.
- C. All baling wire or rope, such as that used in the shipment of mulch shall be disposed of outside the limits of the project in approved areas.
- D. Bark mulch shall be placed on the designated areas to the depth specified in the Plan or as ordered.
- E. On areas treated with bark mulch, the Contractor shall remove weeds and plant material as directed.

3.7 SOIL STABILIZATION PRODUCTS

- A. Surfaces of ditches and slopes to receive soil stabilization products shall conform to the grades and cross sections shown on the plans and shall be finished to a smooth and even condition with all debris, roots, stones, and lumps raked out and removed. The soil surface shall be sufficiently loose to permit bedding of the product. Unless otherwise directed, soil shall be prepared, including the application of lime, fertilizer and seed prior to installation of the specified type of soil stabilization product.
- B. Soil stabilization, of the type specified, shall be installed where shown in the Plan, or as directed by the Owner's Representative. Throughout the entire placement area, the soil stabilization product shall be in uniform contact with the existing underlying soils. It is critical that this contact is achieved in order to maximize any seeding or other vegetative growth specified for this area. Matting, if used, shall not be stretched.
- C. Installation techniques and procedures shall be as recommended by the manufacturer for the particular site characteristics or as directed. Documentation from the product manufacturer regarding installation techniques and procedures shall be submitted to the Owner's Representative at least 10 working days prior to installation.
 - 1. Matting, if used, shall be buried around the edges of catch basins and other structures or obstructions as described in the manufacturer's installation requirements.
 - 2. The spacing of staples shall be as required for specific site considerations depending upon varying factors such as the season of the year or the amount of water encountered or anticipated.
- D. For soil stabilization materials that become loosened, raised, or undermined, or if any matting becomes torn, or any matting staples become loose or raised, satisfactory repairs shall be made within 48 hours.

3.8 SEED FOR EROSION CONTROL

- A. Areas, which are to be left temporarily or regraded or otherwise disturbed later during construction, may need to be seeded with ryegrass to obtain temporary control. The seed shall be sown at the rate of approximately 1 pound per 1,000 square feet.

3.9 HAY BALES FOR EROSION CONTROL

- A. Hay bales shall be placed as shown on the Plan to provide for temporary control of erosion or pollution or both. They shall be staked with the required stakes. Upon completion of the project and hay bales controlling erosion or pollution shall be left in place until ordered removed.

3.10 SILT FENCE

- A. The Contractor shall construct and dismantle the silt fence as shown in the Plan and as recommended by the manufacturer.
 - 1. When two sections of filter fabric adjoin each other, they shall be overlapped by 6 inches, folded, and stapled at a post.
 - 2. Support fence, when required, shall be fastened securely to the fence posts with staples or wire ties.
 - 3. Filter fabric shall be fastened to the support fence, when support fence is required, with ties spaced every 2 feet longitudinally at the top, mid-section, and bottom.
- B. Care shall be taken to maintain the silt fence in a functional condition at all times during the construction period.
 - 1. Silt fences shall be inspected at a minimum according to the Plan schedule of monitoring. In times of prolonged rainfall or water diversion, extra inspections may be necessary. The Contractor shall immediately correct all deficiencies.
 - 2. Remove retained material when "bulges" develop in the silt fence or when deposits reach approximately one-half the height of the silt fence.
 - 3. Fabric which has decomposed, has become ineffective or does not retain silt or suspended solids and is still needed, shall be replaced.
- C. The Contractor shall remove the silt fence after all work has been completed and it is no longer needed or as ordered. Sediment deposits that are removed or left in place after the fabric has been removed shall be graded to conform to the existing topography and shall be vegetated.

3.11 EROSION STONE

- A. Erosion stone shall be placed to provide for temporary control of erosion or pollution including stone check dams, inlet control and stabilized entrances as shown in the Plan. Upon acceptance of the contract, the stone shall be left in place unless considered to be permanent control.

3.12 MAINTENANCE

- A. Erosion and sediment controls shall be maintained by the Contractor throughout the life of the project.

3.13 NOTICE OF TERMINATION

- A. The Contractor shall prepare and submit a General Permit NOT directly to the USEPA within thirty days after the project is done and completely stabilized. A copy of the NOT shall be given to the Owner's Representative.

END OF SECTION 312500

SECTION 315000

EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Temporary excavation support and protection systems.

1.2 PERFORMANCE REQUIREMENTS

- A. Furnish, install, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting soil and hydrostatic pressure and superimposed and construction loads.

1.3 SUBMITTALS

- A. Shop Drawings: For excavation support and protection system, prepared by or under the supervision of a qualified Professional Engineer. System design and calculations must be acceptable to authorities having jurisdiction.

1. Include Shop Drawings signed and sealed by the qualified Professional Engineer responsible for their preparation.

- B. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of Architects and Owners, and other information specified.

- C. Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by excavation support and protection systems.

- D. Vibration monitoring plan in accordance with the City of Dover requirements.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer to assume engineering responsibility and perform work of this Section who has specialized in installed excavation support and protection systems similar to those required for this Project and with a record of successful in-service performance.

- B. Professional Engineer Qualifications: A Professional Engineer who is legally qualified to practice in the jurisdiction where the Project is located and who is experienced in providing engineering services for designing excavation support and protection systems that are similar to those indicated for this Project in material, design, and extent.

1. Engineering Responsibility: Engage a qualified Professional Engineer to prepare or supervise the preparation of data for the excavation support and protection system including drawings and comprehensive engineering analysis that shows the system's compliance with specified requirements.

1.5 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted in writing by the Owner's Representative or the City of Dover and then only after arranging to provide temporary utility services according to requirements indicated.
- B. Project Site Information: Contractor can make test borings and conduct other exploratory operations as necessary to collect information needed for the design of the excavation support and protection system.
 1. The schedule for test borings and other exploratory operations shall be coordinated with the Owner's Representative.
- C. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
 1. During installation of excavation support and protection systems, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Owner's Representative if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: Provide materials that are either new or in serviceable condition.
- B. Structural Steel: ASTM A 36
- C. Steel Sheet Piling: ASTM A 328, ASTM A 572; with continuous interlocks.
- D. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.
- E. Reinforcing Bars: ASTM A 615/, Grade 60, deformed.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation support and protection system operations.

1. Shore, support, and protect utilities encountered.
- B. Install dewatering system to ensure minimum interference with roads, streets, walks, parking areas, and other adjacent occupied and used facilities.
 1. Do not close or obstruct drives, walks, parking areas, or other adjacent occupied or used facilities without permission from Owner's Representative and the City of Dover. Provide alternate routes around closed or obstructed traffic ways if required by the Owner's Representative or City of Dover.
- C. Locate excavation support and protection systems clear of permanent construction and to permit forming and finishing of concrete surfaces.
- D. Monitor excavation support and protection systems daily during excavation progress and for as long as the excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure excavation support and protection systems remain stable.
- E. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

3.2 INSTALLATION

- A. Sheet Piling: Before starting excavation, install one-piece sheet piling lengths and tightly interlock to form a continuous barrier. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to 60 inches. Accurately align exposed faces of sheet piling to vary not more than 2 inches from a horizontal line and not more than 1:120 out of vertical alignment. Cut tops of sheet piling to uniform elevation at top of excavation.
- B. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.
 1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Owner's Representative.
 2. Install internal bracing, if required, to prevent spreading or distortion of braced frames.
 3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.3 REMOVAL

- A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bear soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.
 1. Remove excavation support and protection systems to a minimum depth of 48 inches below overlaying construction and abandon remainder.

END OF SECTION 315000

SECTION 316630

AGGREGATE PIERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Carefully review and examine all other Contract Documents for requirements therein affecting the work of this Section. Furthermore, coordinate and sequence the work of this Section with all other trades affected.

1.2 DESCRIPTION OF WORK

- A. The work of this section includes but is not limited to designing, engineering, furnishing and installing aggregate pier elements to the lines and grades designated on the project foundation plan and as specified herein.
- B. Aggregate pier elements are to be installed for support of building footings and slabs in the area indicated on Contract Document GEO.1 defined as east of column line A4 and south of column lines AE.9, BG.7 and BE.6.
- C. The aggregate pier elements shall be constructed by compacting aggregate into either a predrilled hole or by vertical displacement using special high-energy densification equipment.
- D. The aggregate pier elements shall be in a columnar-type configuration and shall be used to reinforce the existing fill and existing marine deposit soils for the support of four (4) kips per square-foot (ksf) bearing pressure spread footings.
- E. The aggregate pier elements shall extend at least to the surface of the natural glacial till deposit.
- F. References to the Designer herein shall be construed to mean the Aggregate Pier Designer retained by the Aggregate Pier Installer and meet the requirements specified herein.

1.3 COORIDNATION

- A. The Designer and Installer shall coordinate with the aggregate pier locations with all underground utilities to be installed

1.4 APPROVED INSTALLERS

- A. Aggregate pier installer (the Installer) of aggregate piers shall have a minimum of 5 years of experience with the installation of aggregate piers and shall have completed at least 25 similar projects.
- B. Installers shall have demonstrated experience in the design and construction of similar size and types of projects. The Installer shall be approved by the Architect.

1.5 RELATED WORK SPECIFIED ELSEWHERE

- A. Carefully examine all of the Contract Documents for requirements which affect the work of this section. Other specification sections which directly relate to the work of this section include, but are not limited to, the following:

1. Section 312001 – Building Earthwork

1.6 EXAMINATION OF SITE AND DOCUMENTS

- A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of lack of full knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation at the Site.
- B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period, as no allowance will be made for any errors or inaccuracies that may be found except as otherwise provided herein.

1.7 SUBSURFACE CONDITIONS

- A. At locations identified on the subsurface exploration plan included herein in the Contract Documents, borings have been made by a qualified contractor prior to the Construction Contract.
- B. All subsurface data obtained is given on the logs enclosed herein. These data and soil samples are representative of the ground conditions at each exploration location and do not necessarily apply elsewhere.
- C. The explorations were made in order to provide data for foundation design and the results are included solely as information to bidders. Interpretation of the data for purposes of construction is the responsibility of the Contractor.
- D. Reference is made to the Foundation Engineering Reports dated May 14, 2015 and November 2, 2015, and a letter entitled "Revised Foundation Engineering Recommendations" dated March 21, 2016, which are available at the office of the Architect. The reports are provided solely as information to bidders.
- E. Boring logs, subsurface exploration plan, groundwater monitoring log and grain size distributions for on-site soils are included under Division 1. The Contractor is hereby notified of the presence of an active sewer line which traverses the proposed building footprint at the location shown on Drawing C-4.2 approximately located between column lines A14 and A15. The Contractor shall perform all work for the project in such a manner as to protect and maintain the operation of the sewer line.
- F. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but this trade shall have examined them for himself during the bidding period, as no additional compensation will be made for errors or inaccuracies that may be found therein.
- G. Should any obstruction be encountered during aggregate pier installation, the Contractor shall be responsible for promptly removing such obstruction, or the pier shall be relocated or abandoned. Obstructions include, but are not limited to, concrete foundations and slabs, concrete debris, brick foundations, utility lines, etc., which prevent placing the piers to the

required depth, or shall cause the pier to drift from the required location. No additional compensation will be provided to the Installer for advancing the aggregate pier through the existing fill.

1.8 REFERENCE STANDARDS

A. Modulus and Uplift Testing:

1. ASTM D-1143 – Pile Load Test Procedures
2. ASTM D-1194 – Spread Footing Load Test

B. Materials and Inspection:

1. ASTM D-1241 – Aggregate Quality
2. ASTM D-422 – Gradation of Soils

1.9 CERTIFICATIONS AND SUBMITTALS

- A. The Installer shall submit detailed design calculations, construction drawings, and shop drawings, (Design Submittal), for approval at least four week(s) prior to the beginning of construction. A detailed explanation of the design parameters for settlement calculations shall be included in the Design Submittal. Additionally, the quality control test program for aggregate piers, meeting these design requirements, shall be submitted. All calculations and drawings shall be prepared and sealed by a registered professional engineer licensed in the state of New Hampshire.
- B. Modulus Test Reports – Modulus tests are required to be performed at non-production Aggregate Pier elements to verify the design assumptions. The Installer shall furnish the Architect a description of the installation equipment, installation records, complete test data, analysis of the test data and recommended design parameter values for rammed aggregate piers based on the modulus test results. The report shall be prepared under supervision of a registered professional engineer licensed in the state of New Hampshire.
- C. Daily Aggregate Pier Progress Reports – The Installer shall furnish a complete and accurate record of aggregate pier installation to the Contractor. The record shall indicate the pier location, length, mandrel penetration data, mandrel stroke, pier diameter, shaft length, average lift thickness and final elevations of the base and top of piers. The record shall also indicate the type and size of the densification equipment used. The Installer shall immediately report any unusual conditions encountered during installation to the Contractor, to the Owner's On-site Representative, to the Designer and to the Architect.
- D. The Designer shall provide a shop drawing for review, indicating the spacing, location and depth of the aggregate piers.
- E. The Designer shall specify and submit the minimum energy level in foot-pounds of force per minute to be applied by the energy source, if applicable.
- F. The Designer shall specify and submit the procedure and minimum time to install and compact each lift of aggregate, if applicable.
- G. Submit to the Architect for review proposed installation equipment and methods, a sketch of the modulus test setup, and modulus test procedures.
- H. Submit to the Architect for review proposed means and methods to construct grouted piers, if utilized.

1.10 AGGREGATE PIER DESIGN PERFORMANCE REQUIREMENTS

- A. Based on the available subsurface information, the Designer shall select appropriate aggregate pier stiffness on which to base their design. The stiffness modulus value shall be verified by the results of the aggregate pier modulus tests, described in this specification.
- B. Aggregate piers shall be designed in accordance with generally accepted engineering practice and the methods described in these Specifications. The design shall meet the following criteria:
 - 1. Minimum Allowable Bearing Pressure for Aggregate Pier Reinforced Soils:
Four (4) kips per square-foot
 - 2. Maximum allowable spacing for support of slabs-on-grade: 12 feet
 - 3. Estimated Total Long-Term Settlement for Footings and Slabs: \leq 1-inch
 - 4. Estimated Long-Term Differential Settlement of Adjacent Footings: \leq ½-inch
 - 5. The aggregate pier elements shall extend at least to the surface of the natural glacial till deposit.
- C. The design submitted by the Installer shall consider the bearing capacity and settlement of all footings supported by aggregate piers, and shall be in accordance with acceptable engineering practice and these specifications.
- D. The aggregate pier system shall be designed to preclude plastic bulging deformations at the top-of-pier design. The results of the modulus tests shall be used to verify the design assumptions.

1.11 BASIS OF PAYMENT

- A. The base bid for the work of this section shall include the following, and all work incidental thereto:
 - 1. Mobilization and Demobilization.
 - 2. Aggregate pier design to comply with the requirements of the Contract Documents.
 - 3. Installation of the required number and depth of aggregate piers to comply with the design prepared by the Designer.
 - 4. The successful completion of one (1) modulus test.
- B. Aggregate piers rejected due to Installer error will not be paid for. Additional aggregate piers required to compensate for production aggregate piers or replacement aggregate piers installed out of design location will be installed at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Aggregate used for aggregate pier construction shall be pre-approved by the Designer and shall demonstrate suitable performance during modulus testing. Typical aggregate consists of ASTM No. 57 stone or other open-graded aggregate approved by the Designer.
- B. To facilitate construction in soft or loose soils, the maximum particle size aggregate of 2 inches or larger may be used provided the performance is verified with the modulus test and the Designer approves the type and gradation of the aggregate.

- C. Cement shall be Type II Portland Cement.

PART 3 - EXECUTION

3.1 AUGERED AGGREGATE PIER INSTALLATION PROCEDURES

- A. Aggregate pier elements shall be predrilled using mechanical drilling or excavation equipment.
- B. If cave-ins exceeding 10% of the lift volume occur during excavation such that the sidewalls of the hole are deemed to be unstable, the aggregate shall be removed and replaced with fresh aggregate. Steel casing shall be used to stabilize the excavation or a displacement aggregate pier system (Paragraph 3.2) may be used.
- C. Aggregate shall be placed in the augered cavity in lift thicknesses as determined by the Designer.
- D. Special high-energy impact densification apparatus shall be employed to densify the Aggregate pier elements during installation. The apparatus shall apply direct downward impact energy to each lift of aggregate.
- E. The bottom of the excavation shall be densified prior to the placement of the aggregate. If wet, soft or sensitive soils are present, open-graded aggregate, such as ASTM No. 57 stone or other, shall be placed at the bottom of the excavation and compacted to stabilize the element bottom and may serve as the initial lift.
- F. Densification shall be performed using a beveled tamper. The beveled tamper foot is required to adequately increase the lateral earth pressure in the matrix soil during installation.
- G. Downward pressure shall be applied to the tamper shaft during tamping.

3.2 DISPLACEMENT AGGREGATE PIER INSTALLATION PROCEDURES

- A. A bottom feed vibrator or mandrel shall be driven to the design pier depth using crowd force, vibration or impact energy as required and ensure that aggregate can be freely installed to the design bottom of the pier.
- B. The operation of the energy source applied to each aggregate lift shall be performed as specified in the aggregate pier design submittal.
- C. The pier shall be constructed by raising and lowering the vibrator or mandrel as indicated in the design submittal to construct an approximate 1-foot thick compacted lift. Additional energy application and/or alternative lift heights and lowering depths, may be used as appropriate for the project site upon approval by the Designer.
- D. Subsequent lifts shall be constructed following the same procedure described above until the pier is constructed to the top of pier elevation.
- E. Apply crowd pressure to the top of each completed aggregate pier as required by the design submittal.
- F. Special high-energy impact densification apparatus shall be employed to densify the aggregate pier elements during installation. Densification energy shall be applied to each lift.

3.3 PLAN LOCATION AND ELEVATION OF AGGREGATE PIER ELEMENTS

- A. The center of each pier shall be within six (6) inches of the plan locations indicated. Aggregate pier elements installed outside of the above tolerances and deemed not acceptable shall be rebuilt at no additional expense to the Owner.

3.4 REJECTED AGGREGATE PIER ELEMENTS

- A. Aggregate pier elements improperly located or installed beyond the maximum allowable tolerances shall be abandoned and replaced with new piers, unless the Designer approves other remedial measures. All material and labor required to replace rejected piers shall be provided at no additional cost to the Owner, unless the cause of the rejection is due to an obstruction.

3.5 QUALITY CONTROL REPRESENTATIVE

- A. The Installer shall have a full-time Quality Control (QC) representative to verify and report all QC installation procedures. The Installer shall immediately report any unusual conditions encountered during installation to the Design Engineer, the Contractor, to the Owner's On-site Representative and to the Architect. The QC procedures shall include the preparation of Aggregate Pier Progress Reports completed during each day of installation and containing the following information:
 - 1. Footing and aggregate pier location.
 - 2. Volume of aggregate introduced into the pier.
 - 3. Aggregate pier installation depth.
 - 4. Number of lifts.
 - 5. Procedure to construct each lift.
 - 6. Time of raising and downward densification for each lift.
 - 7. Total pier installation time.
 - 8. Hydraulic pressures during installation. (from installation or data record)
 - 9. Volume of aggregate used for pier construction.
 - 10. Planned and actual aggregate pier elevations at the top and bottom of the element (based on installation depth).
 - 11. Type and size of energy source equipment used.
 - 12. Aggregate description.
 - 13. Record of flow rates of water or compressed air pressure (if applicable).
 - 14. Documentation of any unusual conditions encountered.
 - 15. Grout zone.

3.6 MODULUS TESTS

- A. One (1) modulus test shall be performed to verify the parameter values selected for design of rammed aggregate piers. The modulus test shall be of the type and installed in a manner specified herein.
- B. The test piers shall be installed in the same manner as the production piers.
- C. The modulus tests shall be completed and the results transmitted to the Architect prior to the placement of concrete for footings which are supported on aggregate piers.
- D. ASTM D-1143 general test procedures shall be used as a guide to establishing load increments, load increment duration, load decrements, and instrumentation.

- E. With the exception of the load increment representing approximately 115% of the design maximum top of aggregate pier stress, all load increments shall be held for a minimum of 15 minutes, a maximum of 1 hour, and until the rate of deflection reduces to 0.01-inch per hour, or less.
- F. The load increment that represents approximately 115% of the design maximum stress on the aggregate pier shall be held for a minimum of 60 minutes, a maximum of 4 hours and until the rate of deflection reduces to 0.01-inch per hour or less.
- G. A seating load equal to 5 percent of the total load shall be applied to the loaded steel plate prior to application of load increments and prior to measurement of deflections to compensate for surficial disturbance.
- H. The modulus test shall be performed to a minimum of 150% of the design maximum stress.
- I. Modulus testing shall be performed in accordance with the requirements outlined in the Design Submittal.
- J. The location of the modulus testing shall be coordinated with the Architect.
- K. The modulus test pier shall be installed in a manner that will be consistently used throughout the project. The details of the installation procedure shall be recorded by the Quality Control Representative as described above.

3.7 RESPONSIBILITIES OF GEOTECHNICAL ENGINEER

- A. The Owner is responsible for retaining a Geotechnical Engineer to provide quality assurance services.
- B. The Geotechnical Engineer will review the design submittal for conformance with Paragraph 1.9 prior to any aggregate piers being installed on-site.
- C. The Geotechnical Engineer shall observe the modulus tests. The Installer shall provide and install all dial indicators and other measuring devices in general accordance with ASTM D-1143.
- D. The Geotechnical Engineer will observe the installation of aggregate pier elements to verify that the production installation practices are similar to those used during the installation of the modulus test elements.
- E. The Geotechnical Engineer will report any discrepancies to the Installer and Contractor immediately.
- F. There will be full-time observation of all aggregate pier installation operations. No aggregate piers shall be installed except in the presence of the Geotechnical Engineer.
- G. All observation services provided by the Geotechnical Engineer and approvals given by the Architect shall not relieve the Contractor of his responsibilities for performing the work in accordance with these specifications and the Contract Drawings.
- H. Provide 48 hours prior notice to the Geotechnical Engineer that his presence will be required.

3.8 LAYOUT OF THE AGGREGATE PIER ELEMENTS

- A. The Contractor shall provide layout (construction staking) of the aggregate pier locations. The Contractor shall provide ground elevations in sufficient detail to estimate drilling depth elevations to within 2 inches.

3.9 EXCAVATIONS OF OBSTRUCTIONS

- A. Should any obstruction be encountered during Aggregate Pier installation, the General Contractor shall be responsible for promptly removing such obstruction or the pier shall be relocated or abandoned. Obstructions include, but are not limited to, boulders, cobbles, stumps, timbers, concrete, bricks, utility lines, etc., which prevent placing the piers to the required depth, or shall cause the pier to drift from the required location. Refer to Specification 312000 – Earthwork for additional information.

3.10 UTILITY EXCAVATIONS

- A. No excavation will be permitted below a line drawn downward and outward at a 2 horizontal to 1 vertical line from the outside edge of any completed aggregate pier element without providing adequate shoring to prevent undermining or damage to the aggregate pier.
- B. Protection of completed aggregate pier elements is the responsibility of the Contractor. The Contractor shall contact the aggregate pier Designer to develop construction solutions to minimize impacts on the installed aggregate piers.
- C. Recommended procedures may include:
 - 1. Using cement-treated base to construct portions of the aggregate piers subject to future excavations.
 - 2. Replacing excavated soil with compacted Crushed Stone in the portions of excavations where aggregate piers have been disturbed. The placement and compaction of the Crushed Stone shall meet the following requirements:
 - a. The Crushed Stone shall meet the gradation specified by the Designer.
 - b. The Crushed Stone shall be placed in a controlled manner using motorized impact compaction equipment.
 - c. The aggregate should be compacted to 95% of the maximum dry density as determined by the modified Proctor method (ASTM D-1557).
 - d. The Geotechnical Engineer shall be on site to observe placement, compaction, and provide density testing. The test results shall be submitted to the Designer and the Contractor. The Contractor shall provide notification to the Geotechnical Engineer and the Designer when excavation, placement, and compaction will occur and arrange for construction observation and testing.

3.11 FOOTING BOTTOMS

- A. Excavation and surface compaction of all footings shall be the responsibility of the Contractor.
- B. Foundation excavations to expose the tops of aggregate pier elements shall be made in a workmanlike manner, and shall be protected until concrete placement, with procedures and equipment best suited to (1) prevent softening of the matrix soil between and around the aggregate pier elements before pouring structural concrete, and (2) achieving direct and firm contact between the dense, undisturbed aggregate pier elements and the concrete footing.

- C. Recommended procedures for achieving these goals are to:
1. Excavate footing bearing surfaces with a smooth-edge bucket and limit over-excavation below the bottom of the footing to 4 inches.
 2. Compaction of surface soil and top of aggregate pier elements shall be prepared using a motorized impact compactor ("Wacker Packer," "Jumping Jack," or similar). Sled-type tamping devices shall not be used. Compaction shall be performed over the entire footing bottom to compact any loose surface soil and loose surface pier aggregate.
 3. Place footing concrete immediately after footing excavation is made and approved, preferably the same day as the excavation. Footing concrete must be placed on the same day if the footing is bearing on expansive or sensitive soils.
 4. If same day placement of footing concrete is not possible, place a minimum 3-inch thickness of crushed stone immediately after the footing is excavated and approved.

END OF SECTION

SECTION 321216

ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cold milling of existing hot-mix asphalt pavement.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving.
4. Hot-mix asphalt paving overlay.
5. Pavement-marking paint.
6. Testing Requirements.

B. Related Sections:

1. Division 31 Section "Earth Moving" for aggregate subbase and base courses.

1.2 SUBMITTALS

A. Statement of qualifications for the paving contractor.

B. Material Certificates: For each paving material, from manufacturer, stating that proposed materials to be used for the work comply with the Specifications.

C. Submit 25-lb samples, as requested by the Owner's Representative, in containers for each type of material to Owner's Representative.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by New Hampshire Department of Transportation (NHDOT).

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of NHDOT for asphalt paving work.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

C. Pre-paving Conference: Prior to placing any mix, a pre-paving conference shall be held to discuss and approve the paving schedule, source of mix, type and amount of equipment to be used, sequence of paving pattern, rate of mix supply, traffic control, and general continuity of the operations. All field supervisors associated with this operation shall attend this meeting.

1.4 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
 - 1. Tack Coat: Minimum surface temperature of 60 deg F.
 - 2. Asphalt Binder Course: Minimum surface temperature of 40 deg F and rising at time of placement.
 - 3. Asphalt Top (Wearing) Course: Minimum surface temperature of 60 deg F at time of placement.
- B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil-based materials or 55 deg F for water-based materials, and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 AGGREGATES

- A. Coarse Aggregate: Shall be in accordance with NHDOT Section 401 for Plant Mix Pavements. Coarse aggregate shall be crushed stone or crushed gravel and shall have a percentage of wear as determined by AASHTO T 96 of not more than 45 percent unless otherwise specified by contract item. In each stockpile, not less than 50 percent by weight of the particles retained on the No. 4 (4.75 mm) sieve shall have at least one fractured face. Stockpiles consisting of a blend of crushed stone and crushed gravel will be permitted so long as the overall consistency of the stockpile is reasonably maintained and the lesser portion of coarse aggregate material does not exceed 10 percent of the total. This percentage shall be determined on the portion of the total sample by weight that is retained on the No. 4 (4.75 mm) laboratory sieve.
- B. Fine Aggregate: Shall be in accordance with NHDOT Section 401 for Plant Mix Pavements.
 - 1. Fine aggregate shall consist of sound durable particles of sand, crushed stone, or a combination thereof. Fine aggregate shall be free from clay balls and injurious amounts of organic matter. Stone screening shall be produced from stone at least equal in quality to that specified for coarse aggregate.
 - 2. Fine aggregate may be 100 percent manufactured aggregate for base courses and shall consist of at least 25 percent natural sand for wearing courses. If workability problems occur additional natural sand may be required. Fine aggregate stockpiles containing aggregate larger than 3/8 in (9.5 mm) shall not be used.
- C. Mineral Filler: Shall be in accordance with NHDOT Section 401 for Plant Mix Pavements. AASHTO M 17, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

- A. Asphalt Binder: Shall be in accordance with NHDOT Section 401 for Plant Mix Pavements. AASHTO M 320, PG 64-28.

- B. Tack Coat: Shall be in accordance with NHDOT Section 410 for Bituminous Surface Treatment. AASHTO M 140, emulsified asphalt, or AASHTO M 208 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

2.3 AUXILIARY MATERIALS

- A. Pavement-Marking Paint: Paint shall conform to NHDOT 708, NH 4.11 Ready-Mixed White Traffic Paint and NH 4.12 for Ready-Mixed Yellow Traffic Paint.
 - 1. Pavement markings for parking stalls, edge lines, stop bars, lane arrows, and other markings shall be 4, 6, 12, or 24-inches wide or as specified on the Contract Drawings.
 - 2. Paint material shall not lift from the pavement.
 - 3. Paint material shall not smear or spread under normal traffic conditions.

2.4 MIXES

- A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes shall be in accordance with NHDOT Standard Specifications Section 403 Hot Bituminous Pavement, and as approved by NHDOT, and complying with the following requirements:
 - 1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
 - 2. Binder Course: NHDOT 401 Standard Specification for 3/4 inch Aggregate Pavement.
 - 3. Top Course: NHDOT 401 Standard Specification for 1/2 inch Aggregate Pavement.
 - 4. Overlay: NHDOT 401: Standard Specification for 1/2 inch Aggregate Pavement.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
- B. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 COLD MILLING (PLANING)

- A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated on Contract Drawings.
 - 1. Mill a 24-inch wide strip to a depth of 1 inch.

3.3 PATCHING

- A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch, as shown on Contract Drawings, and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 24 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.
- B. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of between 0.02 and 0.05 gallons per square yard, in accordance with NHDOT Standard Specifications.
 - 1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
 - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
- C. Patching: Fill excavated pavements with hot-mix asphalt base mix for full thickness of patch minus wearing course and, while still hot, compact flush with adjacent surface. Place hot-mix asphalt wearing mix over base mix and compact flush with adjacent surface. Compaction shall be in accordance with NHDOT Standard Specifications.

3.4 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
- B. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of between 0.02 and 0.05 gallons per square yard, in accordance with NHDOT Standard Specifications.
 - 1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
 - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.5 HOT-MIX ASPHALT PLACING

- A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. All courses shall be spread and finished to the required thickness by approved, self contained, self-propelled spreading and finishing machines (pavers). Pavers shall be in accordance with NHDOT Standard Specifications.
 - 1. Spread mix at minimum temperature of 260 deg F.
 - 2. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
- B. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted. Extreme care shall be taken to create a surface texture similar to the machine work. Surface material shall be spread by lutes and not by rakes.
- C. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

- D. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.
- E. Pavement shall only be placed during daylight hours.

3.6 JOINTS

- A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
 - 1. Clean contact surfaces and apply tack coat to joints.
 - 2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
 - 3. Offset transverse joints, in successive courses, a minimum of 24 inches.
 - 4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."

3.7 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers. All compaction shall be conducted in accordance with NHDOT Standard Specifications.
 - 1. Complete compaction before mix temperature cools to 185 deg F.
- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
 - 1. Average Density: 92 percent of reference maximum theoretical density according to AASHTO T 209, but not less than 90 percent nor greater than 96 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
- F. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- G. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

- H. The finished surface of the pavement shall be uniform in appearance, free from irregularities in contour and shall present a smooth riding surface.

3.8 INSTALLATION TOLERANCES

- A. Pavement Thickness: Compact each course to produce the thickness indicated on the Contract Drawings within the following tolerances:
 - 1. Binder Course: Plus or minus 1/2 inch.
 - 2. Top Course: Plus 1/4 inch, no minus.
- B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
 - 1. Binder Course: 1/4 inch.
 - 2. Top Course: 1/8 inch.
 - 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

3.9 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Owner's Representative.
- B. Allow paving to age for 2 days before starting pavement marking.
- C. Sweep and clean surface to eliminate loose material and dust.
- D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply in two (2) coats at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Replace and compact hot-mix asphalt where core tests were taken.
- C. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements, at no additional cost to the Owner.

3.11 DISPOSAL

- A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them off-site.

END OF SECTION 321216

SECTION 32 12 93

ARTIFICIAL GRASS FIELDTURF
FIELDTURF MONOFILAMENT
FTRV360-1: REVOLUTION 360

PART 1 - GENERAL

1.1 SUMMARY

- A. Furnish all labor, materials, tools and equipment necessary to install monofilament artificial grass FieldTurf as indicated on the plans and as specified herein; including components and accessories required for a complete installation including but not limited to:
1. Acceptance of prepared sub-base.
 2. Coordination with related trades to ensure a complete, integrated, and timely installation: Aggregate base course, sub-base material (tested for permeability), grading and compacting, piping and drain components (when required); as provided under its respective trade section.

1.2 REFERENCE STANDARDS

- A. FM Factory Mutual
1. P7825 - Approval Guide; Factory Mutual Research Corporation; current edition
- B. ASTM – American Society for Testing and Materials.
1. D1577 - Standard Test Method for Linear Density of Textile Fiber
 2. D5848 - Standard Test Method for Mass Per Unit Area of Pile Yarn Floor Covering
 3. D1338 - Standard Test Method for Tuft Bind of Pile Yarn Floor Covering
 4. D1682 - Standard Method of Test for Breaking Load and Elongation of Textile Fabrics
 5. D5034 - Standard Test Method of Breaking Strength and Elongation of Textile Fabrics (Grab Test)
 6. F1015 - Standard Test Method for Relative Abrasiveness of Synthetic Turf Playing Surfaces
 7. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity
 8. D2859 - Standard Test Method for Ignition Characteristics of Finished Textile Floor Covering Materials
 9. F355 - Standard Test Method for Shock-Absorbing Properties of Playing Surfaces.
 10. F2117 – Standard Test Method for Vertical Rebound Characteristics of Sports Surface Systems: Acoustical Measurements (Soccer)
 11. BS7044, Section 2.2 Methods for Determination of Person/Surface Interaction Method 1: Determination of Traction (Rotational Resistance)
 12. F1551-03 Suffix: DIN 18-035, Part 6: Water Permeability of Synthetic Turf Systems
 13. ASTM F355-10, Procedure A: Testing Services Inc test number TSI 1202

1.3 SUBMITTALS

- A. Substitutions: Other products are acceptable if in compliance with all requirements of these specifications. Submit alternate products to Architect for approval prior to bidding in accordance Section 01 25 13, Product Substitution Procedures.

1. Provide substantiation that proposed system does not violate any other manufacturer's patents, patents allowed or patents pending.
 2. Provide a sample copy of insured, non-prorated warranty and insurance policy information.
- B. Comply with Section 01 33 00, Submittals Procedures. Submit for approval prior to fabrication.
- C. Shop Drawings:
1. Indicate field layout; field marking plan and details for the specified sports; i.e., NFHS Football and soccer; tick marks for boy's and girl's lacrosse and field hockey; roll/seaming layout; methods of attachment, field openings and perimeter conditions.
 2. Show installation methods and construction indicating field verified conditions, clearances, measurements, terminations, drainage.
 3. Provide joint submission with related trades when requested by Architect.
- D. Product Data:
1. Submit manufacturer's catalog cuts, material safety data sheets (MSDS), brochures, specifications; preparation and installation instructions and recommendations; storage, handling requirements and recommendations.
 2. Submit fiber manufacturer's name, type of fiber and composition of fiber.
 3. Submit data in sufficient detail to indicate compliance with the contract documents.
 4. Submit manufacturer's instructions for installation.
 5. Submit manufacturer's instructions for maintenance for the proper care and preventative maintenance of the synthetic turf system, including painting and markings.
- E. Samples: Submit samples, 9 x 12 inches, illustrating details of finished product in amounts as required by General Requirements, or as requested by Architect.
- F. Product Certification:
1. Submit manufacturer's certification that products and materials comply with requirements of the specifications.
 2. Submit test results indicating compliance with Reference Standards.
- G. Project Record Documents: Record actual locations of seams, drains and other pertinent information in accordance with Specifications, General Requirements.
- H. List of existing installations: Submit list including respective Owner's representative and telephone number.
- I. Warranties: Submit warranty and ensure that forms have been completed in Owner's name and registered with approved manufacturer.
- J. Submit Bills of Lading/Material Delivery Receipts for synthetic turf infill materials. Bills of lading shall bear the name of the project/delivery address, quantity of materials delivered, source/location of origin of infill materials and/or manufacturer, and date of delivery.
- K. Testing Certification: Submit certified copies of independent (third-party) laboratory reports on ASTM testing:
1. Pile Height, Face Weight & Total Fabric Weight, ASTM D5848.
 2. Primary & Secondary Backing Weights, ASTM D5848.

3. Tuft Bind, ASTM D1335.
4. Grab Tear Strength, ASTM D1682 or D5034.
5. Water Permeability, ASTM D4491

1.4 QUALITY ASSURANCE

- A. Comply with Section 01 43 00, Quality Assurance.
- B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section. The turf contractor and/or the turf manufacturer:
 1. Shall be experienced in the manufacture and installation of specified type of infilled spined and/or ridged monofilament grass system for a minimum of three years. This includes use of a spined and/or ridged monofilament fiber, backing, the backing coating, and the installation method.
 2. The manufacturer shall operate its own manufacturing plant. Manufacturing the fiber, tufting of the field fibers into the backing materials and coating of the turf system must be done in-house by the turf manufacturer.
 3. The manufacturer must have ISO 9001, ISO 14001 and OHSAS 18001 certifications demonstrating its manufacturing efficiency with regards to quality, environment and safety management systems.
 4. The manufacturer must be a FIFA Preferred Producer.
 5. The manufacturer must be licensed by all of the following major international governing bodies: FIFA, International Rugby Board (IRB), International Hockey Federation (FIH).
 6. Shall have 500 fields in play for at least two years with a spined and/or ridged monofilament fiber. Fields shall be 65,000 ft² or more.
 7. Shall have a minimum of 500 fields that are at least 8 years old, which is equal to the respective warranty period, with the same infill system.
 8. Shall have a minimum of five installations in the State of New Hampshire.
 9. Shall have a minimum of 1000 installations in North America, each of 65,000 ft² or more. Fields shall be 65,000 ft² or more of the specified infill material and a spined and/or ridged monofilament fiber.
 10. Shall provide third party certification confirming minimum requirement of 9 lbs tuft bind.
 11. Specified turf system shall have attained 800 impactions with an Ultimate Gmax of no more than 140G's as per Testing Services Inc test number TSI 1202. Specified turf system must have the same infill composition as the product tested.
- C. Installer: Company shall specialize in performing the work of this section. The Contractor shall provide competent workmen skilled in this specific type of synthetic grass installation.
 1. The designated Supervisory Personnel on the project shall be certified, in writing by the turf manufacturer, as competent in the installation of specified monofilament material, including sewing seams and proper installation of the infill mixture.
 2. Installer shall be certified by the manufacturer and licensed.
 3. The installer supervisor shall have a minimum of 5 years experience as either a construction manager or a supervisor of synthetic turf installations
- D. Pre-Installation Conference: Conduct conference at project site at time to be determined by Architect. Review methods and procedures related to installation including, but not limited to, the following:
 1. Inspect and discuss existing conditions and preparatory work performed under other contracts.

2. In addition to the Contractor and the installer, arrange for the attendance of installers affected by the Work, The Owner's representative, and the Architect.
 - E. The Contractor shall verify special conditions required for the installation of the system.
 - F. The Contractor shall notify the Architect of any discrepancies.
- 1.5 DELIVERY, STORAGE, AND HANDLING
- A. Comply with Section 01 60 00, Product Requirements.
 - B. Prevent contact with materials that may cause dysfunction.
 - C. Deliver and store components with labels intact and legible.
 - D. Store materials/components in a safe place, under cover, and elevated above grade.
 - E. Protect from damage during delivery, storage, handling and installation. Protect from damage by other trades.
 - F. Inspect all delivered materials and products to ensure they are undamaged and in good condition.
 - G. Comply with manufacturer's recommendations.
- 1.6 SEQUENCING AND SCHEDULING
- A. Coordinate the Work with installation of work of related trades as the Work proceeds.
 - B. Sequence the Work in order to prevent deterioration of installed system.
- 1.7 WARRANTY AND GUARANTEE
- A. See Section 01780 - Closeout Submittals, For Additional Warranty Requirements.
 - B. The Contractor shall provide a warranty to the Owner that covers defects in materials and workmanship of the turf for a period of eight (8) years from the date of substantial completion. The turf manufacturer must verify that their representative has inspected the installation and that the work conforms to the manufacturer's requirements. The manufacturer's warranty shall include general wear and damage caused from UV degradation. The warranty shall specifically exclude vandalism, and acts of God beyond the control of the Owner or the manufacturer. The warranty shall be fully third party insured; pre paid for the entire 8 year term and be non-prorated. The Contractor shall provide a warranty to the Owner that covers defects in the installation workmanship, and further warrant that the installation was done in accordance with both the manufacturer's recommendations and any written directives of the manufacturer's representative. Prior to final payment for the synthetic turf, the Contractor shall submit to owner notification in writing that the field is officially added to the annual policy coverage, guaranteeing the warranty to the Owner. The insurance policy must be underwritten by an "AM Best" A rated carrier and must reflect the following values:
 1. Pre-Paid 8-year insured warranty.
 2. Insured Warranty Coverage must be provided in the form of 1 single policy
 3. Maximum per claim coverage amount of \$32,000,000.
 4. Minimum of thirty-two million dollar (\$32,000,000) annual aggregate
 5. Must cover full 100% replacement value of total square footage installed, minimum of \$7.00 per sq ft. (in case of complete product failure, which will include removal and disposal of the existing surface)
 6. Policies that include self insurance or self retention clauses shall not be considered.

7. Policy cannot include any form of deductible amount.
8. Sample policy must be provided at time of bid to prove that policy is in force. A letter from an agent or a sample Certificate of Insurance will not be acceptable.

- C. The artificial grass system must maintain a G-max of less than 200 for the life of the Warranty as per ASTM F1936.

1.8 MAINTENANCE SERVICE

- A. Contractor shall train the Owner's facility maintenance staff in the use of the turf manufacturer's recommended maintenance equipment.
- B. Manufacturer must provide maintenance guidelines and a maintenance video to the facility maintenance staff.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURER

- A. Approved manufacturers are as follows:

1. FieldTurf USA Inc.
175 N. Industrial Blvd
Calhoun, GA 30701
P: 800-724-2969

Model: FieldTurf Revolution 360

2.2 MATERIALS AND PRODUCTS

- A. Artificial grass FieldTurf system materials shall consist of the following:
 1. Carpet made of "spined and/or ridged" monofilament polyethylene fibers tufted into a fibrous, non-perforated, porous backing.
 2. Infill: Controlled mixture of graded sand and cryogenic rubber crumb that partially covers the carpet.
 3. Glue, thread, paint, seaming fabric and other materials used to install and mark the artificial grass monofilament FieldTurf.
- B. The installed artificial grass monofilament FieldTurf shall have the following properties:

Standard	Property	Specification
ASTM D1577	Fiber Denier	14,500
ASTM D1577	Fiber Thickness	380 Microns
	HALS UV Stabilizer	10,000ppm
ASTM D5823	Pile Height	2 1/2"
ASTM D5793	Stitch Gauge	3/4"
ASTM D5848	Pile Weight	42oz/square yard
ASTM D5848	Primary Backing	7+oz/square yard
ASTM D5848	Secondary Backing	14+oz/square yard
ASTM D5848	Total Weight	63+oz/square yard
ASTM D1335	Tuft Bind (Without Infill)	8+ lbs
ASTM D5034	Grab Tear (Width)	200 lbs/force
ASTM D5034	Grab Tear (Length)	200 lbs/force
ASTM D4491	Carpet Permeability	>40 inches/hour

ASTM F1936	Impact Attenuation (Gmax)	<200
	Infill Material Depth	1.75 inches
	Sand Infill Component	6.2lbs/square foot
	SBR Rubber Infill Component	3.0lbs/square foot
	Total Product Weight	1388oz/square yard

- C. Carpet shall consist of spined and/or ridged monofilament fibers tufted into a primary backing with a secondary backing.
- D. Carpet Rolls shall be 15' wide rolls.
1. Rolls shall be long enough to go from field sideline to sideline.
 2. Where the playing field is for football, the perimeter white line shall be tufted into the individual sideline rolls.
- E. Backing:
1. Primary backing shall be a double-layered polypropylene fabric
 2. Secondary backing shall consist of an application of porous, heat-activated urethane to permanently lock the fiber tufts in place.
 3. Perforated (with punched holes), backed carpet are unacceptable.
- F. Fiber shall be 14,500 denier, low friction, and UV-resistant fiber measuring not less than 2 ½ inches high.
1. Systems with less than a 2 ½ inch fibers are unacceptable.
- G. Infill materials shall be approved by the manufacturer.
1. Infill shall consist of a resilient layered granular system, comprising selected and graded sand and cryogenically hammer-milled SBR rubber crumb.
 2. Artificial Grass products without cryogenically processed rubber or a finish application of straight rubber cryogenically processed will not be acceptable.
 3. The sand component of the infill must represent a minimum of 51% or more of the total infill, by weight.
 4. The top layer shall be the FieldTurf® CoolPlay system.
- H. The sand infill will comply within the following characteristics:
1. Average Particle size between 20 and 30 mesh [calculated based on summing the midpoint of sieve pan fractions times the % retained on given screen fractions]
 2. Average Particle shape > 0.4 on the Krumbein scale
 3. Particle structure predominantly single grain
 4. Produce < 0.4%, -50M in API crush test at 80psig
- I. Non-tufted or inlaid lines and markings shall be painted with paint approved by the synthetic turf manufacturer.
- J. Thread for sewing seams of turf shall be as recommended by the synthetic turf manufacturer.
- K. Glue and seaming fabric for inlaying lines and markings shall be as recommended by the synthetic turf manufacturer.

2.3 QUALITY CONTROL IN MANUFACTURING

- A. The manufacturer shall operate its own manufacturing plant. Manufacturing the fiber, tufting of the field fibers into the backing materials and coating of the turf system must be done in-house by the turf manufacturer. Outsourcing of any of these major processes is unacceptable.
- B. The manufacturer shall have full-time certified in-house inspectors at their manufacturing plant that are experts with industry standards.
- C. Primary backing shall be inspected by the manufacturer's full-time certified in-house inspectors before tufting begins.
- D. The manufacturer's full-time in-house certified inspectors shall verify "pick count", yarn density in relation to the backing, to ensure the accurate amount of face yarn per square inch.
- E. The manufacturer's full-time, in-house, certified inspectors shall perform turf inspections at all levels of production including during the tufting process and at the final stages before the turf is loaded onto the truck for delivery.
- F. The manufacturer shall have its own, in-house laboratory where samples of turf are retained and analyzed, based on standard industry tests, performed by full-time, in-house, certified inspectors.

The manufacturer must have ISO 9001, ISO 14001 and OHSAS 18001 certifications demonstrating its manufacturing efficiency with regards to quality, environment and safety management systems.

2.4 QUALITY CONTROL IN FIBER MANUFACTURING

- A. Synthetic turf fiber must perform in a uniform manner or manufacturer quality control issues in the extrusion processes will be suspected. Linear Low Density Polyethylene Polymer ("LLDPE") and batch additives obtained from a reputable manufacturer are required to manufacture superior quality monofilament yarn. The master batch formula must include a UV stabilizer package added to its polymer base.

The LLDPE used to make the artificial grass fiber needs to be a "C6" LLDPE which contains 6 carbon atoms and 13 hydrogen atoms; A C6-based LLDPE produces strong and resilient artificial grass fibers over prolonged periods and thus should provide the basis for long term performance of the system.

Adequate UV protection is essential to the long-term durability of any artificial grass fiber. Typically, stabilizer packages for polyethylene fibers have three components that protect the fibers from degradation: (1) primary antioxidants; (2) secondary antioxidants; and (3) UV stabilizers (i.e., hindered amine light stabilizers ("HALS")). HALS are a particularly important aspect of the stabilizer package. A typical HALS concentration is 10,000 ppm. More developed HALS molecules are methyl stabilized to prevent from degradation.

Streaking refers to color variation in a field due to different degrees of fiber relaxation. Fiber in one row stands up, while fiber in an adjacent row lies flat. The inconsistent relaxation causes differences in the reflection of light off of the fiber, and results in the field having a streaked or striped appearance. Adequate UV protection minimizes the appearance of streaking and other visual flaws during the warranty period.

2.5 FIELD GROOMER & SWEEPER

- A. Supply field groomer as part of the work

- B. Field Groomer shall include a towing attachment compatible with a field utility vehicle.
- C. Field Groomer shall be a FieldTurf GroomRight
- D. Field Sweeper shall include a towing attachment compatible with a field utility vehicle.
- E. Field Sweeper shall be a FieldTurf SweepRight

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that all sub-base leveling is complete prior to installation.
- B. Installer shall examine the surface to receive the synthetic turf and accept the sub-base planarity in writing prior to the beginning of installation.
 - 1. Acceptance is dependent upon the Owner's test results indicating compaction and planarity are in compliance with manufacturer's specifications.
 - 2. The surface shall be accepted by Installer as "clean" as installation commences and shall be maintained in that condition throughout the process.
- C. Compaction of the aggregate base shall be 95%, in accordance with ASTM D1557 (Modified Proctor procedure); and the surface tolerance shall not exceed 0-1/4 inch over 10 feet and 0-1/2" from design grade.
- D. Correct conditions detrimental to timely and proper completion of Work.
- E. Do not proceed until unsatisfactory conditions are corrected.
- F. Beginning of installation means acceptance of existing conditions.

3.2 PREPARATION

- A. Prior to the beginning of installation, inspect the sub-base for tolerance to grade.
- B. Sub-base acceptance shall be subject to receipt of test results (by others) for compaction and planarity that sub-base is in compliance with manufacturer's specifications and recommendations.
- C. Dimensions of the field and locations for markings shall be measured by a registered surveyor to verify conformity to the specifications and applicable standards. A record of the finished field as-built measurements shall be made.
- D. When requested by Architect, installed sub-base shall be tested for porosity prior to the installation of the monofilament turf. A sub base that drains poorly is an unacceptable substrate

3.3 INSTALLATION - GENERAL

- A. The installation shall be performed in full compliance with approved Shop Drawings.
- B. Only trained technicians, skilled in the installation of athletic caliber synthetic turf systems working under the direct supervision of the approved installer supervisors, shall undertake any cutting, sewing, gluing, shearing, topdressing or brushing operations.
- C. The designated Supervisory personnel on the project must be certified, in writing by the turf manufacturer, as competent in the installation of this material, including sewing seams and

proper installation of the Infill mixture.

- D. Designs, markings, layouts, and materials shall conform to all currently applicable National Collegiate Athletic Association rules, NFHS rules, and/or other rules or standards that may apply to this type of synthetic grass installation. Designs, markings and layouts shall first be approved by the Architect or Owner in the form of final shop drawings. All markings will be in full compliance with final shop drawings.

3.4 INSTALLATION

- A. Install at location(s) indicated, to comply with final shop drawings, manufacturers'/installer's instructions.
- B. The Contractor shall strictly adhere to specified procedures. Any variance from these requirements shall be provided in writing, by the manufacturer's on-site representative, and submitted to the Architect and/or Owner, verifying that the changes do not in any way affect the Warranty. Infill materials shall be approved by the manufacturer and installed in accordance with the manufacturer's standard procedures.
- C. Carpet rolls shall be installed directly over the properly prepared aggregate base. Extreme care shall be taken to avoid disturbing the aggregate base, both in regard to compaction and planarity.
 - 1. Repair and properly compact any disturbed areas of the aggregate base as recommended by manufacturer
- D. Full width rolls shall be laid out across the field.
 - 1. Turf shall be of sufficient length to permit full cross-field installation from sideline to sideline.
 - 2. No cross seams will be allowed in the main playing area between the sidelines.
 - 3. Each roll shall be attached to the next roll utilizing standard state-of-the-art sewing procedures.
 - 4. When all of the rolls of the playing surface have been installed, the sideline areas shall be installed at right angles to the playing surface.
- E. Artificial turf panel seams shall be sewn along the selvedge edging flap of the turf roll. Seams secured by other means including gluing are unacceptable. Installation shall be 99% sewn.
 - 1. Minimum gluing will only be permitted to repair problem areas, corner completions, and to cut in any logos or inlaid lines as required by the specifications.
 - 2. Seams shall be flat, tight, and permanent with no separation or fraying.
 - 3. In the case of all lines and logos, turf carpet/field fibers must be sheared to the backing (do not cut the backing) and adhered using hot melt adhesives.
- F. Infill Materials:
 - 1. Infill materials shall be applied in numerous thin lifts. The turf shall be brushed as the mixture is applied. The infill material shall be installed to a depth determined by the manufacturer.
 - 2. Three-layered infill shall be installed in a systematic order.
 - 3. Infill materials shall be installed to fill the voids between the fibers and allow the fibers to remain vertical and non-directional. The Infill installation consists of a base layer of sand followed by a homogenous mixture of the sand and the cryogenically processed rubber. A final application of specifically sized cryogenically processed rubber completes the system. The Infill shall be installed

to the depth of 1 $\frac{3}{4}$ ". Infill density shall consist of no more than 6.2 pounds of sand and at least 3 pounds of rubber per square foot. The Infill shall be placed so that there is a void of $\frac{3}{4}$ " to the top of the fibers.

- G. Non-tufted or inlaid lines and markings shall be painted in accordance with turf and paint manufacturers' recommendations. Number of applications will be dependent upon installation and field conditions.
- H. Synthetic turf shall be attached to the perimeter edge detail in accordance with the manufacturer's standard procedures.
- I. Upon completion of installation, the finished field shall be inspected by the installation crew and an installation supervisor.

3.5 FIELD MARKINGS

- A. Field markings shall be installed in accordance with approved shop drawings. If football is designated as the primary sport, all five yard lines will be tufted-in.
- B. Balance of sports markings will be inlaid or painted in accordance with the Drawings.
- C. Center field logo shall be either painted or inlaid according to artwork indicated on Drawings and in accordance with manufacturer's standard palette of turf colors.
- D. End-zone letters and logos shall be either painted or inlaid according to artwork and fonts indicated on the Drawings, and in accordance with manufacturer's standard palette of turf colors.

3.6 FIELD MAINTENANCE

- A. Perform regularly scheduled periodic maintenance twice per year. The maintenance will include but not be limited to a complete inspection and repair including all materials and cleaners of all areas of the field including: Fiber fibrillation analysis, Seam analysis, Perimeter anchoring, Excessive wear analysis, UV fade inspection, Infill – consistency in depth, Infill – migration analysis, Glued inlay analysis, Base stability analysis, Painted marking inspection, Debris removal, Brushing, Aerating, Grooming, Removal of weeds and moss, Removal of stains, Keeping the infill level.
- B. The inspection and maintenance will be performed by a FieldTurf Authorized Maintainer, if the person is not the same as the previous visit, then credentials will be submitted for approval before the visit.
- C. Approximate number of times is 2 times per year for 8 years through the warranty period.
- D. The maintenance activities will include and not be limited to the most current FieldTurf Maintenance Guidelines at the time the maintenance is being undertaken, including the following FieldTurf Products: FieldTurf Scrub Detergent, FieldTurf Static Control, FieldTurf Gum Remover.

3.7 ADJUSTMENT AND CLEANING

- A. Do not permit traffic over unprotected surface.
- B. Contractor shall provide the labor, supplies, and equipment as necessary for final cleaning of surfaces and installed items.
- C. All usable remnants of new material shall become the property of the Owner.
- D. The Contractor shall keep the area clean throughout the project and clear of debris.
- E. Surfaces, recesses, enclosures, and related spaces shall be cleaned as necessary to leave

the work area in a clean, immaculate condition ready for immediate occupancy and use by the Owner.

3.8 PROTECTION

- A. Protect installation throughout construction process until date of final completion.

END OF SECTION 321293

SECTION 32 13 13

PORTLAND CEMENT CONCRETE PAVING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Coordinate with such trades to assure the steady progress of all work under the Contract.

1.2 SUMMARY

- A. The Work of this Section includes, but is not limited to, the following:
 - 1. Portland Cement Concrete Paving in pedestrian areas
 - 2. Portland Cement Concrete Wheelchair Ramps

1.3 RELATED SECTIONS

- A. Related Sections include the following:
 - 1. SECTION 03 30 00 – CAST-IN-PLACE CONCRETE
 - 2. SECTION 31 20 00 – EARTH MOVING

1.4 REFERENCES

- A. Comply with applicable requirements of:
 - 1. State of New Hampshire, Standard Specification for Roads and Bridge Construction, Department of Transportation, latest edition.
 - 2. City of Dover, of the State of New Hampshire, and of other authorities having jurisdiction. Provide labor, materials, equipment and services to comply with requirements.
 - 3. ASTM: American Society of Testing Materials.
 - 4. AASHTO: American Association of State Highway and Transportation Officials.
 - 5. NBGQA: National Building Granite Quarries Association

1.5 SUBMITTALS

- A. Prepare and submit the following submittals in accordance with the requirements of SECTION 01 33 00 – SUBMITTAL PROCEDURES.
- B. Product Data: submit manufacturer's specifications and installation instructions for:

1. Sealant
 2. Backer Rod
 3. Fiber reinforcing
- C. Design Mix for concrete
- D. Sample panel:
1. Cement Concrete paving: Provide one 4' square sample panel of cement concrete showing full range of surfaces finishes and joint types to be expected in the finished work. The quality of workmanship, joint treatment and surface finish to be approved by Owner's Representative before proceeding with permanent concrete paving. If original sample is not approved, provide additional samples at no cost to the Owner until an approved sample is achieved. The approved sample will become the standard for the entire project.
 2. Sample Panels are not to be constructed in locations becoming part of the final paving. Sample panels are to remain undisturbed until paving is complete and then removed as approved by Owner's Representative.
- E. Certificates: submit materials certificates signed by material producer and Contractor. Provide certifications stating materials comply with requirements. Certification shall be based on independent testing laboratory tests made within last year.
- 1.6 QUALITY ASSURANCE
- A. Work under this Section shall be performed by workmen experienced and familiar with required construction procedures and under full time supervision of a qualified foreman.
 - B. Conform to provisions of SECTION 01 40 00 QUALITY REQUIREMENTS.
- 1.7 DELIVERY AND STORAGE
- A. Store materials on raised platforms. Locate storage piles or stacks to avoid and be protected from traffic. Store materials under an approved roof or covered with waterproof tarpaulins, except when men are working and using materials.
 - B. Handle, store, mix and apply setting materials in strict compliance with manufacturer's recommendations and instructions.
- 1.8 PROTECTION
- A. Protect paving surfaces from damage or defacement.
 - B. Protect adjacent surfaces from staining, soiling and other damage.
- PART 2 - PRODUCTS
- 2.1 PORTLAND CEMENT CONCRETE MATERIALS AND PRODUCTS
- A. Portland cement concrete materials and products: as specified in SECTION 03 30 00 – CAST-IN-PLACE CONCRETE.

2.2 PORTLAND CEMENT MIXES

- A. Portland cement paving mixes: Design mix to provide normal weight concrete complying with requirements of Section 701 and M4 of Standard Specifications. 4,500 psi compressive strength at 28 days, 3/4 aggregate, 658 pounds per cubic yard cement content and 5% to 7% air-entrained with 4" +/- 1" maximum slump.
- B. Mix to be modified to be darkened by adding 1-1/2 to 2 lbs of lamp black per cubic yard at the plant.
- C. Micro-fiber: Add 1 pound of 100% polypropylene micro-fiber per cubic yard during batching at plant and in accordance with manufacturer's instructions. Ensure uniform distribution. Micro-fiber: as manufactured by W. R. Grace or approved equal.

2.3 JOINT FILLER

- A. Sponge rubber in conformance to AASHTO M-153-65, Type I, Fed. Spec. HH-F- 341F, Type II, Class A and ASTM D-1752-67, Type I and be one of the following:
 - 1. Sealtight Sponge Rubber Expansion Joint Filler, manufactured by W.R. Meadows, Inc., Elgin, IL.
 - 2. Vulkem 116 manufactured by Mameko International.
 - 3. Sikaflex-1A manufactured by Sika Chemical Corp.
 - 4. Sonalastic NP-1 manufactured by Sonnenborn Building Products.
 - 5. Or Equal

2.4 BACKER ROD

- A. Continuous round rod of 100% closed cell polyethylene foam, complying with requirements of ASTM C-272.

2.5 JOINT SEALANT

- A. Two or more part, self-leveling, polyurethane based elastomeric sealant, complying with ASTM C920, Fed. Spec. TT-S-00227E Type 1 Class A, having Shore A hardness of not less than 40 + 5 when tested according to ASTM D2240, cured modulus of elasticity at 100% elongation of not more than 150 psi when tested according to ASTM D412, and tear resistance of not less than 50 lbs./inch when tested according to ASTM D624.
 - 1. Provide one of the following:
 - a. Pecora Urexpan NR-200
 - b. Tremco THC 900
 - c. Sika 1A, SL
 - d. Or Equal
 - 2. Where joint surfaces contain bituminous materials, provide modified sealant compatible with bituminous materials encountered.

2.6 EXPANSION DOWELS AND SLEEVES

- A. Stainless steel bars, complying with ASTM A276, Type 304, with smooth end cuts. Provide bar in dimensions and size indicated on Drawings. Provide expansion caps with compatible waxed tube sleeve which permit at least 1 inch movement.

2.7 GRAVEL

- A. Gravel: as specified in SECTION 31 20 00 – EARTH MOVING.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate layout and installation with layout and installation of adjacent paving, curbing, walls and other site improvements to ensure proper alignments.
- B. Make corrections as required to gravel provided under SECTION 31 20 00 – EARTH MOVING, to bring gravel to the proper sections and elevations

3.2 PREPARATION OF GRAVEL BASE

- A. Compact subgrade to achieve a 95% minimum compaction rate consistent throughout subgrade.
- B. Place gravel base in 2" to 3" lifts and as specified in SECTION 31 20 00 – EARTH MOVING.
- C. Compact to achieve a 95% minimum compaction rate consistent throughout gravel base.
- D. Final surface of gravel base to be left 1/8" higher than adjacent surfaces to allow for settlement.

3.3 INSTALLATION OF PORTLAND CEMENT CONCRETE PAVING

- A. Formwork: Set forms accurately to maintain specified tolerances. Remove loose material and clean forms immediately before concrete placement.
- B. Fiber Reinforcing: as specified in Section 03 30 00 - Cast-in-Place Concrete.
- C. Concrete: as specified in Section 03 30 00 - Cast-in-Place Concrete for mixing, placing and curing concrete. Use vibrators to consolidate concrete and to prevent honeycombs.
- D. After consolidating and screeding concrete, float and towel to smooth hard surface and even plane. Check tolerances and make necessary adjustments. Tool edges and form joints to create 1/4 inch radius. Eliminate tool marks on concrete surfaces.
- E. Broom Finish: Slightly roughen concrete surface by brooming with fine bristle broom perpendicular to main traffic directions to achieve uniform medium broom finish. Obtain Owner's Representative's approval.
- G. Expansion Joints: Provide expansion joints using galvanized metal keyway sections where concrete placement is interrupted for more than 1/2 hour and at end of placement and in grid pattern not more than 20 feet on center at locations approved by Owner's Representative. Provide shear dowels and expansion caps at not more than 16 inches on center to transfer vertical loads but permit horizontal movement. Extend joint filler full depth of joint and allow 1/2 inch minimum space at top for insertion of backer rod and sealant. Protect top edge of joint filler with metal cap or other temporary protection. Remove protection after concrete has been placed on both sides of forms

- H. Caulked Construction Joints: Provide caulked construction joints wherever concrete abuts dissimilar material at locations approved by Owner's Representative. Extend joint filler full depth of joint and allow 1/2 inch minimum space at top for insertion of backer rod and sealant. Protect top edge of joint filler with metal cap or other temporary protection. Remove protection after concrete has been placed on both sides of joint.
- I. Tooled Joints: Provide tooled joints, parallel to one another, and perpendicular to paving edge in locations indicated on the drawings.
- J. Saw cut Joints: Provide saw cut joints straight, true and plumb to paving surface, parallel to one another and perpendicular to paving edge in locations indicated on the drawings. Use new saw blades to result in smooth and crisp cuts.
 - 1. Cut every other reinforcing bar or wire at the joint to create a plane of weakness at the control joint.
 - 2. Joints to be cut within 24 hours of pouring the slab.

3.4 PORTLAND CEMENT CONCRETE PAVING TOLERANCES

- A. The following installed tolerances are allowable variations from locations and dimensions on Drawings and shall not be added to allowable tolerances for other work:
 - 1. Allowable Variation from True Level: +/- 1/8 inch in 20 feet
 - 2. Allowable Variation from True Line: +/- 1/8 inch in 20 feet

3.5 ADJUSTING UTILITY STRUCTURES

- A. Existing-to-remain water, sewer, drainage, and communications structures that are located in proposed sidewalk areas shall be made to conform to the newly proposed final grade.
- B. KeySpan and Nstar will adjust existing-to-remain gas and electric structures to final grade, respectively. Contractor shall be responsible for coordinating this work.

END OF SECTION

SECTION 32 13 16

INTEGRALLY COLORED CONCRETE PAVEMENT

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 SUMMARY

- A. The Work of this Section includes, but is not limited to, the following:
 - 1. Integrally colored concrete pavement at Main Entrance and CTC entrance. (ADD ALTERNATE #6)

1.3 RELATED WORK

- A. Related work includes, but is not limited to, the following work covered in other sections:
 - 1. SECTION 03 30 00 – CAST-IN-PLACE CONCRETE
 - 2. SECTION 03 30 60 – SITE ARCHITECTURAL CONCRETE
 - 3. SECTION 31 20 00 – EARTH MOVING
 - 4. SECTION 32 13 13 – PORTLAND CEMENT CONCRETE PAVING

1.4 REFERENCES

- A. Comply with applicable requirements of:
 - 1. State of New Hampshire, Standard Specifications for Roads and Bridge Construction, Department of Transportation, latest edition.
 - 2. Rules, regulations, laws and ordinances of City of Concord, of the State of New Hampshire, and of other authorities having jurisdiction. Provide labor, materials, equipment and services to comply with requirements.
- B. American Concrete Institute (ACI):
 - 1. ACI 301 "Specification for Structural Concrete for Buildings."
 - 2. ACI 302 IR "Recommended Practice for Concrete Floor and Slab Construction."
 - 3. ACI 303.1 "Standard Specification for Cast-In-Place Architectural Concrete."
 - 4. ACI 304 "Recommended Practice for Measuring, Mixing, Transporting and Placing of Concrete."

5. ACI 305R "Recommended Practice for Hot Weather Concreting."

6. ACI 306R "Recommended Practice for Cold Weather Concreting."

C. American Society of Testing and Materials (ASTM):

1. ASTM C309 "Standard Specifications for Liquid Membrane-Forming Compounds for Curing Concrete."

2. ASTM C494 "Standard Specification for Chemical Admixtures for Concrete."

3. ASTM C979 "Standard Specification for Pigments for Integrally Colored Concrete."

D. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M194 "Chemical Admixtures."

1.5 SUBMITTALS

A. Submittals: in accordance with Section 01 33 00 –Submittal Procedures.

B. Product Data: submit manufacturer's specifications and installation instructions for:

1. Colored Admixture
2. Curing Compound
3. Fiber Reinforcing
4. Preformed Joint Filler
5. Joint Sealant
6. Backer Rod

C. Design Mixes: For each type of integrally colored concrete

D. Qualifications: submit written project list and references for other Integrally Colored Concrete project work.

E. Sample panel:

1. Integrally Colored Concrete paving: Provide one 10' square sample panel of cement concrete showing full range of colors, surface finishes and joint types to be expected in the finished work for each color. The quality of workmanship, joint treatment and surface finish to be approved by Owner's Representative before proceeding with permanent concrete paving. If original sample is not approved, provide additional samples at no cost to the Owner until an approved sample is achieved. The approved sample will become the standard for the entire project.
2. Sample Panels are not to be constructed in locations becoming part of the final paving. Sample panels are to remain undisturbed until paving is complete and then removed as approved by Owner's Representative.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer with 10 years-experience in production of specified products.

- B. Installer Qualifications: An installer with 5 years-experience with work of similar scope and quality.
- C. Comply with the requirements of ACI 301.
- D. Obtain each specified material from same source and maintain high degree of consistency in workmanship throughout Project.
- E. Notification of manufacturer's authorized representative shall be given at least 1-week before start of Work.

1.7 DELIVERY AND STORAGE

- A. Colored Admixture: Comply with manufacturer's instructions. Deliver colored admixtures in original, unopened packaging. Store in dry conditions.

1.8 PROJECT CONDITIONS

- A. Integrally Colored Concrete Environmental Requirements:
 - 1. Schedule placement to minimize exposure to wind and hot sun before curing materials are applied.
 - 2. Avoid placing concrete if rain, snow, or frost is forecast within 24-hours. Protect fresh concrete from moisture and freezing.
 - 3. Comply with professional practices described in ACI 305R and ACI 306R.
- B. Schedule delivery of concrete to provide consistent mix times from batching until discharge. Mix times shall meet manufacturer's written recommendations.

PART - MATERIALS

2.1 MANUFACTURER

- A. L.M. Scofield Company, Douglasville, Georgia (800) 800.9900. Local contact: North/East Division Office (201) 672.9051.

2.2 MATERIALS

- A. Colored Admixture for Integrally Colored Concrete:
 - 1. Chromix P® Admixture and Chromix L®; L.M. Scofield Company.
 - a. Admixture shall be a colored, water-reducing, admixture containing no calcium chloride with coloring agents that are lime proof and UV resistant.
 - b. Colored admixture shall conform to the requirements of ACI 303.1, ASTM C979, ASTM C494, and AASHTO M194.
 - 2. Colors:
 - a. Cement: Color shall be gray and of a consistent color throughout the project.
 - b. Concrete Colors:

1. Dark Gray (C-34) on Scofield Color Chart
2. Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup

B. Curing Compound for Integrally Colored Concrete:

1. Curing Compound shall comply with ASTM C309 and be of same manufacturer as colored admixture, for use with integrally colored concrete.
 - a. Exterior Integrally Colored Concrete: LITHOCHROME® COLORWAX; L.M. Scofield Company. Use to cure exterior flatwork that will be allowed to cure.

C. Curing and Sealing Compound:

1. Cureseal™ semi-gloss; L.M. Scofield Company:
 - a. Curing and sealing compound shall comply with ASTM C309 and be the same manufacturer as colored admixture, for use with integrally colored concrete.

2.3 CONCRETE MIX DESIGN

- A. Concrete: 4000 psi with 4" maximum slump.
- B. Portland cement: conform to ASTM C 150 Type I, II, or V, depending on soil conditions.
- C. Aggregates: conform to ASTM C 33.
- D. Mixing water: fresh, clean and potable.
 1. Do not add water to the mix in the field
- E. Admixtures: In freeze-thaw areas only, an air-entraining admixture complying to ASTM C 260 shall be used to achieve an entrained air content for the particular mix used in accordance with the published recommendations of the Portland Cement Association and the American Concrete Institute. No admixtures containing calcium chloride shall be permitted.
 1. Supplemental admixtures shall not be used unless approved by manufacturer.
- F. Add colored admixture to the mix according to manufacturer's written instructions in premeasured bags, not by weight of cement content.

2.4 FIBER REINFORCING

- A. Synthetic Fiber Reinforcement: Fibermesh 150 as manufactured by Propex Concrete Systems, 6025 Lee Highway, Suite 425, Chattanooga, TN 37422, phone # 800.621.1273 or NyCon Incorporated, 101 Cross Street, Westerly, RI 02891-240, phone # 800 456 9266.
 1. Material: 100 percent virgin homopolymer polypropylene multifilament fibers, containing no reprocessed olefin materials.
 2. Conformance: ASTM C 1116, Type III.
 3. Fire Classifications:
 - a. UL Report File No. R8534-11.

b. Southwest Certification Services (SWCS), Omega Point Laboratories No. 8662-1.

4. Fiber Length: Graded
5. Alkali Resistance: Alkali proof.
6. Absorption: Nil.
7. Specific Gravity: 0.91.
8. Melt Point: 324 degrees F (162 degrees C).

2.5 JOINT FILLER

- A. Sponge rubber in conformance to AASHTO M-153-65, Type I, Fed. Spec. HH-F- 341F, Type II, Class A and ASTM D-1752-67, Type I:
1. Sealtight Sponge Rubber Expansion Joint Filler, manufactured by W.R. Meadows, Inc., Elgin, IL.

2.6 BACKER ROD

- A. Continuous round rod of 100% closed cell polyethylene foam, complying with requirements of ASTM C-272.

2.7 JOINT SEALANT

- A. Two or more part, self-leveling, polyurethane based elastomeric sealant, complying with ASTM C920, Fed. Spec. TT-S-00227E Type 1 Class A, having Shore A hardness of not less than 40 + 5 when tested according to ASTM D2240, cured modulus of elasticity at 100% elongation of not more than 150 psi when tested according to ASTM D412, and tear resistance of not less than 50 lbs./inch when tested according to ASTM D624.
1. Provide one of the following:
 - a. Pecora Urexpan NR-200
 - b. Tremco THC 900
 - c. Sika 1A, SL
 2. Where joint surfaces contain bituminous materials, provide modified sealant compatible with bituminous materials encountered.

2.8 EXPANSION DOWELS AND SLEEVES

- A. Stainless steel bars, complying with ASTM A276, Type 304, with smooth end cuts. Provide bar in dimensions and size indicated on Drawings. Provide expansion caps with compatible waxed tube sleeve which permit at least 1 inch movement.

2.9 GRAVEL

- A. Gravel: as specified in SECTION 31 20 00 – EARTH MOVING.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate layout and installation of paving with layout and installation of adjacent paving, curbing, walls and other site improvements to ensure proper alignments.

- B. Make corrections as required to gravel provided under SECTION 31 20 00 – EARTH MOVING, to bring gravel to the proper sections and elevations.

3.2 PREPARATION OF GRAVEL BASE

- A. Compact subgrade to achieve a 95% minimum compaction rate consistent throughout subgrade.
- B. Place gravel base as specified in SECTION 31 20 00 – EARTH MOVING.
- C. Compact to achieve a 95% minimum compaction rate consistent throughout gravel base.
- D. Final surface of gravel base to be left 1/8" higher than adjacent surfaces to allow for settlement.

3.3 PREPARATION FOR PAVING

- A. Formwork; Set forms accurately to maintain specified tolerances. Remove loose material and clean forms immediately before concrete placement.
- B. Mix fiber reinforcing in accordance with manufacturer's instructions including product data and technical brochures.
 - 1. Add fibrous reinforcement to concrete mix at the concrete batch facility.
 - 2. Adding and mixing fibrous reinforcement at the job site will not be allowed.
- C. Concrete: Comply with requirements of Section 03 30 55 – Cast-in-Place Concrete (Site) for mixing, placing and curing concrete. Use vibrators to consolidate concrete and to prevent honeycombs.

3.4 MIXING

- A. Add synthetic fiber reinforcement to concrete mixture in accordance with manufacturer's instructions.
- B. Add synthetic fiber reinforcement into concrete mixer before, during, or after batching other concrete materials.
- C. Application Rate: Add synthetic fiber reinforcement at standard application rate of 1.5 pounds per cubic yard (0.90 kg/m³) of concrete.
- D. Mix synthetic fiber reinforcement in concrete mixer in accordance with mixing time and speed of ASTM C 94 to ensure uniform distribution and random orientation of fibers throughout concrete.

3.5 INSTALLATION PROCEDURES

- A. Install concrete according to requirements of Section 03 30 00 – Cast-in-Place Concrete (Site)
- B. Fiber Reinforcing in Pedestrian Paving Applications: Fibrous reinforcement to be incorporated in accordance with manufacturer's instructions.
- C. Do not add water to the mix in the field.
- D. Surfaces shall be finished uniformly with the following finish:
 - 1. Broomed: Pull broom across freshly floated concrete to produce a medium texture in lines perpendicular to the main line of traffic. Do not dampen brooms.

- E. Control joints: Provide control joints as approved by Owner's Representative to determine the best location for these joints to minimize the visibility of the joints and to minimize unsightly cracking. Cut with a power saw fitted with an abrasive diamond blade within 4 to 12 hours after walk was been placed and finished
- F. Expansion Joints: Provide expansion joints where concrete placement is interrupted for more than 1/2 hour and at end of placement and in grid pattern not more than 30 feet on center at locations approved by Owner's Representative. Provide shear dowels and expansion caps at not more than 16 inches on center to transfer vertical loads but permit horizontal movement. Extend joint filler full depth of joint and allow 1/2 inch minimum space at top for insertion of backer rod and sealant. Protect top edge of joint filler with metal cap or other temporary protection. Remove protection after concrete has been placed on both sides of
- G. Caulked Construction Joints: Provide caulked construction joints wherever concrete abuts dissimilar material at locations approved by Owner's Representative. Extend joint filler full depth of joint and allow 1/2 inch minimum space at top for insertion of backer rod and sealant. Protect top edge of joint filler with metal cap or other temporary protection. Remove protection after concrete has been placed on both sides of joint.

3.6 CURING

- A. Integrally Colored Concrete: Apply curing and sealing compound for integrally colored concrete according to manufacturer's instructions using manufacturer's recommended application techniques. Apply curing and sealing compound at consistent time for each pour to maintain close color consistency.
- B. Curing compound shall be same color as the colored concrete and supplied by same manufacturer of the colored admixture.
- C. Precautions shall be taken in hot weather to prevent plastic cracking resulting from excessively rapid drying at surface as described in CIP 5 Plastic Shrinkage Cracking published by the National Ready Mixed Concrete Association.
- D. Do not cover concrete with plastic sheeting.

END OF SECTION

SECTION 321640
GRANITE CURBING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vertical Granite Curb
2. Sloped Granite Curb

B. Related sections include the following:

1. Division 31 Section "Earth Moving"
2. Division 32 Section "Asphalt Paving"
3. Division 32 Section "Concrete Paving"

C. Reference Standards: Comply with the provisions of the following except as otherwise indicated:

1. 2006 Edition of New Hampshire Department of Transportation Standard Specifications titled, "Standard Specifications for Road and Bridge Construction", Divisions 400 and 600. Paragraphs in these Sections titled "Method of Measurement" and "Basis of Payment" shall not apply.
2. Ramps and curbs shall comply with the requirements of the "American with Disabilities Act" (ADA).
3. City of Dover Construction Standards and Details, latest edition.

1.2 SUBMITTALS

A. Product Data: Material description, dimensions of components and finishes of granite curbing.

B. Material Description: Dimensions of components and finishes of granite curbing.

1.3 QUALITY ASSURANCE

A. Granite Curbing and Edging Installer Qualifications: An experienced curb setter who has completed vertical granite curbing and sloped granite edging installations and whose work has resulted in construction with a record of successful in-service performance.

PART 2 - PRODUCTS

2.1 VERTICAL GRANITE CURBING

A. Vertical Granite Curb shall be 5-inches wide and 16 to 18 inches deep.

- B. Granite shall be hard, durable, reasonably uniform in appearance, and free from weakening seams. Solid quartz or feldspar veins will not be cause for rejection.
- C. Surfaces of each stone (granite) shall be furnished in accordance with the requirements of NHDOT Section 609. The top of curb shall be uniform in treatment, all gang sawed or all wire sawed. Otherwise, gang sawed and wire sawed curb tops may be intermixed, or adjacent. Other exposed faces of all comparable curbs on the project shall be smooth quarry split. Bottom surfaces may be sawed or split.
- D. Radius curbing for vertical curbing shall conform to the following:

Radius (Feet)	Maximum Length (Feet)
21	3
22-28	4
29-35	5
36-42	6
43-49	7
50-56	8
57-60	9
Over 60	10

- E. The setting revealed for vertical granite curb (the vertical height of the exposed face of the stone when set) shall be 6-inches.
- F. Tip downs at driveway locations shall be at least 7 feet in length.

2.2 SLOPED GRANITE CURBING

- A. Sloped Granite Curb shall be 6- to 8-inches wide and 12 inches deep.
- B. Granite shall be hard, durable, reasonably uniform in appearance, and free from weakening seams. Solid quartz or feldspar veins will not be cause for rejection.
- C. Surfaces of each stone (granite) shall be furnished in accordance with the requirements of NHDOT Section 609. The top of curb shall be uniform in treatment, all gang sawed or all wire sawed. Otherwise, gang sawed and wire sawed curb tops may be intermixed, or adjacent. Other exposed faces of all comparable curbs on the project shall be smooth quarry split. Bottom surfaces may be sawed or split.
- D. Radius curbing for sloped granite curbing shall conform to the following:

Radius for Stones with Square Joints (Feet)	Maximum Length (Feet)
16-28	6" – 1'
29-41	2
42-55	3
56-68	4
69-82	5
83-96	6
97-110	7
Over 110	8

- E. The setting revealed for sloped granite curb (the vertical height of the exposed face of the stone when set) shall be 4-inches.
- F. Tip downs at driveway locations shall be at least 7 feet in length.

2.3 CEMENT

- A. Cement shall be straight Portland Cement, Type I, II, or Type I/II.

2.4 MORTAR SAND

- A. Mortar Sand shall meet the following gradation requirements:

<u>Sieve Size</u>	<u>% Passing</u>
No. 8	100
No. 16	60-100
No. 50	15-35
No. 100	2-15
No. 200	0-5

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Excavation for curb shall be made to the required depth, and the base upon which the curb is to be set shall be compacted to a firm even surface.
- B. Installation of curbing shall be so that the front top arris line conforms to the line and grade required. All spaces under the curbing shall be filled with material conforming to the requirements for roadway base course. This material shall be thoroughly tamped.
- C. Joints shall be approximately 1-inch wide. Joints shall be pointed with mortar and the exposed portions finished with a jointer.
- D. Curbing to be salvaged and reset shall be carefully removed and stored. The Contractor shall replace any curbing damaged or lost because of Contractor negligence. All exposed portions of reset curbing shall be cleaned by sand blasting.
- E. Backfilling shall be accomplished immediately after the curb is set and jointed. Backfill shall be of approved material, placed and thoroughly tamped in layers not exceeding 6-inches in depth.
 - 1. Compaction shall be achieved through the use of a vibratory plate compactor or a "Jumping" jack compactor. The use of hand compaction (i.e. tamping) will not be permitted.
 - 2. Concrete Class B in accordance with NHDOT Section 520 may be substituted for aggregate base course and hot bituminous base courses in the curb patch on the roadway side of granite curb. Concrete thickness shall be not less than that of the adjacent pavement.

3.2 REPAIRS AND PROTECTION

- A. Remove and replace curbing that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Owner's Representative.
- B. Protect curbing from damage using traffic control devices (cones).
- C. Maintain curbing as clean as possible by removing surface stains, dirt, discoloration, spillage of materials, and other foreign material as they occur.

END OF SECTION 321640

SECTION 321829
SYNTHETIC RUNNING TRACK SURFACE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. Drawings and general provisions of Contract, including General Conditions and Division One Specification Sections, apply to Work of this Section.

1.2 RELATED SECTIONS:

- A. Section 321216 – Asphalt Paving

1.3 REFERENCE STANDARD:

- A. Applicable standards and details of New Hampshire Department of Transportation.

1.4 WORK DESCRIPTION:

- A. Construct synthetic running track surface as indicated on civil drawings. Work of this section shall include following:
 - 1. Excavation and preparation of sub-grade for area designated to receive track surfacing. Legally dispose of excess materials offsite.
 - 2. Construction of a suitable base for track surfacing.
 - 3. Construction of track surfacing, including lane striping.
- B. Track surfacing shall be uniform in thickness, texture, and color, in accordance with grades, cross sections, and pitch required by Drawings, and free of all depressions and ridges.

1.5 SUBMITTALS:

- A. Submit running track surfacing manufacturer's product data, catalog cuts, color chart, application specifications, maintenance information and office samples. Samples shall be 12" x 12".

1.6 QUALITY ASSURANCE:

- A. Installer of running track shall be certified by approved manufacturer, and shall use only workmen who are trained and experienced in installation of track surface. The track construction shall be conducted by a Certified Track Builder. The track builder shall be certified by the American Sports Builders Association.
- B. Running Track: finished system shall meet following criteria:
 - 1. Force Reduction: 35 percent to 50 percent, inclusive.
 - 2. Modified Vertical Deformation: 0.6mm to 2.5mm, inclusive.
 - 3. Resistant to scuffing and shedding of granules.

- C. Single Source Responsibility: Track surfacing materials shall be supplied by one manufacturer. Track and field event surfacing and equipment construction shall be provided by a Contractor with a minimum of 5 years experience in construction of similar projects.
- D. Construction shall be performed in strict accordance with written instructions of surfacing and equipment Manufacturers.

1.7 WARRANTY:

- A. Provide a minimum one (1) year warranty, covering materials and installation. Contractor shall repair or replace defective surface, at no cost to Owner during warranty period.

PART 2 - PRODUCTS

- A. Running Track Surfacing: An impermeable polyurethane synthetic track system comprised of a base layer of polyurethane bound Styrene Butadiene Resin (SBR) rubber granules, an impermeable layer (seal coat) of a two-component urethane, and topped with a spray-applied coating of single-component polyurethane and EPDM granules. Nominal thickness: 3/8 inch. Gradation of granules: Between 1 and 6 millimeters containing less than 4 percent dust when retained on a number 30 sieve.
 - 1. Approved Manufacturers:
 - a. "BSS-200" Synthetic Track Surfacing, Beynon, A Tarkett Sports Company, Hunt Valley, Maryland (basis of specification).
 - b. Pre-bid approved substitution in accordance with Division 1 specifications.
- B. Marking Paint: 100 percent acrylic line marking paint approved by the track surface manufacturer.
- C. Track Surface Base: Existing rehabilitated track base or new base as shown on the drawings. All materials and methods shall be in accordance with NHDOT specifications.
- D. Any substituted system must be submitted for approval by the Owner's Representative.
- E. Colors: Surface base color shall be selected by Architect. Line marking colors shall be in accordance with track and field standards, or as otherwise directed by the Owners' representative.

PART 3 - EXECUTION

3.1 INSPECTION:

- A. Examine areas and conditions under which Work of this Section shall be installed. Correct conditions detrimental to proper completion of Work. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION:

- A. Fill excavated areas to minimum depths of stone and bituminous concrete base as indicated in PART 2. Base shall be allowed to cure for a minimum of fourteen (14) days prior to application of running track surface or as recommended by the manufacturer,

whichever is longer. Base shall be clean, dry, free draining, and free of foreign materials.

- B. Verify weather conditions before beginning installation of track surface. Do not place track materials when ambient nighttime temperature is expected to fall below 50°F.

3.3 INSTALLATION:

- A. Once base has cured, and prior to installation of track surface, apply a prime coat of manufacturer's approved binder (one (1) part water to one (1) part binder). Apply in rate (gallons per yard) as specified by Manufacturer. Asphalt emulsions are not acceptable.
- B. Base layer: Evenly apply rubber granules manually or by means of mechanical spreader, at rate specified by Manufacturer. Base layer shall be saturated with approved binder, mixed and spray-applied in accordance with Manufacturer's specifications. Allow this layer to cure for a minimum of twenty-four (24) hours under dry weather conditions.
- C. Apply second and third layers of rubber granules, installed in same manner as base layer, at rate as specified by Manufacturer. Saturate this layer with approved binder.
- D. Surface course: Apply rubber buffings in number of applications and rates (2.6 pounds per square yard) as required by Manufacturer's specifications. Final surface layer shall be pigmented with the color selected by the architect.
- E. Line Marking:
 - 1. Using approved line marking paint, install all striping in accordance with National Federation of High Schools for 400 meters running surfaces. Required striping, including event markings and lane numbers, shall receive two (2) coats of paint.
 - 2. Lane striping shall be based on 42-inch lane widths measured center to center of lane lines.

3.4 POST CONSTRUCTION TESTING AND ACCEPTANCE:

- A. Finished running track surface shall be uniform in thickness and texture. Thickness shall meet Manufacturer's minimum recommended thickness. Owner reserves right to perform thickness testing, and if found non-compliant, require Contractor to install additional courses until recommended minimum is achieved. Owner also reserves right to reject installation based on non-uniform distribution of granule sizes.

3.5 PROTECTION:

- A. Protect running track surfaces from damage by work of other trades until accepted by Owner.

3.6 CLEAN UP:

- A. Remove all excess materials and debris associated with Work of this Section from project area and legally dispose of offsite.

END OF SECTION

SECTION 32 31 13

CHAIN LINK FENCES

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Coordinate with such trades to assure the steady progress of all work under the Contract.

1.2 SUMMARY

- A. The work of this Section consists of all temporary tree and plant material protection as shown on the Drawings and as specified herein and includes, but is not limited to, the following:
 - 1. Chain-Link Fences: Industrial

1.3 RELATED SECTIONS

- A. Related Sections include the following:
 - 1. SECTION 03 30 00 – CAST-IN-PLACE CONCRETE
 - 2. SECTION 31 20 00 – EARTH MOVING

1.4 REFERENCES

- A. Comply with applicable requirements of:
 - 1. State of New Hampshire, Standard Specification for Roads and Bridge Construction, Department of Transportation, latest edition.
 - 2. City of Dover, of the State of New Hampshire, and of other authorities having jurisdiction. Provide labor, materials, equipment and services to comply with requirements.

1.5 SUBMITTALS

- A. Prepare and submit the following submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.
- B. Product Data: For each type of product indicated.
- C. Shop Drawings: Show locations, components, materials, dimensions, sizes, weights, and finishes of components. Include plans, gate elevations, sections, details of post anchorage, attachments, bracing, and other required installation and operational clearances.

D. Samples:

1. Polymer-coated steel wire for fabric.
2. Polymer coating on framing and accessories.

1.5 QUALITY ASSURANCE

- A. Conform to provisions of SECITON 01 40 00 QUALITY REQUIREMENTS.

PART 2 - PRODUCTS

2.1 CHAIN LINK FENCE FABRIC

- A. General: Height to be as noted on drawings. Comply with ASTM A 392, CLFMI CLF 2445, and requirements indicated below:

1. Steel Wire Fabric: Polymer-coated wire with a diameter of 0.192 inch.
 - a. Mesh Size: 2-118 inches
 1. Color: Black
2. Selvage: Knuckled at both selvages

2.2 INDUSTRIAL FENCE FRAMING

- A. Posts and Rails: Comply with ASTM F 1043 for framing, ASTM F 1083 for Group IC round pipe, and the following:

1. Group: Round steel pipe Schedule 40.
2. Fence Height: As noted in drawings
3. Strength Requirement: Heavy industrial according to ASTM F 1043.
4. Coating for Steel Framing:
 - a. Polymer coating over metallic coating.
 - b. Fabric-covered.
5. Set bases of posts in cast concrete bases.

2.3 TENSION WIRE

- A. General: Provide horizontal tension wire at top and bottom of fence fabric.

2.4 FITTINGS

- A. General: Comply with ASTM F 626.
- B. Finish:

1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz. /sq. ft. zinc.

2.5 CONCRETE FOOTINGS

- A. Concrete for footings chain link fence posts as specified in Section 03 30 00, Cast-in-Place Concrete.

2.6 POLYMER FINISHES

- A. Supplemental Color Coating: In addition to specified metallic coatings for steel, provide fence components with polymer coating.
- B. Color: Black, complying with ASTM F 934.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install chain-link fencing to comply with ASTM F 567 and more stringent requirements specified.
- B. Terminal Posts: Locate terminal end, comer, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment.
- C. Line Posts: Space line posts uniformly as shown on drawings.
- D. Post Bracing and Intermediate Rails: Install according to ASTM F 567. Install braces at end and gate posts and at both sides of comer and pull posts.
- E. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing.
- F. Top Rail: Install according to ASTM F 567.
- G. Bottom Rails: Install, spanning between posts.
- H. Chain-Link Fabric: Apply fabric to outside of enclosing framework. Leave 2 inches between finish grade or surface and bottom selvage, unless otherwise indicated.
- I. Tie Wires: Attach wire per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.
- J. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

END OF SECTION

SECTION 32 32 23.13

SEGMENTAL RETAINING WALL SYSTEM

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 SUMMARY

- A. The Work of this Section includes, but is not limited to, the following:
 - 1. Segmental Retaining Wall System

1.3 RELATED WORK

- A. Related work includes, but is not limited to, the following work covered in other sections:
 - 1. SECTION 31 20 00 – EARTH MOVING

1.4 REFERENCES

- A. Comply with applicable requirements of:
 - 1. State of New Hampshire, Standard Specification for Roads and Bridge Construction, Department of Transportation, latest edition.
 - 2. City of Dover, of the State of New Hampshire, and of other authorities having jurisdiction. Provide labor, materials, equipment and services to comply with requirements.
- B. Segmental Retaining Wall Units
 - 1. ASTM C 140 – Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
 - 2. ASTM C 1372 – Standard Specification for Dry-Cast Segmental Retaining Wall Units.
- C. Geosynthetic Reinforcement
 - 1. ASTM D 4595 – Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.

2. ASTM D 5262 – Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics.
3. ASTM D 5321 – Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear.
4. ASTM D 5818 – Standard Practice for Exposure and Retrieval of Samples to Evaluate Installation Damage of Geosynthetics.
5. ASTM D 6706 – Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil.

D. Soils

1. ASTM D 698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
2. ASTM D 2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
3. ASTM D 422 – Standard Test Method for Particle-Size Analysis of Soils.
4. ASTM D 4318 – Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils.
5. ASTM G 51 – Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing

E. Drainage Pipe

1. ASTM F 758 – Standard Specification for Smooth-Wall Polyvinyl Chloride (PVC) Plastic Underdrain Systems for Highway, Airport or Similar Drainage.
2. ASTM F 405 – Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings.

F. Engineering Design

1. “NCMA Design Manual for Segmental Retaining Walls,” 3rd Edition, 2009.

G. Where specifications and reference documents conflict, the Wall Design Engineer shall make the final determination of applicable document.

1.5 SUBMITTALS

- A. Materials Submittals: The Contractor shall submit manufacturers' certifications two weeks prior to start of work stating that the SRW units and geosynthetic reinforcement meet the requirements of Section 2 of this specification.
- B. Design Submittal: The Contractor shall submit two sets of detailed design calculations and final retaining wall plans for approval at least two weeks prior to the beginning of wall construction. All calculations and drawings shall be prepared and sealed by a professional Civil Engineer (P.E.) – (Wall Design Engineer) experienced in SRW design and licensed in the state where the

wall is to be built.

1.6 EXAMINATION OF SITE AND DOCUMENTS

- A. Contractor responsible for judging extent of work requirements involved. By submitting bid, Contractor affirms he has carefully examined the site and conditions affecting work.

1.7 PERMITS AND CODES

- A. Work shall conform to Drawings and Specifications and shall comply with applicable codes and regulations.
- B. Arrange for and obtain permits and licenses required to complete Work. Fees not waived shall be paid by Contractor.
- C. Do not close or obstruct streets, sidewalks, alleys or passageways without prior notification and permission. Conduct operations to minimize interference with use of roads, driveways, alleys, sidewalks, or other facilities near enough to Work to be affected.

1.8 QUALITY ASSURANCE

- A. Segmented wall components shall be free of cracks, seams, starts or other defects which impair strength, durability or appearance. Color, texture and finish shall be within range of samples approved by the Owner's Representative.
- B. Segmented Retaining Wall System Installation shall be performed by experienced contractors under the full time supervision of qualified foreman.

1.9 DELIVERY, STORAGE AND HANDLING

- A. Contractor shall check materials upon delivery to ensure that the specified type and grade of materials have been received and proper color and texture of SRW units have been received.
- B. Contractor shall store and handle materials in accordance with manufacturer's recommendations and in a manner to prevent deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breaking, chipping or other causes.
- C. Contractor shall prevent excessive mud, wet concrete, epoxies and similar materials that may affix themselves from coming in contact with materials.
- D. Contractor shall protect materials from damage; no damaged material shall be incorporated into the segmental wall.
- E. Geosynthetic shall be protected from UV exposure and the protective covering on geosynthetic shall remain until immediately before installation and shall be stored at temperatures above -10 degrees F.

PART 2 - PRODUCTS

2.1 SEGMENTAL RETAINING WALL UNITS (SRW)

- A. SRW units shall be machine-formed, Portland cement concrete blocks specifically designed for retaining wall applications. SRW units currently approved for this project are:
 - 1. VERSA-LOK Mosaic® Retaining Wall System that includes three unit types: VERSA-LOK Standard units, VERSA-LOK Cobble® units and VERSA-LOK Accent® units, as manufactured by Versa-Lok of New England, 5 Northern Boulevard, Unit 15, Amherst, MA. Phone: (603) 883-3042.
- B. Color of SRW units shall be 'Fieldstone Blend'
- C. Finish of SRW units shall be 'Weathered'.
- D. SRW unit faces shall be of straight geometry.
- E. SRW unit height shall be both 4 and 6 inches.
- F. SRW units shall be designed to stack in "panels" 10 inches high by 24 inches wide consisting of the three SRW unit types that can be stacked in varied patterns to create a random look.
- G. SRW units shall provide a minimum weight of 120 psf wall face area.
- H. SRW units shall be solid through the full depth of the unit.
- I. SRW units shall have a depth (front face to rear) to height ratio of 2:1, minimum.
- J. SRW units shall be capable of being erected with the horizontal gap between adjacent units not exceeding 1/8 inch.
- K. SRW units shall be interlocked with connection pins that provide 3/4-inch setback from unit below (4- and 6-inch-high units stacked alternately, yielding an overall 8.5-degree cant from vertical).
- L. SRW units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the structure. Any cracks or chips observed during construction shall fall within the guidelines outlined in ASTM C 1372.
- M. Concrete SRW units shall conform to the requirements of ASTM C 1372 and have a minimum net average 28 days compressive strength of 3000 psi. Compressive strength test specimens shall conform to the saw-cut coupon provisions of ASTM C 140.
- N. SRW units' molded dimensions shall not differ more than $\pm 1/8$ inch from that specified, as measured in accordance with ASTM C 140. This tolerance does not apply to architectural surfaces, such as split-faces.

2.2 SEGMENTAL RETAINING WALL UNIT CONNECTION PINS

- A. Setting bed mortar shall conform to ASTM C 270, Type S, except that latex polymer additive shall be mixed with cementitious materials and aggregate in lieu of water.

- A. SRW units shall be interlocked with VERSA-TUFF® Snap-Off connection pins, 6.8 inches in length, with a section that can snap off, yielding a 4.6-inch long pin. The pins shall consist of glass-reinforced nylon made for the expressed use with the SRW units supplied.

2.3 GEOSYNTHETIC REINFORCEMENT

- A. Geosynthetic reinforcement shall consist of high-tenacity PET geogrids, HDPE geogrids, or geotextiles manufactured for soil reinforcement applications. The type, strength and placement of the geosynthetic reinforcement shall be determined by procedures outlined in this specification and the “NCMA Design Manual for Segmental Retaining Walls,” (3rd Edition, 2009), and materials shall be specified by Wall Design Engineer in their final wall plans and specifications. The manufacturers/suppliers of the geosynthetic reinforcement shall have demonstrated construction of similar size and types of segmental retaining walls on previous projects.
 - 1. The geosynthetic type must be approved one week prior to bid opening. Geosynthetic types currently approved for this project are:
 - a. VERSA-Grid® Geogrids
- B. The type, strength and placement of the reinforcing geosynthetic shall be as determined by the Wall Design Engineer, as shown on the final, P.E.-sealed retaining wall plans.

2.4 LEVELING PAD

- A. Material for leveling pad shall consist of compacted sand, gravel, or combination thereof (USCS soil types GP, GW, SP and SW) and shall be a minimum of 6 inches in depth. Lean concrete with a strength of 200-300 psi and 3 inches thick maximum may also be used as a leveling pad material. The leveling pad should extend laterally at least a distance of 6 inches from the toe and heel of the lowermost SRW unit.

2.5 DRAINAGE AGGREGATE

- A. Drainage aggregate shall be angular, clean stone or granular fill meeting the following gradation as determined in accordance with ASTM D 422:

Sieve Size	Percent Passing
1 inch	100
3/4 inch	75-100
No. 4	0-60
No. 40	0-50
No. 200	0-5

2.6 DRAINAGE PIPE

- A. The drainage collection pipe shall be a perforated or slotted PVC, or corrugated HDPE pipe. The drainage pipe may be wrapped with a geotextile to function as a filter.
- B. Drainage pipe shall be manufactured in accordance with ASTM F 405 or ASTM F 758.

2.7 REINFORCED BACKFILL SOIL

- A. The reinforced soil material shall be free of debris. Unless otherwise noted on the final, P.E.-sealed, retaining wall plans prepared by the Wall Design Engineer, the reinforced material shall consist of the inorganic USCS soil types GP, GW, SW, SP and SM, meeting the following gradation, as determined in accordance with ASTM D 422:

Sieve Size	Percent Passing
1 inch	100
No. 4	20-100
No. 40	0-60
No. 200	0-35

- B. The maximum particle size of poorly-graded gravels (GP) (no fines) should not exceed 3/4 inch unless expressly approved by the Wall Design Engineer and the long-term design strength (LTDS) of the geosynthetic is reduced to account for additional installation damage from particles larger than this maximum.
- C. The plasticity of the fine fraction shall be less than 20.
- D. The pH of the backfill material shall be between 3 and 9 when tested in accordance with ASTM G 51.

2.8 GEOTEXTILE FILTER

- A. Drainage geotextile shall consist of geosynthetic specifically manufactured for use as a preamble soil filter that retains soil while still allowing water to pass throughout the life of the structure. The type and placement of the geotextile filter material shall be as required by the Wall Design Engineer in their final wall plans and specifications.

PART 3 - EXECUTION

3.1 DESIGN

- A. The design analysis for the final, P.E.-sealed retaining wall plans prepared by the Wall Design Engineer shall consider the external stability against sliding and overturning, internal stability and facial stability of the reinforced soil mass, and shall be in accordance with acceptable engineering practice and these specifications. The internal and external stability analysis shall be performed in accordance with the "NCMA Design Manual for Segmental Retaining Walls," (3rd Edition, 2009), using the recommended minimum factors of safety in this manual.
- B. External stability analysis for bearing capacity, global stability, and total and differential settlement shall be the responsibility of the Owner and the Owner's Geotechnical Engineer. The Geotechnical Engineer shall perform bearing capacity, settlement estimates, and global stability analysis based on the final wall design provided by the Wall Design Engineer and coordinate any required changes with the Wall Design Engineer.
- C. While vertical spacing between geogrid layers may vary, it shall not exceed 20 inches maximum in the wall design.

- D. The geosynthetic placement in the wall design shall have 100% continuous coverage parallel to the wall face. Gapping between horizontally adjacent layers of geosynthetic (partial coverage) will not be allowed.

3.2 INSPECTION

- A. The Owner or Owner's Engineer is responsible for verifying that the materials supplied by the Contractor meet all the requirements of the specification. This includes all submittals for materials and design, qualifications and proper installation of wall system.
- B. Contractor's field construction supervisor shall have demonstrated experience and be qualified to direct all work at the site.

3.3 EXCAVATION

- A. Contractor shall excavate to the lines and grades shown on the project grading plans. Contractor shall take precautions to minimize over-excavation. Over-excavation shall be filled with compacted infill material, or as directed by the Wall Design Engineer, at the Contractor's expense.
- B. Contractor shall verify location of existing structures and utilities prior to excavation. Contractor shall ensure all surrounding structures are protected from the effects of wall excavation. Excavation support, if required, is the responsibility of the Contractor.

3.4 FOUNDATION PREPARATION

- A. Following the excavation, the foundation soil shall be examined by the Owner's Engineer to assure actual foundation soil strength meets or exceeds the assumed design bearing strength. Soils not meeting the required strength shall be removed and replaced with infill soils, as directed by the Owner's Geotechnical Engineer.
- B. Foundation soil shall be proof-rolled and compacted to 95% standard Proctor density and inspected by the Owner's Geotechnical Engineer prior to placement of leveling pad materials.

3.5 LEVELING PAD CONSTRUCTION

- A. Leveling pad shall be placed as shown on the final, P.E.-sealed retaining wall plans with a minimum thickness of 6 inches. The leveling pad should extend laterally at least a distance of 6 inches from the toe and heel of the lowermost SRW unit.
- B. Granular leveling pad material shall be compacted to provide a firm, level bearing surface on which to place the first course of units. Well-graded sand can be used to smooth the top 1/4 inch to 1/2 inch of the leveling pad. Compaction will be with mechanical plate compactors to achieve 95% of maximum standard Proctor density (ASTM D 698).

3.6 SRW UNIT CONSTRUCTION

- A. All SRW units shall be installed at the proper elevation and orientation as shown on the final, P.E.-sealed wall plans and details or as directed by the Wall Design Engineer. The SRW units shall be installed in general accordance with the manufacturer's recommendations. The specifications and drawings shall govern in any conflict between the two requirements.

- B. For ease of installation, generally the base course of SRW units shall be all 6-inch-high Standard units placed on the leveling pad. The units shall be leveled side-to-side, front-to-rear and with adjacent units, and aligned to ensure intimate contact with the leveling pad. The base course is the most important to ensure accurate and acceptable results. No gaps shall be left between the front of adjacent units. Alignment may be done by means of a stringline or offset from baseline to the back of the units. Placing panels of Mosaic directly on the leveling pad is also acceptable. In this case, the entire 10-inch-high course of panels must be installed before the level and alignment can be checked.
- C. All excess debris shall be cleaned from top of units and the next course of units installed on top of the units below.
- D. Mosaic panels shall be placed on the units below. Each panel shall be installed completely prior to installing horizontally adjacent panels. Each Mosaic panel shall be 10 inches high by 24 inches wide, consisting of one Standard unit, one Cobble unit, and two Accent units. With each adjacent panel, the units at the bottom of the panels should be alternated from 4-inch-high units to 6-inch-high units. As an example, one panel shall have Accent units at the base of the panel with Standard and Cobble units on top. The next adjacent panel shall have the Standard and Cobble units at the bottom and Accent units on top. The order of the Cobble and Standard units shall be randomly mixed within the panels to avoid a repetitive pattern. The entire length of each 10-inch-high course of panels shall be installed before starting the next course of panels.
- E. Each unit in a Mosaic panel shall be pinned to the units below in the following manner: Two VERSA-TUFF connection pins shall be inserted through the pin holes of each unit into receiving slots in units below, creating an approximate $\frac{3}{4}$ -inch setback from the unit below. Pins shall be fully seated in the pin slot below. When pinning 4-inch-high Accent units, the top 2 inches of the 6.8-inch VERSA-Tuff Snap-off pin will initially extend above the Accent unit. The top of the pin shall be snapped off by hitting the top of the pin from the side. Once pinned, the units shall be pushed forward to remove any looseness in the unit-to-unit connection.
 - 1. Prior to placement of next course of panels, the level and alignment of the units shall be checked and corrected where needed.
- F. The next course of panels shall be placed so that it is staggered at least 4 inches from the vertical joints between the panels below. The patterns in the Mosaic panels generally shall not line up with the course below. The bond of the panels shall be varied on subsequent courses to create a random look.
- G. Layout of curves and corners shall be installed in accordance with the wall plan details or in general accordance with SRW manufacturer's installation guidelines. Walls meeting at corners shall be interlocked by overlapping successive courses.
- H. Procedures C. through G. shall be repeated until reaching top of wall units, just below the height of the cap units. Geosynthetic reinforcement, drainage materials, and reinforced backfill shall be placed in sequence with unit installation as described in Section 4.06, 4.07 and 4.08.

3.7 GEOSYNTHETIC REINFORCEMENT PLACEMENT

- A. All geosynthetic reinforcement shall be installed at the proper elevation and orientation as shown on the final P.E.-sealed retaining wall plan profiles and details, or as directed by

the Wall Design Engineer. When used, geosynthetic reinforcement will be installed at the tops of the 10-inch Mosaic panels.

- B. At the elevations shown on the final plans, (after the units, drainage material and backfill have been placed to this elevation) the geosynthetic reinforcement shall be laid horizontally on compacted infill and on top of the concrete SRW units, to within 1 inch of the front face of the unit below. Embedment of the geosynthetic in the SRW units shall be consistent with SRW manufacturer's recommendations. Correct orientation of the geosynthetic reinforcement shall be verified by the Contractor to be in accordance with the geosynthetic manufacturer's recommendations. The highest-strength direction of the geosynthetic must be perpendicular to the wall face.
- C. Geosynthetic reinforcement layers shall be one continuous piece for their entire embedment length. Splicing of the geosynthetic in the design-strength direction (perpendicular to the wall face) shall not be permitted. Along the length of the wall, horizontally adjacent sections of geosynthetic reinforcement shall be butted in a manner to assure 100% coverage parallel to the wall face.
- D. Tracked construction equipment shall not be operated directly on the geosynthetic reinforcement. A minimum of 6 inches of backfill is required prior to operation of tracked vehicles over the geosynthetic. Turning should be kept to a minimum. Rubber-tired equipment may pass over the geosynthetic reinforcement at slow speeds (less than 5 mph).
- E. The geosynthetic reinforcement shall be free of wrinkles prior to placement of soil fill. The nominal tension shall be applied to the reinforcement and secured in place with staples, stakes or by hand tensioning until reinforcement is covered by 6 inches of fill.

3.8 DRAINAGE AGGREGATE AND DRAINAGE MATERIAL PLACEMENT

- A. Drainage aggregate shall be installed to the line, grades and sections shown on the final P.E.-sealed retaining wall plans. Drainage aggregate shall be placed to the minimum thickness shown on the construction plans between and behind units (a minimum of 1 cubic foot for each exposed square foot of wall face unless otherwise noted on the final wall plans).
- B. Drainage collection pipes shall be installed to maintain gravity flow of water outside the reinforced-soil zone. The drainage collection pipe shall be installed at the locations shown on the final construction drawings. The drainage collection pipe shall daylight into a storm sewer or along a slope, at an elevation below the lowest point of the pipe within the aggregate drain. Drainage laterals shall be spaced at a maximum 50-foot spacing along the wall face.

3.9 BACKFILL PLACEMENT

- A. The reinforced backfill shall be placed as shown in the final wall plans in the maximum compacted lift thickness of 8 inches and shall be compacted to a minimum of 95% of standard Proctor density (ASTM D 698) at a moisture content within -1% point to +3% points of optimum. The backfill shall be placed and spread in such a manner as to eliminate wrinkles or movement of the geosynthetic reinforcement and the SRW units.
- B. Only hand-operated compaction equipment shall be allowed within 3 feet of the back of the wall units. Compaction within the 3 feet behind the wall units shall be achieved by at least three passes of a lightweight mechanical tamper, plate, or roller.

- C. At the end of each day's operation, the Contractor shall slope the last level of backfill away from the wall facing and reinforced backfill to direct water runoff away from the wall face.
- D. At completion of wall construction, backfill shall be placed level with final top of wall elevation. If final grading, paving, landscaping and/or storm drainage installation adjacent to the wall is not placed immediately after wall completion, temporary grading and drainage shall be provided to ensure water runoff is not directed at the wall nor allowed to collect or pond behind the wall until final construction adjacent to the wall is completed.

3.10 SRW CAPS

- A. SRW caps shall be properly aligned and glued to underlying units with VERSA-LOK adhesive, a flexible, high-strength concrete adhesive. Rigid adhesive or mortar are not acceptable.
- B. Caps shall overhang the top course of units by 3/4 inch to 1 inch. Slight variation in overhang is allowed to correct alignment at the top of the wall.

3.11 CONSTRUCTION ADJACENT TO COMPLETED WALL

- A. The Owner or Owner's Representative is responsible for ensuring that construction by others adjacent to the wall does not disturb the wall or place temporary construction loads on the wall that exceed design loads, including loads such as water pressure, temporary grades, or equipment loading. Heavy paving or grading equipment shall be kept a minimum of 3 feet behind the back of the wall face. Equipment with wheel loads in excess of 150 psf live load shall not be operated within 10 feet of the face of the retaining wall during construction adjacent to the wall. Care should be taken by the General Contractor to ensure water runoff is directed away from the wall structure until final grading and surface drainage collection systems are completed.

END OF SECTION

SECTION 328400
IRRIGATION SYSTEM ALTERNATE #3

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. Include GENERAL CONDITIONS and applicable parts of Division 1 as part of this Section.
- B. Coordinate work of this Section with new and existing underground utilities and with trades responsible for their installation. Refer to respective drawings pertaining to other work.

1.2 WORK TO BE DONE

- A. Work to be done includes furnishing labor, materials, equipment and services required to complete irrigation work indicated on the drawings, as specified herein, or both.
- B. The mechanical point of connections for the irrigation systems shall be domestic water building supplies provided.**
- C. The electrical point of connection for the irrigation system shall be to a 120-volt, 20-amp building electrical circuit in building mechanical room for irrigation controller.
- D. The drawings and specifications must be interpreted and are intended to complement each other. Furnish and install all parts, which may be required by the drawings and omitted by the specifications, or vice versa, just as though required by both. Should there appear to be discrepancies or question of intent, the matter shall be referred to the Owner's Representative for decision, and his interpretation shall be final, conclusive and binding.
- E. Necessary changes to the drawings to avoid obstacles shall be made with the approval of the Owner's Representative.
- F. Trench excavation, backfilling and bedding materials, together with the testing of the completed installation shall be included in this work.
- G. The Work shall be constructed and finished in every respect in a good, workmanlike and substantial manner, to the full intent and meaning of the drawings and specifications. Parts necessary for the proper and complete execution of the Work, whether the same may have been specifically mentioned or not, or indicated on the drawings, shall be done or furnished in a manner corresponding with the rest of the work as if the same were specifically herein described.
- H. Record drawing as well as Operating & Maintenance Manual generation, in accordance to these specifications shall also be included in this work.

1.3 SCOPE

- A. The irrigation systems shown on the drawings and described within these specifications represents a single controller, turf and landscape, and athletic field's irrigation system supplied from domestic water supplies. The system is designed for 100 gallons per minute. Minimum 70-psi dynamic pressure at full system flow is required from the irrigation point of connection for the site and ball field system. The system is designed for 16 gallons per minute. Minimum 65-psi dynamic pressure at full system flow is required from the irrigation point of connection for the court yard system.

1.4 RELATED WORK

- A. Carefully examine the Contract Documents for requirements that affect the Work of this Section.
 - 1. Grading Section - 310000
 - 2. Planting - Section 329300
 - 3. Electrical Power Supply - Division 26

1.5 ORDINANCES, PERMITS AND FEES

- A. The Work under this Section shall comply with ordinances and regulations of authorities having jurisdiction.
- B. Permits, tests, and certifications required for the execution of Work under this Section shall be obtained and paid for.
- C. Furnish copies of Permits, Certifications and Approval Notices to the Owner's Representative prior to requesting payment.
- D. Include in the bid charges by Utility Companies, or other authorities for work done by them.

1.6 EXAMINATION OF CONDITIONS

- A. Be fully informed of existing conditions on the site before submitting bid, and be fully responsible for carrying out work required to fully and properly execute the work of the Contract, regardless of the conditions encountered in the actual Work. No claim for extra compensation or extension of time will be allowed on account of actual conditions inconsistent with those assumed, except those conditions described in the GENERAL CONDITIONS.

1.7 QUALITY ASSURANCE

- A. Installer: A firm which has at least five (5) years' experience in work of the type and size required by this Section and which is acceptable to the Owner's Representative.

- B. References: Supply three references for work of this type and size with the bid including names and phone numbers of contact person(s).
- C. Applicable requirements of accepted Standards and Codes shall apply to the Work of this Section and shall be so labeled or listed:
 - 1. American Society for Testing & Materials (ASTM)
 - a. ASTM: A536 Ductile Iron Castings
 - b. ASTM: D1784 Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
 - c. ASTM: D1785 Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and CI200.
 - d. ASTM: D2464 Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 - e. ASTM: D2466 Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
 - f. ASTM: D2564 Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
 - g. ASTM: B43-98 Brass pipe.
 - h. ASTM: B88-99 Seamless Copper Water Tube
 - i. ASTM: B828-00 Soldered Copper Joints.
 - j. ASTM: F477 Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
 - k. ASTM: D2737-99 Polyethylene (PE) Pressure rated tube.
 - 2. National Standard Plumbing Code (NSPC)
 - 3. National Electric Code (NEC)
 - 4. National Sanitary Foundation (NSF)
 - 5. American Society of Agricultural and Biological Engineers (ASABE)
 - 6. Underwriters Laboratories, Inc. (UL)
 - 7. Occupational Safety and Health Administration (OSHA)
 - 8. American Society of Irrigation Consultants (ASIC)

1.8 TESTS

- A. Observation: Owner's Representative will be on site at various times to insure the system is being installed according to the specifications and drawings.
- B. Coverage Test: After completion of the system, test the operation of entire system and adjust sprinklers as directed by the Owner's Representative. Demonstrate to the Owner's Representative that irrigated areas are being adequately covered. Furnish and install materials required to correct inadequacies of coverage due to deviations from the drawings or where the system is obviously inadequate or inappropriate. (See Part 3 - Execution).
- C. The Owner's Representative shall be notified 7 days in advance for observations.

1.9 SHOP DRAWINGS

- A. Provide copies of product specification sheets on proposed equipment to be installed to the Owner's Representative for approval prior to the start of work, in accordance with the parameters of Division-1. Work on the irrigation system may not commence until product sheets are submitted and approved. Submittals shall be marked up to show proper nozzles, sizes, flows, etc. Equipment to be included:
 - 1. Sprinklers
 - 2. Flood Bubbler Assemblies
 - 3. Valves: Manual and Automatic
 - 4. Moisture Sensor Controller/Enclosure
 - 5. Valve Boxes
 - 6. Pipe and Fittings
 - 7. Wire and Connectors
 - 8. Quick Coupling Valves
 - 9. Rain Sensor
 - 10. Decoders
 - 11. Surge Arrestors
 - 12. Moisture Sensors
 - 13. Flow Sensor
 - 14. Decoder Cable Fuse Device

15. Air/Vacuum Relief Valve
 16. Grounding Equipment
- B. Project Record Documents:
1. Provide and keep up-to-date a complete redlined record set of drawings of the system as the project proceeds. Drawings shall be corrected daily, showing every change from the original drawings and specifications. Record drawings shall specify and exactly locate sprinkler type; pop up height and nozzle for each sprinkler installed. Each valve box location to be referenced by distance from a minimum of two permanent locations. Controller, decoders, flow sensor, lightning surge arrestors, isolation valves, rain sensor, moisture sensors, quick coupling valve and other equipment shall be indicated on the drawings. Wire routing, wire size and splices shall be indicated. Mainline pipe and wire route shall have two (2) distinctly different graphic symbols (line types). This redlined record set of drawings shall be kept at job site and shall be used only as a record set.
 2. Make neat and legible notations on this record set of drawings daily as the Work proceeds, showing the Work as actually installed. For example, should a piece of equipment be installed in a location that does not match the plan, indicate that equipment in a graphic manner in the location of installation and so as to match the original symbols as indicated in the irrigation legend. Should the equipment be different from that specified, indicate with a new graphic symbol both on the drawings and the irrigation legend. The relocated equipment dimensions and northing and easting coordinates should then be transferred to the appropriate drawing in this record set of drawings at the proper time.
 3. On or before the date of final field observation, deliver corrected and completed AutoCAD computer plots of "record drawings" on vellum and AutoCAD electronic files on disk to Owner's Representative as part of contract closeout. Delivery of plots will not relieve the responsibility of furnishing required information that may have been omitted from the prints.

1.10 DELIVERY, STORAGE AND HANDLING

- A. Store and handle materials in compliance with manufacturer instructions and recommendations. Protect from possible damage. Minimize on-site storage.

1.11 GUARANTEE

- A. Obtain in the Owner's name the standard written manufacturer's guarantee of materials furnished under this Section where such guarantees are offered in the manufacturer's published product data. Guarantees shall be in addition to, and not in lieu of, other liabilities that the Contractor performing the work under contract may have by law.
- B. In addition to the manufacturer's guarantees the entire irrigation system shall be warrantied, both parts and labor for a period of one (1) year from the date of acceptance by the Owner.

- C. As part of the one-year warranty the first year-end winterization and spring start-up for the irrigation system shall be performed.
- D. Should problems develop within the warranty period because of inferior or faulty materials or workmanship, they shall be corrected to the satisfaction of the Owner's Representative at no additional expense to the Owner.
- E. A written warranty showing date of completion and period of warranty shall be supplied upon completion of the project.

1.12 COORDINATION

- A. Work shall be coordinated closely with the Owner's Representative to avoid misunderstandings and to efficiently bring the project to completion. Owner's Representative shall be notified as to the start of work, progression and completion, as well as changes to the drawings before the change is made. Coordinate work with those of other trades.
- B. Be responsible and pay for damage to other work caused by work or workmen. Repairing of such damage shall be done by the Company who installed the work as directed by the Owner's Representative.

1.13 MAINTENANCE AND OPERATING INSTRUCTIONS

- A. Include in Bid an allowance for four (4) hours of instruction of Owner and/or Owner's personnel upon completion of check/test/start-up/adjust operations by a competent operator (Owner's Representative office shall be notified at least one (1) week in advance of check/test/start-up/adjust operations).
- B. Upon completion of work and prior to application for acceptance and final payment, a minimum of three (3) three ring, hard cover binders titled MAINTENANCE AND OPERATING INSTRUCTIONS FOR THE DOVER HIGH SCHOOL & CAREER CENTER, DOVER, NH IRRIGATION SYSTEM, shall be submitted to the Owner's Representative office. After review and approval, the copies will be forwarded to the Owner. Included in the Maintenance and Operating binders shall be:
 - 1. Table of Contents
 - 2. Written description of Irrigation System.
 - 3. System drawings:
 - a. One (1) copy of the original irrigation plan;
 - b. One (1) copy of the Record Drawing;
 - c. One (1) reproducible of the Record Drawing;
 - d. One (1) copy of the controller valve system wiring diagram

4. Listing of Manufacturers.
5. Manufacturers' data where multiple model, type and size listings are included; clearly and conspicuously indicating those that are pertinent to this installation.
 - a. "APPROVED" submittals of irrigation equipment;
 - b. Operation:
 - c. Maintenance: including complete troubleshooting charts.
 - d. Parts list.
 - e. Names, addresses and telephone numbers of recommended repair and service companies.
6. A copy of the suggested "System Operating Schedule" which shall call out the controller program required (zone run time in minutes per day and days per week) in order to provide the desired amount of water to each area under "no-rain" conditions.
7. Winterization and spring start-up procedures.
8. Guarantee data.

1.14 PROCEDURE

- A. Notify city departments and/or public utility owners concerned, of the time and location of work that may affect them. Cooperate and coordinate with them in the protection and/or repairs of utilities.
- B. Provide and install temporary support, adequate protection and maintenance of structures, drains, sewers, and other obstructions encountered. Where grade or alignment is obstructed, the obstruction shall be permanently supported, relocated, removed or reconstructed as directed by the Owner's Representative.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Materials to be incorporated in this system shall be new and without flaws or defects and of quality and performance as specified and meeting the requirements of the system. All material overages at the completion of the installation shall be removed from the site.
- B. No material substitutions from the irrigation products described in these specifications and shown on the drawings shall be made without prior approval and acceptance from the Owner's Representative.

2.2 PVC IRRIGATION PIPE

- A. Pipe shall bear the following markings: Manufacturer's name, nominal pipe size, schedule or class, pressure rating in psi, and date of extrusion.
- B. Lateral pipe in sizes 2-1/2 inches and smaller shall be PVC, Class 200, Type 1120, SDR 21, Solvent-Weld PVC, conforming to ASTM No. D2241 as manufactured by Certainteed, Cresline, JM Eagle or equal.
- C. Mainline pipe in sizes 2-1/2 inches and larger shall be PVC, Class 200, Type 1120, SDR 21, Gasket-Joint PVC, conforming to ASTM No. D178 as manufactured by Certainteed, Cresline, JM Eagle or equal.
- D. The pipe insertion mark shall be visible to show the proper depth into spigot.

2.3 BRASS PIPE AND FITTINGS

- A. Brass pipe shall be 125lb., cast bronze, ground joint pattern, threaded, ASTM B43-98.
- B. Brass fittings shall be cast bronze, screwed, 125lb. Class.

2.4 PVC PIPE SLEEVES

- A. Pipe sleeves beneath non-soil areas shall be minimum PVC, Class 160 water pipe as manufactured by Certainteed, Cresline, JM Eagle or equal. Minimum sleeve size to be 3-inch.

2.5 WIRE CONDUIT

- A. Conduit for wiring beneath non-soil areas shall be PVC, SCH-40 conduit with solvent-weld joints, as manufactured by Cresline, Carson, JMM or equal.
- B. Communication cable and flow sensor cable, shall be installed within individual schedule 40 1-inch PVC conduit with solvent welded joints a minimum of 18-inches below grade. Provide 6-inch minimum separation between communication cable conduit and irrigation pressure mainline piping.
- C. Install communication cables and flow sensor cables in separate conduits.
- D. Sweep ells shall be standard electrical type PVC schedule 40 long sweep elbows.
- E. Above ground wiring to rain sensor or controller shall be schedule 40 PVC rigid electrical conduit.

2.6 PVC IRRIGATION FITTINGS

- A. Fittings for solvent weld PVC pipe, 2-1/2 inch and smaller in size, shall be Schedule 40 solvent weld PVC fittings as manufactured by Dura, Lasco, Spears or equal.

- B. Fittings shall bear manufacturer's name or trademark, material designation, size, and applicable I.P.S. schedule.
- C. PVC threaded connections in and out of valves shall be made using Schedule 80 toe nipples and Schedule 40 couplers or socket fittings. Schedule 40 threads will not be approved for installation.
- D. PVC solvent shall be NSF approved, for Type I and Type II PVC pipe, and Schedule 40 and 80 fittings. Cement shall be medium not fast or hot, no wet and dry. Cement is to meet ASTM D2564 and FF493 for potable water pipes. PVC solvent cement shall be Rectorseal Gold, IPS Weld-ON 711, Oatey Heavy Duty Cement or equal, and shall be used in conjunction with the appropriate primer. Primer shall be NSF approved, and formulated for PVC and CPVC pipe applications. Primer is to meet ASTM F 656. Primer shall be Rectorseal Jim PR-2, IPS Weld-ON P-70, Oatey Primer for PVC and CPVC, or equal. Clear primers shall not be allowed.
- E. Fittings for PVC mainline pipe, for directional changes, pipe reductions and plugs 2-1/2-inch and larger in size shall be deep bell push-on gasket joint ductile iron fittings for PVC pipe. Fittings shall be manufactured of ductile iron, grade 70-55-05 in accord with ASTM A536 and gaskets shall meet ASTM F477. Fittings shall be as manufactured by Harrington Corporation, or equal. For mainline pipe to zone valve / lateral pipe connections, Harco or equal push-on gasket joint ductile iron service tees shall be used. Saddles, (strap, bolt down or snap) will not be approved for installation.
- F. Nipples to be schedule 80 PVC.

2.7 POLYETHYLENE IRRIGATION PIPE

- A. Lateral piping 1-1/4 inch and smaller in size as indicated on the drawings may also be installed with polyethylene (PE3408) pipe, SDR 15, Class 100, Type III, Grade 3, Class C conforming to ASTM D2239, with a minimum pressure rating of 100 psi as manufactured by Oil Creek or equal.
- B. All ballfield piping shall be Class 200 PVC piping. No polyethylene piping to be used on athletic fields.

2.8 POLYETHYLENE IRRIGATION FITTINGS

- A. Fittings for polyethylene pipe shall be insert PVC or Nylon type fittings. Fittings shall conform to NSF standards and be attached with two (2) dog-eared stainless steel clamps. Clamps shall be as manufactured by Oetiker or approved equal.
- B. Supply only pipes and fittings that are marked by the manufacturer with the appropriate ASTM designations and pressure ratings and are free from cracks, wrinkles, blisters, dents or other damage. Fittings shall be per ASTM D2609 as manufactured by Dura, Lasco, Spears, or approved equal.

2.9 SPRAY SPRINKLERS

- A. Full and part circle pop up spray sprinklers shall be pressure regulating (30-psi), plastic construction with ratcheting riser, removable nozzle and check valve. Nozzle size shall be as indicated on the drawing and in the legend. Pop-up height shall be 6 inches for turf and 12 inches for ground cover, shrubs and annual beds.
- B. Sprinkler shall carry a minimum 3-year exchange warranty against defects. Sprinklers shall be manufactured by Toro, model 570Z-PRX-COM, Rain Bird, model 1800-SAM-PRS, Hunter Industries, model PRO30-CV or approved equal.

2.10 FLOOD BUBBLER ASSEMBLIES

- A. Flood bubbler assemblies shall be pressure compensating, have a non-adjustable flow rate, 1/2-inch female threads and a 1/2-inch filter screen. Bubblers shall have a flow of 0.5 gallons per minute.
- B. Assemblies shall include 4-inch basket weave canister, check valve, 4-inch plastic grate with steel clasp and 1/2-inch sch-80 PVC riser.
- C. Flood bubbler assemblies shall be manufactured by Rain Bird model RWS-BCG02, Hunter Industries model RZWS-36-50-CV or approved equal.

2.11 SMALL/MEDIUM ROTARY SPRINKLERS

- A. Small/medium rotary sprinklers shall be gear-driven, rotary type sprinklers, designed for in-ground installation with integral check valves and in-riser flow shut-off capability. Sprinkler shall be capable of covering an 18-45 foot radius and flow range of 0.5-8.5 gpm at 40 pounds per square inch of pressure. Sprinklers shall have a one hundred percent warranty for two years minimum against defects in workmanship.
- B. The nozzle assembly shall elevate minimum four inches when in operation and retraction shall be achieved by a stainless steel spring. Riser assembly shall be plastic. A nozzle wiper seal shall be included in the sprinkler for continuous operation under the presence of sand and other foreign material.
- C. Sprinkler parts shall be removable through the top of the unit through the removal of a heavy-duty threaded cap. The sprinkler shall have a three quarter-inch (3/4") IPS water connection on the bottom of the sprinkler.
- D. Sprinklers shall be manufactured by, Hunter Industries model I20-04 or approved equal.
- E. Approved Performance Chart (18' Spacing):

Model	Pressure	Arc	Nozzle	Flow	Radius
Hunter I20-04	40psi	90 Deg.	.50SR	0.50	18'

Hunter I20-04	40psi	180 Deg.	1.0SR	1.0	18'
Hunter I20-04	40psi	360 Deg.	2.0SR	2.0	18'

F. Approved Performance Chart (25' Spacing):

Model	Pressure	Arc	Nozzle	Flow	Radius
Toro T5P-COM	40psi	90 Deg.	1.5LA	0.94	28'
Toro T5P-COM	40psi	180 Deg.	2.0LA	1.72	31'
Toro T5P-COM	40psi	360 Deg.	3.0LA	2.60	33'
Rain Bird 5004-PL-SAM	40psi	90 Deg.	MPR 25Q	0.88	24'
Rain Bird 5004-PL-SAM	40psi	180 Deg.	MPR 25H	1.73	24'
Rain Bird 5004-PL-SAM	40psi	360 Deg.	MPR 25F	3.34	24'
Hunter I20-04	40psi	90 Deg.	.75SR	0.68	24'
Hunter I20-04	40psi	180 Deg.	1.5SR	1.3	24'
Hunter I20-04	40psi	360 Deg.	3.0SR	2.70	24'

G. Approved Performance Chart (35' Spacing):

Model	Pressure	Arc	Nozzle	Flow	Radius
Toro T5P-COM	40psi	90 Deg.	2.0	1.8	36'
Toro T5P-COM	40psi	180 Deg.	4.0	3.55	40'
Toro T5P-COM	40psi	360 Deg.	8.0	7.10	43'
Rain Bird 5004-PL-SAM	40psi	90 Deg.	1.5	1.40	30'

Rain Bird 5004-PL-SAM	40psi	180 Deg.	3.0	2.69	30'
Rain Bird 5004-PL-SAM	40psi	360 Deg.	6.0	5.08	35'
Hunter I20-ADV	40psi	90 Deg.	2.0	2.0	34'
Hunter I20-ADV	40psi	180 Deg.	4.0	4.0	40'
Hunter I20-36V	40psi	360 Deg.	8.0	8.5	44'

2.12 LARGE ROTARY SPRINKLERS

- A. Large rotary sprinklers shall be gear-driven, rotary type with drain check valve and stainless steel riser designed for in-ground installation. The nozzle assembly shall elevate three inches when in operation and retraction shall be achieved by a stainless steel spring. Check valve shall be capable of holding up to 10 feet of elevation. Sprinkler shall be capable of covering a 49-61 foot radius and flow range of 7.5 to 15.7 gpm at 40 pounds per square inch of pressure.
- B. Sprinkler parts shall be removable through the top of the unit by removing a heavy-duty threaded cap. The sprinkler shall have a one-inch (1") IPS water connection on the bottom of the sprinkler.
- C. Sprinklers shall be manufactured by Toro model TR70XT, Hunter Industries model I25-04-SS, Rain Bird model 8005-SS or approved equal.
- D. Approved Performance Chart (45' Spacing):

Model	Pressure	Arc	Nozzle	Flow	Radius
Toro TR70XT	40psi	90 Deg.	7	6.8	46'
Toro TR70XT	40psi	180/360 Deg.	12	9.95	50'
Rain Bird 8005-SS	40psi	90 Deg.	6	3.8	39'
Rain Bird 8005-SS	40psi	180/360 Deg.	8	6.6	49'
Hunter I25-04-SS	40psi	90 Deg.	4	3.8	40'
Hunter I25-04-SS	40psi	180/360 Deg.	8	7.7	47'

2.13 ELECTRIC CONTROL VALVES

- A. Electric control valves shall be one, one and one half and two-inch remote control, diaphragm type, fiberglass or reinforced nylon body plastic valves with manual flow control, manual bleed screw and 200 psi pressure rating.
- B. Valves shall be manufactured by Toro model P220, Rain Bird model PEB, Hunter Industries model ICV or approved equal.

2.14 VALVE BOXES

- A. All valve boxes shall be manufactured from unformed resin with a tensile strength of 3,100-5,500 psi conforming to ASTM D638. All boxes shall be green in color.
- B. Valve boxes for air/vacuum relief valves shall be 18-inch jumbo valve boxes with metal detection, bolt down cover and 6-inch extensions. Use extensions to bring box to grade.
- C. Valve boxes for single 1 inch and 1-1/2 inch electric valves, isolation valve, decoder cable fuse devices, lightning surge arrestors, and quick coupling valves shall be 10-inch round valve boxes with metal detection, t-tops, and bolt down covers
- D. Valve boxes for single 2 inch and multiple electric valves shall be 12-inch standard valve boxes with metal detection, t-tops, and bolt down covers. When multiple electric valves are installed in the same area, they are to be installed two (2) 1-1/2 inch valves or up to two (2) 1 inch valves in a 12-inch standard box
- E. Valve boxes for three 1 inch, three 1-1/2 inch and dual 2 inch electric valves with isolation shall be 18-inch jumbo valve boxes with metal detection, bolt down covers and t-top lids.
- F. Valve boxes for wire splices shall be 10 inch round valve boxes with metal detection, bolt down covers and t-top lids. All splices shall be in separate valve boxes and not included with isolation valves. 24 volt splices shall have gray lids.
- G. Valve box extensions shall be provided and installed as required for proper box depth. Valve box extensions shall be made by the same manufacturer.
- H. Valve boxes shall be manufactured by Highline Products, Olde Castle Specifications Grade, NDS Pro Series or approved equal.

2.15 AUTOMATIC CONTROLLER

- A. All controllers shall be manufactured by Baseline Inc, in Meridian, Idaho model BL3200XS and installed per Manufacturer's Specifications, and as specified herein.
- B. Each controller shall be able to operate:
 - 1. Up to 200 zones along a two-wire path and/or a conventional wire path
 - 2. Up to 25 moisture sensors

3. Up to 6 pause device inputs (3 normally closed along the two-wire path and 3 hard-wired normally closed pause interrupts)
 4. Up to 4 normally open or normally closed master valves
 5. Up to 4 flow meters
 6. Up to 110 devices on a two-wire path
- C. Each controller shall be capable of fully automatic, semi-automatic, and manual operation using a 6-button keypad and 16 position rotary dial that is an integrated part of the controller. Each controller shall be capable of storing irrigation schedules, monitoring and managing flow without the Central Computer (i.e. if the Central Computer is turned off, removed, or if communication from/to the Central Computer fails, the field controllers will continue to perform moisture and flow management functions). The controller shall display on-screen instructions making it easier for a user to operate the controller.
- D. The controller shall be able to send alerts to central software at an offsite location utilizing supported devices. Alerts shall be processed at both the field controller location and/or the Central Computer location. Communication options shall be as follows:
1. Cellular modem
 2. Wireless internet modem
 3. Phone modem
 4. Ethernet modem
 5. Direct connection serial interface
- E. The controller's main screen shall be able to display water usage, soil moisture graph, next program run time, temperature of the controller, design flow or actual flow, two-wire current, program reports, pause reports, and a color zone status (watering, soaking, waiting, paused, disabled, and error) without affecting active programs. The controller shall provide an on-screen color code legend that describe each zones state. The controller shall be able to log data collected from each flow meter and zone (run time, soak time).
- F. The controller shall have the ability to report:
1. The last date a program ran
 2. A progress bar for all currently running programs describing how much run time is remaining
 3. The next run date of a program
 4. Water consumption used by program per run estimation
 5. 14 days of moisture readings displayed graphically
 6. Water flow estimation in gallons per minute
 7. Total daily, current month, and previous month's water consumption estimation in gallons
 8. Actual water used and flow rate for each flow meter
 9. A report for every pause condition event
 10. Monthly water budget.
- G. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor

variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.

2.16 DECODERS

- A. Decoders shall be installed between the central controller and the electric control valves to provide the 24-volt power supply for individual valves. Each decoder shall be available in 1, 2 or 4-station devices. Decoder shall have a unique serial number and controller-assigned address to identify it in the network.
- B. Decoder shall be manufactured by Baseline, model biLine or approved equal.
- C. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.

2.17 SOIL MOISTURE SENSORS

- A. Soil moisture sensors shall provide the following:
 - 1. Measures soil moisture using patented modified TDT technology.
 - 2. Sensor is self-calibrating for all soil types and conditions.
 - 3. Moisture range measurement from 5% moisture to fully saturated soil (45%).
 - 4. Measures soil temperature.
 - 5. Moisture readings are consistent in salty conditions.
- B. Sensor shall be completely sealed and shall be resistant to power surges, shock, freezing, heat, salts and fertilizers.
- C. Sensor shall have the following accuracy and repeatability:
 - 1. Range: 5% to 45% volumetric (fully saturated)
 - 2. Raw Sensor Resolution: 0.01% volumetric
 - 3. Volumetric Moisture Accuracy: +/- 0.1%
 - 4. Volumetric Calibration: +/- 2% of calibrated sample
 - 5. Soil Temperature: +/- 2C/3.6F
- D. Sensor shall be 24 to 28 VAC.
- E. Sensor shall be manufactured by Baseline, Model biosensor, 18-inch length or approve equal.

- F. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.

2.18 SURGE ARRESTOR (TWO WIRE PATH)

- A. It shall directly connect to the two wire path and requires no power from the two wire path.
- B. The surge arrestor shall be fully sealed and capable of direct burial. It shall have three wires. The red and black wire 12-inches in length connect to the two wire path, and the green ground wire connects to the grounding system.
- C. Sensor shall be manufactured by Baseline, Model BL-LA01, or approved equal.
- D. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.

2.19 SURGE ARRESTOR (CONTROLLER)

- A. The modular surge arrester shall be a single phase, two pole arrester designed to protect single or split phase 120 volt or 120/240 volt electrical systems. Electrical connections shall be embedded in a UL recognized epoxy to seal and protect them from moisture and corrosion.
- B. The surge arrestor shall be molded from weather and UV resistant polycarbonate, complying with the UL Standard for flame and strength resistance.
- C. Surge Arrester shall be manufactured by Paige Electric, model 250090LED with mounting bracket.
- D. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.

2.20 WIRE

- A. All valve control wire from the decoder to the valve shall be minimum #14-awg, common #14-awg, single strand, solid copper; UL- approved direct burial AWG-U.F. 600V and shall meet all state and local codes for this service. Individual wires must be used for each zone valve. Common wire shall be white in color, and control wire shall be red in color. White color shall be used for common wire only.
- B. In ground wire connections shall be UL listed, manufactured by 3M, model DBR/Y-6 splice kits or equal. All wire splices shall be made in valve boxes, electrical junction boxes, at the controller or at valves. See Mechanical/Electrical/Plumbing Drawings.
- C. All valve control wire from the controller to the decoder shall be through two-wire. Wiring shall be polyethylene double-jacketed or UF-B UL PVC double-jacketed two-conductor solid copper designed for direct burial systems. Wire connections shall be DBR/Y-6 or equivalent on the wire side of the decoder and shall utilize DBR/Y-6 or equivalent on the valve side. All connections shall be installed as per their manufacturers' instructions. Wire shall be manufactured by Paige Electric (maxi wire) or approved equal. Wire gauge shall be AWG #14.
- D. Wire type and method of installation shall be in accordance with local codes for NEC Class II circuits of 30-volt A.C. or less.
- E. All wiring shall be in strict accordance with all national, state and local electrical codes.
- F. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.

2.21 FLOW SENSOR

- A. An irrigation mainline flow sensor shall be provided and installed in accordance with drawings. Refer to drawings for locations. Be responsible for installation, hook-ups, materials, components, and connection of flow sensors. Install decoders as required for flow sensors.
- B. The flow sensors shall be as manufactured by Creative Sensor Technology. Install as recommended by manufacturer, and as indicated on drawings, and specified.**
 - 1. Use CST-FSI-T20-001 for site and ballfield system**
 - 2. Use CST-FSI-T10-001 for court yard system.**

- C. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.

2.22 QUICK COUPLING VALVES

- A. The valve body shall be of cast brass construction with a working pressure of 125 psi. The valve seat disc plunger body shall be spring loaded so that the valve is normally closed under all conditions when the key is not inserted.
- B. The top of the valve body receiving the key shall be equipped with ACME threads and smooth face to allow the key to open and close the valve slowly. The quick coupling valve shall be equipped with a vinyl cover.
- C. The valve body construction shall be such that the coupler seal washer may be removed from the top for cleaning or replacement without disassembling other parts of the valve.
- D. Keys shall be ACME with 1-inch male thread and 3/4-inch female thread at the top.
- E. Quick coupling valves, keys and swivels shall be manufactured by Toro models 100-ATLVC, 100-AK and 075-MHS, Hunter Industries, model HQ-44RC-AW, HK-44A and HS-1 or approved equal.

2.23 ISOLATION VALVES

- A. Isolation valves 2 inches and smaller in size shall be gate type, of bronze construction, US Manufacture, 200 WOG with steel cross handle and 200 psi rating. Gate valves to be as manufactured by Nibco, model T-113-K, or approved equal.
- B. Isolation valves 2-1/2-nches and larger in size shall be cast iron epoxy coated inside and outside, long bell length ring-tite valves, 200 psi rated, US manufacturer, stainless steel stem, 2 inch operating nut and replaceable disc as manufactured by Waterous 500 Series, Clow 2630 Series, Kennedy Ken-Seal Series, or approved equal.
- C. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.

2.24 SWING JOINTS

- A. Spray sprinklers and small and medium rotary sprinklers shall be installed on swing pipe assemblies, minimum length 12 inches and maximum length of 18 inches.
- B. Swing pipe operating pressure shall be up to 80 psi with an inside diameter of 0.49 inches, manufactured of low-density polyethylene material meeting ASTM D2104, D2239 and D2737. Swing joint swing pipe and fittings shall be manufactured by Hunter Industries, model FLEXsg, with HSBE-050 and HSBE-075 fittings or approved equal
- C. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.
- D. Large rotary sprinklers shall be installed on 1-inch prefabricated PVC unitized swing joint assemblies with double O-ring seals, minimum 315 psi rating and minimum length of 12 inches. Prefabricated PVC swing joints shall be as manufactured by Lasco, model G132-212 or G132-218.
- E. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.
- F. Quick coupling valves to be installed on 1-inch prefabricated PVC unitized swing joint assemblies with double O-ring seals, minimum 315 psi rating and minimum length of 12 inches with brass insert and stabilizer (unless stabilizer is an integral part of the quick coupling valve). Prefabricated PVC swing joints shall be as manufactured by Dura, Lasco, or Spears.
- G. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.

2.25 AUTOMATIC RAIN SENSOR

- A. Rain sensor shall be plastic in construction with adjustable interruption point, 1/2-inch IPS threads and stainless steel vandal resistant guard. Rain sensor shall be manufactured by Hunter Industries and be provided with a sensor guard and conduit mount, model MINI-CLIK-C with SG-MC stainless steel sensor guard.
- B. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.

2.26 CABLE FUSE SWITCH DEVICES

- A. Cable fuse switch device (DCFD) to isolate cable paths shall be installed where shown on the drawings. Cable fuse switch device shall be capable of connecting and disconnecting cable paths with the removal of a 20-amp mini automotive fuse. Voltage can be measured by connecting the probes of a meter to red/black posts. Current flow shall be measurable when a fuse is removed and the probes of an in line amp meter are connected to the posts on each side of the empty fuse holder. Device shall be in a waterproof capsule. Access to fuses shall be by unscrewing the cap. Wire leads shall be #14 AWG, type UF/TWU direct burial, 36 inches long.
- B. Cable fuse switch device shall be as manufactured by Paige Electric, model 270DCFD/270DCFD3 or approved equal. Model shall be as indicated on the drawings.

2.27 GROUNDING EQUIPMENT

- A. Controller installed inside building water mechanical room shall be installed with a grounding strap connected to the metal water pipe.
- B. Ground strap shall be 1-inch wide by 0.015 inch thick with punched holes. Length and hole sizes shall be to NEC requirements.
- C. Ground strap shall be as manufactured by ABL Electronic Supplies Inc., model GS-8 or approved equal.
- D. Manufacturer's names and/or model numbers identified herein are intended to assist in establishing a general level of quality, configuration, functionality, and appearance required. This is NOT a proprietary specification and it should be noted that "Or equal" applies to all products denoted herein. It is understood that all manufactures will have minor variations in configuration, appearance, and product specifications and such minor variations shall not eliminate such manufacturers as an equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.

2.28 GROUNDING EQUIPMENT (TWO WIRE PATH)

- A. Two-wire communication path shall be grounded at 600 foot maximum intervals and at every termination of a part of the wire path to a surge arrestor decoder. Any branch exceeding 50 feet requires a lightning surge arrestor and grounding. Each surge decoder shall be connected to a grounding plate. Minimum 10-foot separation between plate and other equipment.
- B. Grounding plate, 4-inch x 96-inch x 0.0625-inch copper grounding plate, shall be installed at a 36-inch depth with 50 lbs. of ground enhancement material, non-migrating material, or approved equal ground enhancement material spread evenly below the plate and evenly above the plate, two (2) 50 pound bags. Each grounding plate is to be covered with same cover as used for the vents, thirty-six inches of 4-inch corrugated HDPE shall extend from the surface to the ground enhancement material.
- C. Ground plates shall be UL listed.

2.29 COMBINATION AIR/VACUUM RELIEF VALVE

- A. Combination air vacuum/relief valves to be 1 inch NPT inlet and a 1 inch air and vacuum outlet with a 3/32 inch pressure air release orifice. The valve body shall be cast iron body with stainless steel internals and float and Buna-N seating material. The valves shall exhaust large quantities of air on system start-up and allow air to re-enter the pipeline when the line is being emptied or drained. The valves shall also automatically vent air that accumulates while the system is under pressure.
- B. A 1 inch ball valve and bronze wye strainer shall be installed below the air/vacuum relief valve. Wye strainer shall utilize a 3/4 inch boiler drain for cleaning. See detail.
- C. Relief valve outlet shall be piped with brass elbows and nipples to direct the air out of the valve as shown in the detail.

2.30 CRUSHED STONE

- A. Crushed stone shall be as specified in SECTION: EARTHWORK. Crushed stone shall be used under valve boxes.

2.31 SAND

- A. Sand used for backfilling of trenches; under, around and over PVC lines shall be as specified in SECTION: EARTHWORK.

2.32 THRUST BLOCKS

- A. Standard concrete mix shall be in accordance with ASTM C150, ASTM C-33, and ASTM C-94 with a compressive strength (28 days) of 3,000 psi.
- B. All bell and gasket mainline pipe and fittings shall have thrust blocks sized and placed in accordance with pipe manufacturer's recommendations for standard concrete mix. Thrust

blocks shall be installed at all tees, elbows, crosses, reducers, plugs, caps and valves. Company performing the work shall be responsible to insure the stability of all thrust blocks.

2.33 SPARE PARTS

- A. Supply the following tools and equipment to the Owner's Representative before final observation:
 - 1. Two (2) wrenches or keys for disassembling and adjusting each type of sprinkler provided.
 - 2. Two (2) quick coupler key assemblies.
 - 3. Five (5) of each type sprinkler and pattern (PC & FC) used in the project.
 - 4. Five (5) of each type nozzle used in the project.
 - 5. One (1) of each type decoder.
- B. Before final observation can occur, written evidence that the Owner's Representative has received the tools and equipment must be shown.

PART 3 - EXECUTION

3.1 GENERAL

- A. Before work is commenced, hold a conference with the Owner's Representative to discuss general details of the work.
- B. Examine all contract documents applying to this Section noting discrepancies and bringing the same to the attention of the Owner's Representative for timely resolution.
- C. All works indicated on drawings shall be provided whether or not specifically mentioned in the specifications.
- D. If there are ambiguities between drawings and specifications, and specific interpretation or clarification is not issued prior to bidding, the interpretation or clarification will be made only by Owner's Representative, and compliance with the decisions shall be required. In the event the installation contradicts the directions given, the installation shall be corrected at no additional cost to Owner.
- E. Verify dimensions and grades at job site before work is commenced. Do not proceed with installation of the irrigation system when it is apparent that obstructions or grade differences exist or if conflicts in construction details, legend or specific notes are discovered. All such obstructions, conflicts, or discrepancies shall be brought to the attention of the Owner's Representative.
- F. Make all field measurements necessary for the work noting the relationship of the irrigation work to the other trades. Coordinate with other trades (landscaping and other site work

trades). Project shall be laid out essentially as indicated on the Irrigation Plans, making minor adjustments for variations in the planting arrangement. Major changes shall be reviewed with the Owner's Representative prior to proceeding.

- G. Layout of sprinkler lines indicated on drawings is diagrammatic. Location of sprinkler equipment is contingent upon and subject to integration with all other underground utilities. Employ all data contained in the Contract Documents and verify this information at the construction site to confirm the manner by which it relates to the installation.
- H. Coordinate installation of all sprinkler materials, including pipe, to avoid conflict with the trees, shrubs, or other plantings.
- I. During progress of work, a competent superintendent and all assistants necessary shall be on site. All shall be satisfactory to the Owner's Representative. The superintendent shall not be changed, except with the consent of the Owner's Representative, unless that person proves unsatisfactory and ceases to be employed. Directions given to the superintendent shall be binding.
- J. At all times, protect existing irrigation, landscaping, paving, structures, walls, footings, etc. from damage. Inadvertent damage to the work of another trade shall be reported at once.
- K. Replace, or repair to the satisfaction of the Owner, all existing paving disturbed during course of work. New paving shall be the same type, strength, texture, finish, and be equal in every way to removed paving.

3.2 PIPE AND FITTINGS INSTALLATION

- A. Using proper width trencher chain, excavate a straight (vertical) and true trench to a depth of 2-inch of pipe invert elevation.
- B. Loam or topsoil encountered within the limits of trench excavation for irrigation mains and branch lines shall be carefully removed to the lines and depths as shown on the drawings and stockpiled for subsequent replacement in the upper 6 inches of the trench from which it is excavated. Such removal and replacement of the quantities of loam shall be considered incidental to the irrigation system and no additional compensation will be allowed therefore.
- C. Pipe shall be laid on undisturbed trench bottom provided suitable base is available - no rock; if not, excavate to 2-inch below pipe invert and provide and install sand base or crushed stone upon which to lay pipe.
- D. Backfilling shall be accomplished as follows: backfill material shall contain no foreign matter and no rock. Carefully place material around pipe and wire and tamp in place. Remainder of backfill shall be laid-up in 6-inch (maximum) lifts and tamped to compaction with mechanical equipment. Compact backfill in trenches to dry density equal to the adjacent undisturbed soil, and conform to adjacent grades without dips, sunken area, humps, or other irregularities. Frozen material shall not be used for backfill.
- E. Clean bell and spigot ends and make all gasketed joints in strict accordance with manufacturer's recommendations, making certain not to apply an excess of lubricant, and

wiping off excess lubricant from each connection. Maximum deflection per joint shall not exceed manufacturer's recommendations.

- F. Make all solvent-weld joints in strict accordance with manufacturer's recommendations, making certain not to apply an excess of primer or solvent, and wiping off excess solvent from each connection. Allow welded joints at least 15 minutes set-up/curing time before moving or handling. When the temperature is above 80° F, allow connections to set minimum 24 hours before pulling or pressure is applied to the system. When temperature is below 80° F, follow manufacturer's recommendations. Provide and install for expansion and contraction as recommended. Wire shall be laid in same trench as mainline and at pipe invert (see Wire Installation).
- G. Mainline pipe shall have minimum 22 inches of COVER (excavate to invert as required by pipe size). Lateral pipe shall have minimum 16 inches of COVER for PVC and 12 inches of cover for Polyethylene (excavate to invert as required by pipe size).
- H. Cut plastic pipe with handsaw or pipe-cutting tool, removing all burrs at cut ends. All pipe cuts are to be square and true. Bevel cut end as required to conform to Manufacturer's Specifications.
- I. Every precaution shall be taken to prevent foreign material from entering the pipe while it is being placed in the trench. At times, when installation of the piping is not in progress, the open end(s) of the pipe shall be closed by a watertight plug or other means. All piping, which cannot temporarily be joined, shall be sealed to make as watertight as possible. This provision shall apply during the lunch hour as well as overnight. Pipe not to be installed that day shall not be laid out. Should water enter the trench during or after installation of the piping, no additional piping may be installed or backfilled until all water is removed from the trench. Pipe shall not be installed when water is in the trench, when precipitation is occurring, or when the ambient temperature is at 40° F or below. Pipe installed at temperatures below 40° F shall be removed and replaced at no cost to the Owner. PVC pipe shall be snaked in the trench to accommodate for expansion and contraction due to changes in temperature.
- J. In installing irrigation pipe route the pipe as necessary to prevent damage to tree roots. Where trenching must occur near trees provide proper root pruning and sealing methods to all roots 1-inch and larger.
- K. Maintain 6-inch minimum clearance between sprinkler lines and lines of other trades. Do not install sprinkler lines directly above another line of any kind.
- L. Maintain 1-inch minimum between lines which cross at angles of 45 to 90 degrees.
- M. Throughout the guarantee period refill trenches that have settled due to incomplete compaction.
- N. Pulling of pipe will be allowed provided soil is suitable and specified depth of bury can be maintained.

3.3 THRUST BLOCKING

- A. All ringtite bell-end fittings shall be blocked with an adequately sized thrust block as per ASABE Standard S376.2 and as depicted in the details. Blocking shall be in accordance with pipe and fitting manufacturer's recommendations. Thrust blocks shall be required at all changes in size and direction of bends, reducers, plugs and tees. Thrust blocks shall be installed against undisturbed soil in all cases. Concrete thrust blocks shall utilize 3,000-psi standard concrete mixture. Bricks, stones, boulders, etc. will not be accepted as thrust blocks or thrust block material. Sackcrete will not be permitted as a thrust blocking material. Supply all material needed for thrust blocking.
- B. Size of thrust block shall be determined by working pressure, size and type of fitting, and soil conditions. Calculate area required for concrete thrust block in contact with soil. Refer to fittings manufacturer's thrust block sizing table and ASABE S376.2 to determine size of thrust block for each condition.
- C. Ensure stability of thrust blocks.
- D. Under no circumstances will concrete block be approved for thrust blocks.

3.4 ELECTRICAL WIRE CONDUIT INSTALLATION

- A. Electrical conduit shall be installed in all non-soil areas, as well as for all above ground wiring where wire passes under or through walls, walks and paving to controller and rain sensor.
- B. Conduit shall extend 18 inches beyond edges of walls and pavement.

3.5 PIPE SLEEVING INSTALLATION

- A. Sleeving shall be installed wherever piping is going under hardscape areas where indicated on the drawings. Minimum cover over all sleeving pipe shall be 24 inches as shown on the detail.
- B. Sleeving shall extend 18 inches beyond edges of walls and pavement. Prior to the installation of irrigation piping and wiring, the ends of all sleeving shall be field marked with a vertical wood stake extending above grade to allow field location at the time of irrigation installation.
- C. Ensure all required sleeving is installed prior to starting pavement operations. Review all sleeve locations in the field to confirm that sleeves are properly located for the required irrigation pipe runs. In no case will saw cutting into newly installed pavements or jacking under new pavements be permitted to install sleeving which was not installed in proper sequence or in the required orientations or locations.

3.6 ISOLATION VALVE INSTALLATION

- A. Install isolation valves per detail where indicated on the drawings. Install all isolation valves on a level crushed stone base so that they can be easily opened or closed with the appropriate valve wrench. Install specified valve box over each isolation valve.
- B. Check and tighten valve bonnet packing before valve box and backfill installation.
- C. Provide and install thrust blocks for ring-tite valves as per detail.

3.7 VALVE BOX INSTALLATION

- A. Furnish and install a valve access box for each electric valve, decoder, surge arrestor, quick coupling valve, isolation valve, and wire splice.
- B. All valve access boxes shall be installed on a minimum 4-inch crushed stone base. Finish elevation of all boxes shall be at grade. Supply all crushed stone and install before valve box. Crushed stone shall not be poured into previously installed valve boxes.
- C. Valve boxes shall be installed neatly at all times. Boxes shall be parallel or perpendicular to hardscape edges and to other valve boxes installed in the same location. A sufficient amount of turf shall remain in place between each valve box and between valve boxes and hardscapes.
- D. Valve box extensions shall be provided as required on valve boxes in order to install valve box covers at grade.
- E. Bricks, stones, etc. shall not be used to support valve boxes.

3.8 24 VOLT CONTROL VALVE INSTALLATION

- A. Control valves shall be installed on a level crushed stone base. Grade of bases shall be consistent throughout the project so that finish grades fall within the limits of work. Valves shall be set plumb with adjusting handle and all bolts, screws and wiring accessible through the valve box opening. Valves shall be set in a plumb position with 24-inch minimum maintenance clearance from other equipment.
- B. Install at sufficient depth to provide more than 6-inch, nor less than 4-inch cover from top of valve to finish grade.
- C. Adjust zone valve operation after installation using flow control device on valve.

3.9 WIRING INSTALLATION

- A. Wiring shall be installed along with the mainline. Wire shall be laid beside, and at the same invert as, the irrigation lines. Sufficient slack for expansion and contraction shall be maintained and wiring shall at no point be installed tightly. Provide and install an additional 8 inches to 12 inches slack at all changes of direction. Wiring in valve boxes shall be a sufficient length to allow the valve solenoid, decoder, splice, and all connections to be

brought above grade for servicing. This additional slack shall be coiled for neatness in the valve box. Each valve shall have a separate wire back to the controller.

- B. All wire shall be laid in trenches and shall be carefully back-filled to avoid \ damage to the wire insulation or wire conductors themselves. In areas of unsuitable material, the trench shall have a 2 inches layer of sand or stone dust on the bottom before the wires are laid into the trench and back-filled. The wires shall have a minimum of 22 inches of cover (See Detail). Wire not to be installed that day shall not be laid out.
- C. An expansion curl shall be provided and installed within 6 inches of each wire connection to a solenoid. Expansion curls can be formed by wrapping five (5) turns of wire around a 1-inch diameter or larger pipe and then withdrawing the pipe.
- D. Service wiring in connection with drawings and local codes for low voltage service. All in-ground wire connections shall be waterproofed with 3M DBR/Y-6 splice kits. All splices shall be made in valve boxes (wire runs requiring splices between valve locations shall be provided and installed in splice box-valve box shall be used). Splice locations shall be shown on the record drawings.
- E. Provide a complete wiring diagram showing wire routing for the connections between the controller, decoder, and valves. See section one for the inclusion of wiring diagram in operation and maintenance manuals.

3.10 CONTROLLER INSTALLATION

- A. Install controller on wall in mechanical room, per detail. Wire communication cable valves and rain sensor into controller and set proper program. Wire flow sensors into irrigation controller. Isolate flow sensor for both control panels.
- B. Wire controller to electrical supply furnished and installed to the controller location.
- C. Keys shall be turned over to Owner's Representative.

3.11 FLOW SENSOR INSTALLATION

- A. Flow sensor shall be installed where indicated on the drawings in a 10-inch round valve box on a 4-inch crushed stone base. Flow sensors shall have sections of straight, uninterrupted pipe equal to ten times the pipe diameter upstream and five times the pipe diameter downstream of the sensor. Wire sensor to controller using minimum 18AWG wire. All wire connections shall be made using UL 98U1 Listed waterproof connectors with separate wire nut and sealant filled tube that includes a locking, wire strain relief cap. Splice shall only be made at the sensor and controller.

3.12 CONTROLLER GROUNDING INSTALLATION

- A. Attach #6 solid, insulated copper wire to controller using 1-1/2-inch conduit. Route wire to domestic ductile iron water pipe in 1-1/2-inch conduit and attach wire to copper grounding strap using a copper grounding split nut and bolt through ground strap holes. Water pipe should be exiting building into soil.

- B. Attach controller surge arrestor to ground strap.
- C. When tested, grounding grid shall meet the minimum requirements of the NEC.

3.13 DECODER GROUNDING INSTALLATION

- A. Lightning arrestor shall be installed per manufacture's recommendations and instructions.
- B. Each surge decoder shall be grounded to one rod and plate. Plate shall be installed at a 36-inch depth with 50 lbs of non-migrating ground enhancement material or approved equal spread evenly below the plate and evenly above the plate. The grounding electrode shall be installed at least 10 feet from wires connected to the surge arrestor.
- C. Each surge arrestor shall have a separate ground.
- D. The grounding rod shall be driven into the ground its full length minimum 10-feet from the surge arrestor and connected via a fusion type connector or approved equal connection to #10 solid, bare copper wire. The copper wire is to be installed in as straight a line as possible, and if it is necessary to make a turn or bend, it shall be done in a sweeping curve with a minimum radius of 8 inches and a minimum included angle of 90 degrees. There shall be no splices in the bare copper wire. The top of the ground rod shall be driven below the ground surface. A 4-inch grated cover as specified, set a minimum of 1-inch below grade, shall be placed over the ground rod and fusion type connector or approved equal connection for periodic maintenance. Cover shall be installed on a minimum of 6 inches of 4-inch corrugated polyethylene, perforated drainage pipe.
- E. Grounding plate shall be installed 36 inches below grade with 50 lbs of ground enhancement, non-migrating, or approved equal ground enhancement material spread evenly below the plate and evenly above the plate in accordance with the manufacturer's requirements. Plate shall also be covered with a 4 inch grated cover as specified, set a minimum of 1-inch below grade, to facilitate drainage onto the plate. Cover shall be installed on a minimum of 36 inches of 4-inch or approved equal corrugated polyethylene, perforated drainage pipe.
- F. When tested, grounding grid shall have an earth resistance no greater than 10 ohms from any electrical device or wire to earth ground. If earth resistance is greater than 10 ohms, additional grounding rods and/or plates and enhancement material shall be added to system until desired test results have been meet.
- G. Grates shall be set a minimum of 1-inch below grade.

3.14 RAIN SENSOR INSTALLATION

- A. Install rain sensor on exterior building roof line, generally where indicated on the drawings. Coordinate final location of rain sensor with Owner's Representative. Rain sensor shall be in direct contact with the weather and not in contact with the irrigation spray.
- B. Install rain sensor wiring within 1/2-inch conduit where exposed. All above ground wires shall be installed in conduits.

3.15 MOISTURE SENSOR INSTALLATION

- A. Moisture sensors shall be installed per manufacture's recommendations and instructions. The sensors shall be buried consistent with the root zone of the material being watered.
- B. Supply each moisture sensor with 50 feet of cable and splice sensors in electrical control valve boxes where possible.

3.16 FLOOD BUBBLER INSTALLATION

- A. Flood bubbler assemblies shall be installed two per tree, flush to grade. Bubblers shall be properly placed beside root balls to irrigate the trees.

3.17 SPRINKLER INSTALLATION

- A. Spray sprinklers, small and medium rotary sprinklers shall be installed flush (perpendicular) to grade on swing pipe assemblies, minimum length 6 inches, maximum 18 inches.
- B. Large rotary sprinklers shall be installed flush to grade on 1-inch prefabricated PVC unitized swing joint assemblies with integral O-rings, minimum length 12 inches.
- C. Sprinklers shall not exceed maximum spacing indicated
- D. Adjust sprinkler zone after installation using flow control device on valve.

3.18 QUICK COUPLING VALVE INSTALLATION

- A. Provide and install quick coupling valves where indicated on the drawings.
- B. Quick coupling valves to be mounted on 1-inch prefabricated PVC unitized swing joint assemblies with integral O-rings, minimum length 12 inches with brass insert and stabilizer as per details.

3.19 AIR/VACUUM RELIEF VALVE INSTALLATION

- A. Install air vacuum/relief valves as per detail at locations shown on the drawings.
- B. Provide ball valve shut-off, boiler drain and wye strainer under all air vacuum/relief valves as per detail. Ball valve shut-off shall be easily accessible through the valve box. Install boiler drains on discharge of wye strainers.
- C. Drill thirty two (32), 3/8 inch holes in air vacuum/relief valve box covers for air passage.
- D. Air vacuum/relief valve shall be installed straight up from mainline and not on the side. This may require additional mainline depth at air vacuum/relief valve locations.
- E. The air vacuum/relief valve shall be installed at the highest point of the mainline in the vicinity of where shown on the drawings.

3.20 DECODER CABLE FUSE DEVICES

- A. Install in 10-inch valve box with 4-inches of crushed gravel... Splice into communication cable using UL approved splice kits, 3MDBR/Y-6. Leave three feet of slack in each spliced cable to bring above grade during trouble shooting.

3.21 CHECK/TEST/START-UP/ADJUST

- A. Flushing:
 - 1. After all piping, valves, sprinkler bodies, pipelines and risers are in place and connected, but prior to installation of sprinkler internals and drip line open the control valves and flush out the system under a full head of water.
 - 2. Sprinkler internals and nozzles shall be installed only after flushing of the system has been accomplished to the full satisfaction of the Owner's Representative.
 - 3. Flush the entire system after installation is complete and service clogged nozzles for thirty (30) days after substantial completion of this portion of the landscape irrigation system.
- B. Testing:
 - 1. Leakage test: test all lines for leaks under operating pressure. Repair all leaks and re-test.
 - 2. Coverage test: perform a coverage test in the presence of the Owner's Representative (notify Owner's Representative at least seven (7) days in advance of scheduled coverage test). Representative will determine if the water coverage is complete and adequate. Readjust sprinklers and/or sprinkler locations as necessary or directed to achieve proper coverage.
 - 3. All testing shall be at no additional expense to the Owner.

3.22 CLEANING AND ADJUSTING

- A. At the completion of the work, all parts of the installation shall be thoroughly cleaned. All equipment, pipe, valves and fittings shall be cleaned of grease, metal cuttings and sludge which may have accumulated by the operation of the system for testing.
- B. Adjust sprinklers, valve boxes, and quick coupling valves to grade as required, so that they will not be damaged by mowing operations.
- C. Continue sprinkler coverage adjustment as required by settlement, etc., throughout the guarantee period.
- D. Each control zone shall be operated for a minimum of 5 minutes and all sprinkler zones checked for consistency of delivering water. Adjustments shall be made to sprinklers and bubblers that are not consistent to the point that they match the manufacturer's standards.

All sprinklers, valves, timing devices, or other mechanical or electrical components, which fail to meet these standards, shall be rejected, replaced and tested until they meet the manufacturer's standards.

3.23 ACCEPTANCE AND OPERATION BY OWNER

- A. Upon completion of the work and acceptance by the Owner, train the Owner's Personnel in the operation of the system (provide minimum 7 day written notice in advance of test). Furnish, in addition to the record drawings and operational manuals, copies of all available specification sheets and catalog sheets to the Owner's personnel responsible for the operation of the irrigation system. Guarantee all parts and labor for a minimum period of one (1) year from date of acceptance.

3.24 CLEAN UP

- A. Upon completion of all installation work remove all leftover materials and equipment from the site in a safe and legal manner.
- B. Remove all debris resulting from work of this section.
- C. Regrade, lightly compact, and replant around sprinklers where necessary to maintain proper vertical positioning in relation to established grade.
- D. Fill all depressions and eroded channels with sufficient soil mix to adjust grade to ensure proper drainage. Compact lightly, and replant filled areas in accord with drawings requirements.

END OF SECTION

SECTION 32 90 00

PLANTING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Coordinate with such trades to assure the steady progress of all work under the Contract.

1.2 SUMMARY

- A. The Work of this Section includes, but is not limited to, the following:
 - 1. Planting trees, shrubs, groundcovers, and other woody and herbaceous plant materials.
 - 2. Staking, guying and anchoring trees.
 - 3. Fertilizing, incorporating of planting additives, pruning, mulching, fertilizing and watering new plantings.

1.3 RELATED SECTIONS

- A. Related Sections include the following:
 - 1. SECTION 31 20 00 – EARTH MOVING
 - 2. SECTION 31 22 19 – FINE GRADING
 - 3. SECTION 32 19 14 – PLANTING SOILS
 - 4. SECTION 32 92 00 – LAWNS
 - 5. SECTION 32 93 53 – PLANTING MAINTENANCE

1.4 REFERENCES

- A. Comply with applicable requirements of:
 - 1. State of New Hampshire, Standard Specification for Roads and Bridge Construction, Department of Transportation, latest edition.
 - 2. City of Dover, of the State of New Hampshire, and of other authorities having jurisdiction. Provide labor, materials, equipment and services to comply with requirements.
 - 3. ASTM: American Society of Testing Materials:

- a. ASTM: American Society of Testing Materials.
- b. AAN: American Association of Nurserymen.
- c. ISA: International Society of Arboriculture.
- d. ANSI: American National Standards Institute.
- e. AOAC: Association of Official Agricultural Chemists.
- f. USDA: United States Department of Agriculture.

1.5 DEFINITIONS

- A. Finish Grade: Elevation of finished surface of planting soil..
- B. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.

1.6 SUBMITTALS

- A. Prepare and submit the following submittals in accordance with the requirements of SECTION 01 33 00 – SUBMITTAL PROCEDURES.
- B. Product Data: Submit most recent printed information from manufacturers for:
 - 1. Antidesiccant
 - 2. Root Barrier
 - 3. Liquid Seaweed Concentrate
 - 4. Plant Growth Biostimulant
 - 5. Mycorrhizae Granules
- C. Samples: Submit samples of:
 - 1. Organic Mulch: Submit one cubic foot sample and manufacturer/supplier's name.
 - 2. Tree Guying Accessories: One set.
 - 3. Tree Wrap (for protection during transport only)
- D. Certificates:
 - 1. Submit certification of New Hampshire state arborist.
- E. Plant List:
 - 1. Within 30 days of receipt of Contract, submit plant list for review by Owner's Representative which includes:
 - a. Plant materials proposed for project and corresponding nursery source where plants are to be selected.
 - b. Written documentation indicating nursery(s) have available the plants in the species, quantity and size(s) shown on Drawings.
 - 2. Schedule for review at nursery source by Owner's Representative with Contractor present.

3. Substitutions: plant list shall indicate unavailable materials and document a thorough search for materials. For unavailable materials list sources contacted with telephone number, date and person's name at source.

F. Schedules

1. Submit planting schedule for approval.

1.7 QUALITY ASSURANCE

- A. Planting shall be performed by a certified landscape contractor with a minimum of five years planting work experience and under full time supervision of a qualified supervisor.
- B. Conform to provisions of SECTION 01 40 00 QUALITY REQUIREMENTS.

1.8 SELECTION AND INSPECTION OF PLANTS

- A. Plants shall be selected by Owner's Representative at place of growth for conformity to specification requirements as to quality, size and variety. Such approval shall not impair right of inspection and rejection upon delivery at site or during progress of work. Cost of replacement shall be borne by Contractor.
- B. Notify Owner's Representative in writing upon selection of planting subcontractor. State name, address, telephone number and supervisor for planting subcontractor.
- C. Schedule selection and tagging of nursery stock so Owner's Representative can tag trees and representative shrubs for project at place of growth. Advise Owner's Representative of schedule a minimum of one month (30 day minimum) in advance of selection/tagging dates so Owner's Representative and Owner can make proper travel arrangements. If Contractor fails to provide one month (30 day minimum) notice, any additional travel expenses shall be backcharged to Contractor. If Owner's Representative has to make additional trips to select/tag plants in the event that inadequate, insufficient or unacceptable plant material was available at the inspection location, then additional travel expenses shall be backcharged to Contractor.
- D. Contractor to pay for Designer's travel expenses: air fare, car rental, automobile mileage and tolls; meals and overnight accommodations if necessary, for Designer's during time period required to select and tag plant material. Planting subcontractor shall provide representative to travel with Designer while tagging plant material.
- E. Notify Designer a minimum of five business days prior to each shipment of proposed arrival of plant material on site.
- F. Layout tree locations, bed outlines and individual planting on site for inspection by Designer prior to planting. Arrange for adequate manpower and equipment on site at time of plant material inspection and installation to provide complete staked layout and to unload, open and handle plant material during inspection.

1.9 DELIVERY, STORAGE AND HANDLING OF FERTILIZER AND MULCH

- A. Packing and Shipping: deliver materials in unopened containers bearing manufacturer's name and guaranteed statement of analysis. Transport materials without damage. Protect finishes from abrasion, dirt, oils, grease, and chemicals. Pack materials to protect from weather.
- B. Acceptance at Site: verify in writing that delivered materials conform to specifications and approved submittals.
- C. Storage and Protection:
 - 1. Materials shall be uniform in composition, dry and free flowing. Store materials in dry place, on pallets, off ground; protect from sun. Store materials in a manner which does not diminish their usability and effectiveness.
 - 2. Protect materials from theft, damage, weather, dirt, oils, grease, and construction.

1.10 DELIVERY, STORAGE AND HANDLING OF PLANTS

- A. Plants during shipping and delivery and plants requiring storage on site shall be properly wrapped and covered to prevent wind-drying and desiccation of branches, leaves, or buds. Plant balls shall be firmly bound, unbroken, reasonably moist to indicate watering prior to delivery and during storage. Trees shall be free from fresh scars and damage in handling. Root masses of container grown plants shall be kept moist and containers screened from direct sun.
- B. Wrap tree trunks at nursery prior to shipping, then unwrap for inspection by Owner's Representative prior to installation. Report damaged plants to Owner's Representative.
- C. Apply antidessicant to plants before digging at nursery and/or as directed by Owner's Representative once plants are delivered to site.

1.11 PROJECT/SITE CONDITIONS

- A. Environmental Requirements: do not deliver or handle soils when dry, wet, or frozen.
 - 1. Field Test
 - a. Form soil in palm of hand, if soil retains shape and crumbles upon touching, the soil may be worked.
 - b. If the soil will not retain shape it is too dry and should not be worked.
 - c. If the soil retains shape and will not crumble, it is too wet and should not be worked.
- B. Planting Season: planting seasons shall be those indicated below. Plants planted out-of-season shall receive special attention as directed. Out-of-season planting and or transplanting shall be at Contractor's risk and expense No planting shall be done in frozen or muddy ground or when snow covers the ground, or soil is otherwise in an unsatisfactory condition for planting.
 - 1. Seasons for Planting:

Spring: Deciduous materials - March 21 - May 1
Evergreen Materials - April 15 - June 1

Fall: Deciduous materials - October 1 - December 1
Evergreen Materials - August 15 - October 15

1.12 SEQUENCING AND SCHEDULING

- A. No plantings to be installed prior to acceptance of rough grading.

1.13 SUBSTANTIAL COMPLETION

- A. See SECTION 32 93 53 – PLANTING MAINTENANCE.

1.14 MAINTENANCE

- A. See SECTION 32 93 53 – PLANTING MAINTENANCE.

1.15 ACCEPTANCE

- A. See SECTION 32 93 53 – PLANTING MAINTENANCE.

1.16 GUARANTY

- A. Start of Guaranty Period: when Designer issues letter of acceptance.
- B. Term: one year for trees, shrubs, groundcovers, grasses, bamboo and vines.
- C. Requirements: plant material to be alive and in healthy, vigorous condition.
 - 1. Quarterly reviews will be made with Contractor and Designer during guaranty period. Reviews will assess condition of installed plant materials.
 - 2. Replace plants that are dead or, as determined by Designer, are in an unhealthy or unsightly condition, and have lost their natural shape due to dead branches, or other causes.
- D. End of Guaranty Period: when Designer issues letter of Final Acceptance, one year from date of substantial completion; two years from date of substantial completion for trees.

1.17 FINAL ACCEPTANCE

- A. Designer reviews work and finds it complete and in accordance with Drawings and Specifications.
- B. Designer will issue a letter of Final Acceptance, at which time project becomes responsibility of Owner.

PART 2 - PRODUCTS

2.1 PLANTS

- A. Plant Identification and Standards: Nomenclature conforms to current edition of Standardized Plant Names, published by American Joint Committee on Horticultural Nomenclature. Plants conform to varieties and sizes specified in plant list, and to code of standards set forth by American Association of Nurserymen, Inc. in American Standard for Nursery Stock, ANSI Z60.1 - latest edition. Substitutions shall not be permitted without consent of Owner's Representative. Plants shall be properly identified with plant labels securely attached to plants, in order to identify plants on site. Information regarding sources of plant material shall be furnished to Owner's Representative.
- B. Plant List: If there are discrepancies between the quantities shown on plant list and work shown on Drawings, Contractor shall supply plants necessary to complete work as intended on Drawings. Where size of plant on the plant list is a variation between a minimum and maximum dimension, the sizes of plants furnished shall be equal to average of two dimensions. Where a single dimension is given, dimension represents the minimum size of plants to be furnished.
- C. General Plants: Unless specified otherwise, plants shall be nursery grown under climatic conditions similar to those in locality of project and shall have been previously been transplanted or root pruned at least once in last three years. Plants shall possess a normal balance between height and spread. Plants shall be typical of their species and variety with a normal habit of growth, densely foliated when in leaf, and a well-developed branch structure with a fibrous, healthy root system with no girdling roots. Plants shall be sound and healthy, free from dead wood, defects, disfiguring knots, sun scald, injuries or abrasions of roots or bark. Plants shall be freshly dug. No heeled-in plants or plants from cold storage shall be used. Parts of plant shall be moist and show active green cambium when cut. Plants shall be free of plant diseases, insects, pests, eggs, larvae, and forms of infestations.
- D. Balled and Burlapped Plants: Plants designated on plant list as "B&B" shall be healthy, vigorous, well-rooted exterior plants dug with firm, natural balls of earth in which they are grown, with ball size not less than diameter and depth to encompass fibrous and feeding root system necessary for healthy development of plants recommended by ANSI Z60.1 For type and size of tree or shrub required; wrapped, tied, rigidly supported, and drum-laced as recommended by ANSI Z60.1. Balls shall be wrapped firmly with biodegradable material, and bound carefully with twine or cord. Tree balls may also be placed in a wire basket of diameter suitable for the size of the root ball. No plant shall be accepted when ball of earth surrounding roots has been badly cracked or broken, either before or during process of planting, or after burlap, ropes, etc., required for transplanting have been unfastened. Plants and root balls shall remain intact as a unit during operations. Plants that cannot be planted at once must be protected and watered.
- E. Bare Root Plants: Plants designated "BR" on the plant list shall be dug while dormant. Bare root plants shall be maintained in a healthy condition during storage, transportation, and operations.
- F. Container-Grown Stock: Healthy, vigorous, well-rooted exterior plants grown in a container with well-established root system reaching sides of container and maintaining a firm ball when removed from container without being in a rootbound condition. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1

for kind, type, and size of exterior plant required. Container plants shall have been acclimatized for one growing season in container. Plants shall remain in container until planted.

- G. Trees: Trees to be hand dug and balled and burlapped rootballs. Root balls shall be custom dug to special widths and depths to accommodate shallow soil conditions of this Project. Trees, except when a clump form is designated, shall be straight and symmetrical with a crown having a persistent single, main leader, and growing from a single, unmutilated crown of roots. No part of trunk shall be conspicuously crooked as compared with normal trees of same variety. Trunk shall be free from sunscald, frost cracks, or wounds resulting from abrasions, fire, or other causes. No pruning wounds shall be present having diameter of more than two inches (2") and wounds must show vigorous bark on edges. Pruning wounds over 3/4 inch in diameter must be completely calloused over. Evergreen trees shall be branched to within one foot of ground. Height of trees, measured from crown of roots to top of top branch, and caliper, measured as specified herein, shall not be less than minimum size designated in plant list. Take caliper measurements 6 in. above ground on trees up to and including 4 in. caliper, and at 12 in. above ground for larger sizes.
- H. Shrubs and Small Plants: Shrubs and small plants, unless otherwise designated, shall be well-formed and bushy with well-spaced side branches, and shall have a crown and stem(s) typical of species and variety. Plants shall be well-branched to ground. Plants shall meet requirements for spread and/or height stated in Plant List. Measurements for height are to be taken from ground level to average height of top of shrub and not to longest branch. Thickness of each shrub shall correspond to trade classification "No. 1". Single stemmed or thin plants will not be accepted.
- I. Plants larger than those specified in the Plant List may be used if approved by Owner's Representative, but use of such plants shall not increase the Contract Price. If use of larger plants is approved, spread of roots or ball of earth shall be increased in proportion to size of plant.

2.2 PLANTING ADDITIVES

- A. Liquid Seaweed Concentrate: Dry, water soluble seaweed extract powder from Ascophym nodosum. Stress-X as manufactured by North Country Organics, Bradford, Vermont 05033. Phone: 802.222.4277.
- B. Plant Growth Biostimulant: Dry, water soluble plant growth biostimulant made from beneficial bacteria humic extracts, cold water sea kelp extract, essential amino acids, vitamins, root growth factors and sugars. Bio-Magic as manufactured by North Country Organics, Bradford, Vermont 05033. Phone: 802.222.4277.
- C. Mycorrhizae granules: transplant granules for inoculating plants with beneficial mycorrhizal fungi prior to planting. Myco-Magic as manufactured by North Country Organics, Bradford, Vermont 05033. Phone: 802.222.4277.

2.3 BARK MULCH

- A. Bark mulch: shredded granular outer bark of evergreen trees and minimum of hardwood bark and shall be aged for period of at least 6 months and not longer than two years. Bark mulch shall not have be subjected to anaerobic conditions and must be partially decomposed and dark brown in color, Bark chunks shall average 1/2 inch to 2 inches in length and no chunks three

inches or more in size and thicker than 1/4 inch shall be left on site. Moisture content shall be 40 percent or more, retained with normal watering and/or rainfall. Mulch shall be free of dirt, leaves, twigs, and other materials deleterious to plant life. Mulch shall not contain chipped construction materials.

2.4 POST PLANTING FERTILIZER

A. Post Planting Fertilizer:

1. Complete, fertilizer made from all-natural ingredients complying with State and Federal fertilizer laws. Fertilizer shall contain the following available plant food by weight, unless soils test indicate a need for different composition
2. Pro Gro 5-3-4 manufactured by North Country Organics, Bradford, Vermont 05033. Phone: 802.222.4277.
3. Fertilizer to be delivered in original unopened standard size bags showing weigh, analysis ingredients and manufacturer's name.

2.5 WATER

- A. Water: furnished by Contractor, suitable for irrigation and free from ingredients harmful to plant life, until available from on-site source. Hose and other watering equipment required for work shall be furnished by Contractor.

2.6 GUYING AND STAKING MATERIALS

- A. Guying and Staking: Contractor responsible for providing a guying and staking system at their discretion to maintain plants in a plumb condition and in order to withstand the severe environmental conditions of the site adjacent to the harbor. Contractor to submit system for Owner's Representative's information.
- B. Wood or Metal Stakes: If Contractor chooses to stake or guy trees with an above grade solution consisting of wood or metal stakes, then wood stakes shall be fabricated from smooth, straight wood and wood or metal surfaces shall be painted or stained as approved by Owner's Representative.
- C. Below Grade Guying: If Contractor chooses to guy with a below grade guying system, then guys should have ribbons attached to guys to make pedestrians aware of presence of guys.
- D. Materials for guying and anchoring trees shall be in accordance with the following schedule. Specific applications shall be governed by Drawings.

1. Schedule:

Tree Caliper	Guying Cable	Turnbuckle Size
2"-3-1/2"	1/8" (7x19)	5/16"x4"
4"-7-1/2"	3/16" (7x19)	3/8"x6"

- E. Guying and Staking System for supporting trees: a subsurface system anchoring system resulting in only the guy wires being visible above finish grade.
- F. Wire for tree bracing and guying: pliable 12-gauge galvanized soft steel wire.
- G. Turnbuckles: galvanized. Thread diameter and body size indicated in schedule above.
- H. Hose: New Two-Ply fiber-bearing garden hose, not less than 1/2 in. inside diameter, 12 in. long. Color shall be black.
- I. Vine supports to support vines on walls shall be soft lead hooks or green plastic disks with green vinyl-coated wire ties manufactured specifically for that purpose and fastened to a galvanized steel polyester resin adhesive anchoring system, spaced in accordance with the manufacturer's recommendations.

2.7 ANTIDESSICANT

- A. Antidesiccants: emulsions or materials which provide a protective film over plant surfaces permeable enough to permit transpiration and specifically manufactured for that purpose. Antidesiccant shall be delivered in manufacturer's containers and used according to manufacturer's instructions.

2.8 CHEMICALS, HERBICIDES, FUNGICIDES AND INSECTICIDES

- A. Provide chemicals, herbicides, fungicides and insecticides as needed for fungus or pest control. Chemicals and insecticides shall be approved by Massachusetts Department of Environmental Protection for intended use and application rates. No pesticides shall be used on site without knowledge and approval of Owner's Representative. Pesticides shall be handled by State licensed operators only.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: in the event field conditions are not in conformance with Contract Documents, notify Owner's Representative in writing.
 - 1. Spot and Invert Elevations: verify field elevations of site improvements such as drainage and utility fixtures, pavements, existing plantings, and subsurface piping conform to Drawings.
 - 2. Finish Grade: verify specified elevations and prior grading operations have shaped, trimmed, and finished gradients.

3.2 PREPARATION

- A. Protection:

1. Contact "Dig Safe" prior to doing excavation on site. If work is to be done around underground utilities, appropriate authority of utility must be notified of impending work. Hand excavate areas adjacent to utilities. Contractor shall be responsible for damages done by himself or his personnel to existing utilities, which shall be repaired or paid for by Contractor.
2. Dust Control: upon acceptance of finish grades provide dust control.
3. Erosion Control: upon acceptance of finish grades provide erosion control.
4. Agricultural Chemicals: protect site improvements from contact with agricultural chemicals, soil amendments, and fertilizers.

3.3 DIGGING, HANDLING, AND PROTECTION OF PLANTS

- A. Dig balled and burlapped (B & B) plants with firm natural balls of earth, of sufficient diameter and depth to include fibrous roots and conforming to standards of American Nurserymen Association. No synthetic burlap will be accepted. No plant moved with a ball will be accepted if ball is cracked or broken before or during planting operations.
- B. Protect roots or balls of plants from sun and drying winds.
- C. Set plants on ground in shady location and protect with soil, bark mulch, or other acceptable materials, balled and burlapped plants which cannot be planted immediately upon delivery. Water stored plants and regularly verify rootballs are moist. Owner's Representative will reject stored plants found with dried rootballs.
- D. Open bundles of plants immediately and plants and separate before roots are covered. Care shall be taken to prevent air pockets among roots. During planting operations, bare roots shall be covered with canvas, hay or other suitable material. No plant shall be bound with wire or rope as to damage the bark or break branches.

3.4 OBSTRUCTIONS BELOW GROUND

- A. If rock, underground construction work, or other obstructions are encountered in plant pit excavation work, alternate locations may be selected by Owner's Representative at no additional cost to Owner.
- B. Where locations cannot be changed, obstruction shall be removed, subject to Owner's Representative's approval, to a depth of not less than three feet (3') below grade and no less than six inches (6") below bottom of ball or roots when plant is properly set at required grade.
- C. Contractor shall be paid extra for removal of rock or underground obstructions encountered. See payment items in SECTION 31 20 00 – EARTH MOVING.

3.5 PREPARATION AND PLACEMENT OF PLANTING SOILS

- A. See SECTION 32 19 14 – PLANTING SOILS.

3.6 FINE GRADING

- A. See SECTION 31 22 19 – FINE GRADING.

3.7 PLANTING OPERATIONS

- A. Stake out locations of plants and secure Owner's Representative's approval before excavating plant pits.

B. Excavating

1. Place tree next to tree pit excavation and remove burlap from top of root ball. If trunk flair is not visible gently loosen and remove soil with a blunt tool or air spade until trunk flair and large horizontal lateral roots are located. Use care not to damage root system. Following removal of excess soil over root ball measure depth of root ball to determine depth of tree pit excavation.
2. Dig tree pits and plant pits by hand and take care not to disturb utilities. If utilities are disturbed during planting operation, Contractor shall repair damage at Contractor's expense.
3. Excavate plant pits with sloping sides so planting hole is saucer shaped. Plant pit shall be no deeper than root ball.
4. Tree pits shall be four times diameter of soil ball in width.

C. Setting, Backfilling and Fertilizing

1. In the event trees are containerize in wire baskets, lay tree on its side and cut the bottom of the cage off, roll the tree into the hole and remove the sides of the wire basket.
2. Set plants in center of pits plumb, straight and at an elevation where after settlement the root flare and lateral roots of plant will be at surrounding finished grade. Root ball shall not be broken. When trees are set, compact base material under the root balls to fill voids and support plants at proper height. Remove burlap and rope from upper two thirds of balls and have Designer inspect removal prior to backfilling.
3. Remove groundcovers and perennials from containers immediately before planting. Handle plants carefully to prevent damaging roots. Groundcover plants may be planted after bark mulch is placed.
4. Sprinkle michorrhizal granules continuously around perimeter of root ball as well as incorporating granules into top of rootball following removal of top 1/3 of burlap in accordance with manufacturer's recommend
5. Mix liquid seaweed concentrate or plant growth bio-stimulant with water at a rate of 3 grams of liquid seaweed concentrate powder per gallon of water or 1 teaspoon of plant growth biostimulant per gallon of water.

6. Backfill hole around plants to two-thirds full, firm soil, flood with water mixed with additives, after water has drained away backfill to finished grade without additional firming. Immediately after plant pit is backfilled, a shallow basin slightly larger than pit shall be formed with ridge of soil to facilitate and contain water. After planting, cultivate soil in shrub beds between shrub pits, rake smooth and outline beds neatly.

3.8 DRAINAGE TEST

- A. Perform drainage test on trees and in representative shrub beds.
 1. After excavation, fill pit twice successively with water.
 2. Water shall drain out of plant pit minimum 2 inches per hour.
 3. Plant pits draining slower than 2 inches per hour will require provision for drainage.
- B. Documentation: note on the planting plan, pits that pass drainage test and plants that fail drainage test.

3.9 FIELD QUALITY CONTROL

- A. Observation:
 1. Owner's Representative to review plant pits without positive drainage.
 2. Owner's Representative to review plant pit excavation and planting.

3.10 GUYING, AND STAKING

- A. Guying and staking plants is not required though Contractor responsible for maintaining plants in upright, vertical position and for maintaining guying and staking materials. If Contractor determines guying and staking is required, Contractor shall submit recommendations for Designer's approval.

3.11 PRUNING

- A. Prune trees and shrubs only with approval of Owner's Representative. Prune according to American Nurserymen's' Association Standards to preserve natural character of plant and as directed by Owner's Representative. No leaders shall be cut.
- B. Pruning shall be done with clean, sharp tools. Dead wood or suckers and broken or badly bruised branches shall be removed back to live bud, branch, or stem.

3.12 MULCHING

- A. Immediately after planting operations are completed, cover tree and shrub pits and planting beds with a two inch layer of specified mulch. Taper depth of mulch to be two inches at mulched perimeter and decreasing in depth toward trunk to be flush where trunk or stem meets root ball. Do not place mulch against trunk or stem. Cover tree, shrub and groundcover planting beds with bark mulch.

3.13 WATERING

- A. Flood plants with water twice within first 24 hours of time of planting, and water plants during the maintenance period at least twice per week. Contractor shall be responsible for watering all plants during the guaranty period at least once per week, until Final Acceptance, except when the ground is frozen. At each watering thoroughly saturate the soil around each tree or shrub. If sufficient moisture is retained in soil, as determined by Owner's Representative, required watering may be reduced. Each tree will require a minimum of ten gallons of water.

3.14 POST PLANTING FERTILIZER

- A. Apply uniform application of Post Planting Fertilizer (5-3-4) at rate of 5 lbs. per 1000 square feet, 30 days after planting.

3.15 CLEANING

- A. Wash and sweep clean paving, site improvements and building surfaces. Clean spills and overspray immediately. Remove and dispose off-site excess planting mixture, soil and debris.
- B. Following Acceptance at the end of 90 Maintenance Period of planting areas, remove materials and equipment not required for other planting or maintenance work. Materials and equipment remaining on site shall be stored in locations which do not interfere with Owner's maintenance of accepted lawns or other construction operations.

END OF SECTION

SECTION 32 91 00

PLANTING SOILS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Coordinate with such trades to assure the steady progress of all work under the Contract.

1.2 SUMMARY

- A. The Work of this Section includes, but is not limited to, the following:
 - 1. Preparation and placement of Planting Bed Soil.
 - 2. Preparation and placement of Lawn Soil.

1.3 RELATED SECTIONS

- A. Related Sections include the following:
 - 1. SECTION 31 20 00 – EARTH MOVING
 - 2. SECTION 31 22 16 – FINE GRADING
 - 3. SECTION 32 93 00 – PLANTING

1.4 REFERENCES AND STANDARDS

- A. Comply with applicable requirements of:
 - 1. State of New Hampshire, Standard Specification for Roads and Bridge Construction, Department of Transportation, latest edition.
 - 2. City of Dover, of the State of New Hampshire, and of other authorities having jurisdiction. Provide labor, materials, equipment and services to comply with requirements.
- B. American Society for Testing and Materials (ASTM) Standards, Methods:
 - 1. C 136-01: "Standard Test Method For Sieve Analysis of Fine and Course Aggregates" (Dry Sieving).

2. D 422-63 (2002): “Standard Test Method For Particle-Size Analysis of Soils” (Hydrometer).
 3. D 698: “Standard Test Methods For Laboratory Compaction Characteristics of Soil Using Standard Effort” (Standard Proctor).
 4. D 1556-00: Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
 5. D 2167-94: Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
 6. D 2922-01: Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
 7. D 4972-01: “Standard Test Method For pH of Soils” using distilled water.
 8. F 1647-02a: “Standard Test Method For Organic Matter Content of Putting Green and Sports Turf Zone Mixes.
- C. Woods End Research Laboratory, Mt. Vernon, Maine:
1. Solvita Manual, Version 3.5.
- D. Recommended Soil Testing Procedures for the Northeastern United States, 2nd Edition, Northeastern Regional Publication No. 493, Agricultural Experiment Stations of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and West Virginia, Revised, December 15, 1995: Referenced Document may be obtained on the web at <http://ag.udel.edu/EXTENSION/agnr/soiltesting.htm>. Tests include the following:
1. Test for soil Organic Matter by loss of weight on ignition, as described in Northeastern Regional Publication No. 493, p. 59.
 2. Test for soil CEC by exchangeable acidity method as described in Northeastern Regional Publication No. 493, p. 64.
 3. Test for soil Soluble Salts shall be by the 1:2 (v:v) Soil:Water Extract Method as described in Northeastern Regional Publication No. 493, p. 74.
 4. Test for Buffer pH by the SMP method as described in Northeastern Regional Publication No. 493, p. 20.
- E. Code of Federal Regulations Title 40, Chapter I-Environmental Protection Agency:
1. 40 CFR Part 503 rule, Table 3, page 9392, Vol. 58 No. 32.
- F. American Society of Agronomy

- G. American Association of Nurserymen, American Standards for Nursery Stock, (ANSI Z60.1), latest edition, published by the American Association of Nurserymen, 1250 I Street, N.W., Suite 500 Washington, D.C. 20005.
- H. ANSI: American National Standards Institute.

1.5 DEFINITIONS

- A. Subgrade: Soil material and levels resulting from the approved rough grading work. Subgrade soil shall be existing soil or other materials which are either undisturbed or have been placed resulting from the approved rough grading work. Loosening of all subgrade areas prior to placement of Planting Soils is included in this Section.
- B. Planting Soils: Planting Soils are composed of a blend of three base components: base loam, organic material and sand. The quality of the blend depends on the quality of the original components. Contractor is responsible for locating and obtaining approval of sources for base loam, organic material and sand that meet the Specification requirements. Contractor is then responsible for mixing the components. Approximate mixing ratios are provided, but may require adjustment, depending on the final materials and with the approval of the Landscape Architect or their representative, in order to meet Specification requirements for each blend.

1.6 SUBMITTALS

- A. Prepare and submit in accordance with SECTION 01 33 00 – SUBMITTAL PROCEDURES.
- B. At least 30 days prior to ordering materials, submit to the Owner's Representative samples, certifications, manufacturer's product data and certified test results for materials as specified below for approval in conformance with the requirements of this Specification. No materials shall be ordered or delivered until the required submittals have been reviewed and approved by the Owner's Representative. Delivered materials shall closely match the approved samples. Approval shall not constitute final acceptance. Owner's Representative reserves the right to reject, on or after delivery, material that does not meet these Specifications. Contractor responsible for recognizing that these critical project materials warrant timely and serious attention, that testing process to achieve approved materials should be considered a lead time item, and under no circumstance shall failure to comply with specification requirements be an excuse for "staying on project construction schedule."
- C. Product Data: submit most recent printed information from manufacturer.
 - 1. Organic Material: identify the material(s) from of which is it composed and identify the location where material was composted.
 - 2. Fertilizers
 - 3. Ground Limestone
 - 4. Superphosphate

5. Aeration piping, couplings, connections, and perforated end caps.
- D. Samples: Submit 1 gallon planting soil samples in two phases. Submit samples concurrent with horticultural soil test reports in both phases. Submit as phase one, planting soil base components for approval. Only after approval of phase one components, submit as phase two, soil blend mixes / mediums for approval. Each sample shall be a composite of a minimum of ten (10) individual samples taken from representative portions of a pile or source combined, thoroughly mixed and bagged. In addition to providing samples in quantities as required by testing agencies, submit one gallon split-samples of Base Components and Planting Soils to the Landscape Architect, Owner's Representative and Soil Scientist for review. Do not order materials until Landscape Architect's, Owner's Representative's and Soil Scientist's approval has been obtained. Delivered materials shall closely match the approved samples.
1. Phase One Submittals of Planting Soil Base Components:
 1. Base Loam
 2. Organic Material
 3. Sand
 2. Phase Two Submittals of Planting Mediums: mixing and batching of mediums to be prepared in the same manner as bulk soils will be prepared prior to delivery to site.
 1. Plant Bed Soil
 2. Horticultural Subsoil
 3. Lawn Soil
 3. Phase Three Submittals of Planting Mediums: After Planting Soil test batches have been accepted, mix and amend as necessary in production, batches of up to 300 cubic yards for each soil type listed in 1.06.D.2. Each batch must be sampled, tested for gradation and organic content, and approved prior to delivery to the job site.
- E. Sources for Soil Components and Soil Mixes: Submit information identifying sources for all soil components and the firm responsible for mixing of soil mixes.
1. Landscape Architect, Soil Scientist and Owner's Representative shall have the right to reject any soil supplier.
 2. Soil mix supplier shall have a minimum of five years experience at supplying custom planting soil mixes.
 3. Submit supplier name, address, telephone and fax numbers and contact name.
 4. Submit certification that accepted supplier is able to provide sufficient quantities of materials and mixes for the entire project.
- F. Horticultural Soil Test Reports: Submit reports in two phases. Submit reports concurrent with samples in both phases. Submit as phase one, reports for planting soil base components above for approval. Only after approval of phase one components, submit as phase two, reports for

soil blend mixes /mediums for approval. Test results must be less than 60 days old and represent materials that are available for delivery to the site in the quantity required.

- G. Submit reports for each of the above samples: Submit sample from each proposed source for testing and approval. Deliver samples to both the testing laboratory and the project soil scientist and pay costs. Send report directly to Owner's Representative.
1. Testing for Base Loam, Plant Bed Soil, Lawn Soil, and on-site stripped topsoil.
 2. Inform testing agency soil test is for both tree and shrub planting and lawn applications.
 3. Mechanical and chemical analysis shall be conducted by a public extension service agency or a certified private testing laboratory in accordance with the current "standards" of the American Society of Agronomy.
 4. Gradation tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422 after destruction of organic matter by ignition.
 5. Test for agricultural suitability analysis including:
 - a. particle size and characteristics
 - b. soil pH by water pH and buffer (smp) pH tests.
 - c. percentage organic content
 - d. nitrate nitrogen
 - e. ammonium nitrogen
 - f. phosphorus
 - g. potassium
 - h. calcium
 - i. aluminum
 - j. magnesium
 - k. manganese
 - l. Micronutrients
 - m. Toxins including but not limited to lead, cadmium, arsenic and mercury.
 6. Test results: test data and recommendations for soil amendments including but not limited to: nitrogen, phosphorus, potassium and limestone.
 7. Testing for Organic Amendment Materials
 - a. Tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422 after destruction of organic matter by ignition.
 - b. Test for agricultural suitability analysis as defined in Article 2.02 – Organic Amendment Materials (Compost).
 8. Testing for Sand
 - a. Test for particle size gradation and pH

1.7 QUALITY ASSURANCE

A. Qualifications for Horticultural Soil Installations:

1. Work of horticultural planting soil installation shall be performed with personnel familiar and experienced with horticultural soil preparation and related requirements associated with lawn and planting installations under the supervision of a foreman experienced in landscape work.
2. Foreman on the job shall speak English and be able to exhibit at least five (5) years experience in the installation of horticultural soils and soil mixes.

B. Qualifications for Inspecting and Testing Horticultural Materials: Qualifications of Contractor's Agricultural Chemist / Testing Laboratory / Agency shall be submitted to and approved by Architect prior to start of procurement of soil materials, placing or amending planting soil materials, and planting operations on Project.

1. Agricultural Chemist: Experienced person or persons employed by public or private soils testing laboratory, qualified and capable of performing tests, making soil recommendations, and issuing reports as specified herein.
2. Soils Testing Laboratory: An independent laboratory with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed and capable of making soil recommendations, and issuing reports as specified herein.

a. Acceptable Planting Soil Materials Testing Laboratories:

1. Physical and Chemical Testing of Soils: Hummel & Company, Inc., 35 King Street, P.O. Box 606, Trumansburg, NY 14886, (607) 387 5694 – phone; (607) 837 9499.
2. Physical and Chemical Testing of Soils or Compost: University of Massachusetts West Experiment Station, Amherst Massachusetts, 01003, phone 413-545-2311, fax 413-545-1931.
3. Compost Testing: Woods End Research Laboratory, PO Box 297, Mt. Vernon, Maine 04352, (207) 293 2457 – phone; (207) 293 2488.
4. Approved equal.

C. Pre-Installation Conference: A pre-installation conference shall be held prior to commencement of field operations to establish procedures to maintain optimum working conditions, to coordinate requirements for testing, and to coordinate this Work with related and adjacent work.

D. Inspections and Testing of Horticultural Soil Materials: in addition to the requirements of Section 3.3 D, the following conditions and requirements shall apply:

1. Material Testing, General: Contractor shall engage and pay for the services of a qualified Agricultural Chemist / Soils Testing Laboratory / Agency to perform all materials testing

and inspections of Project-related Base Components and Planting Soils, as well as any other material testing and soil mix material testing required in this Section or additionally required by the Landscape Architect and/or Construction Manager.

2. On-site Quality Control Testing and Inspections: Owner will engage and pay for the services of a qualified Testing Laboratory / Inspection Agency to perform on-site observations, testing, and inspections. Soil placement, and other earthwork will be subject to quality control inspections and testing by Owner's Testing Laboratory / Agency as specified or, if any questionable conditions, additionally as directed by the Lead Landscape Architect.
 - a. Contractor shall cooperate in obtaining samples and performing tests of in-place materials and shall furnish incidental field labor in connection with any tests to be performed by Owner's Testing Laboratory / Agency.
3. Construction Monitoring:
 - a. During landscape construction operations, in addition to Owner's Testing Laboratory / Agency, Lead Landscape Architect, Construction Manager or Owner may be present at the site to observe and monitor placing and amending soil material operations and shall be permitted free and unrestricted access to the site and work.
 - b. Landscape Architect, Construction Manager or Owner reserve the right to take and analyze at any time such additional samples of horticultural soil and soil amendment materials as deemed necessary for verification of conformance with the Contract Documents. The Contractor shall furnish samples for this purpose upon request and shall perform material testing as requested. The Lead Landscape Architect or Construction Manager may, at their discretion, take additional tests or order additional tests made by either the Contractor's or Owner's Testing Laboratory/Agency respective to conditions.
 - c. Based on observations and evaluation of quality control tests, the Contractor's or Owner's Testing Laboratory/Agency shall make recommendations to the Landscape Architect and Construction Manager regarding conformance of the soil material and placing operations to Contract Documents and compatibility of actual subsurface conditions to required subsurface conditions.
 - d. Landscape Architect or designated representative will evaluate the recommendations of respective Testing Laboratory/Agency and, together with Construction Manager and Owner, will judge the compliance of the work with Contract Documents, issue any changes or revisions required to Contract Documents to accommodate subsurface conditions which differ from design assumptions, or advise the Construction Manager to direct remedial work where the completed work does not comply with Contract Documents.
 - e. Planting Soils and/or other components delivered to the site may be periodically sampled and tested for compliance. Materials not matching the approved previously submitted Samples shall be removed from site at no additional cost to Owner.

4. Materials in question shall not be used, pending test results of conformance to specified requirements.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Packing and Shipping: deliver materials in unopened containers bearing manufacturer's name and guaranteed statement of analysis. Transport materials without damage. Protect finishes from abrasion, dirt, oils, grease, and chemicals. Pack materials to protect from weather.
- B. Base Components and Planting Soils shall not be handled, hauled, or placed when wet, during or immediately after a heavy rainfall, or frozen. Soil should be handled only when the moisture content is less than or equal to the optimum water content as determined for the Standard Proctor test. The Landscape Architect, the Soil Scientist and the Owner shall be consulted to determine if the soil is too wet to handle.
- C. Store and handle packaged materials in strict compliance with manufacturer's instructions and recommendations. Protect all materials from weather, damage, injury and theft.
- D. Sequence deliveries to avoid delay. On-site storage space is permissible only with written notice from Construction Manager. Deliver materials only after preparations for placement of planting soil have been completed.
- E. Prohibit vehicular and pedestrian traffic on or around stockpiled planting soil.
- F. Soil that is to be stockpiled longer than two weeks, whether on- or off-site, shall not be placed in mounds greater than six feet high. Provide all means and methods required to prevent anaerobic conditions at no additional cost to the Owner.
- G. Vehicular access to the site is restricted. Before construction, the Contractor shall submit for approval a plan showing proposed routing for deliveries and site access.
- H. Work and Protection Plans:
 - 1 On-Site Soil Storage: Submit proposed locations and means and methods for storage/stockpiling of soil materials on-site.
 - 2 Soil Placement and Settlement Plans: Submit a plan of implementation with a schedule describing the proposed methods intended for placing horticultural planting soils and for allowing natural settling of installed soils.
- I. Data Submitted for Information and Reference:
 1. Copies of permits necessary to transport materials off site.
 2. Location of legal disposal sites for waste materials from this work of Project, if any.

1.9 PROJECT/SITE CONDITIONS

- A. Environmental Requirements: do not deliver or handle soils when dry, wet, or frozen.
1. No planting Soil shall be trucked, placed, compacted or otherwise handled when its moisture content is greater than optimum as determined by ASTM 698. In addition, no soil shall be compacted if its moisture content is sufficiently high that its saturated hydraulic conductivity falls below its minimum rate as specified below. Normally, but not always, this requirement will be met when the moisture content is at or below optimum. The Contractor shall conduct moisture content tests using the Speedy Moisture Test or other approved Equipment as necessary to ensure conformation with maximum allowable moisture contents. The Contractor shall coordinate his procedures to allow for drying of planting soils that exceed maximum allowable moisture contents.
 2. The Contractor shall ensure that all soils shipped from a soil supplier meet moisture requirements when they are shipped. Moisture testing shall be carried out at the soil supplier's facility prior to shipping. Soil stockpiles shall be protected by tarps or other measures as necessary to prevent base soils and mixed soils from becoming wet.
 3. Additional Field Tests
 - a. Form soil in palm of hand, if soil retains shape and crumbles upon touching, the soil may be worked.
 - b. If the soil will not retain shape it is too dry and should not be worked.
 - c. If the soil retains shape and will not crumble, it is too wet and should not be worked.
 - d. If the soil glistens or free water is present after lightly patting the sample, the soil is too wet and should not be worked.

PART 2 - MATERIALS

2.1 BASE LOAM

- A. Base Loam shall be Stripped Existing Topsoil or Imported Base Loam and shall be free of sub-soil, large stones, earth clods, sticks, stumps, clay lumps, roots or other objectionable, extraneous matter or debris. Base Loam shall be from a natural source without admixture of compost, sand or any other extraneous material. Base Loam shall also be free of quack-grass rhizomes, Agropyron Repens, and the nut-like tubers of nutgrass, Cyperus Esculentus, and all other primary noxious weeds. Base Loam shall not be delivered or mixed while in a frozen or muddy condition. Base Loam for mixing shall conform to the following grain size distribution for material passing the #10 sieve:

U.S. Sieve Size Number	Percent Passing	
	Minimum	Maximum
10	---	100
18	85	100
35	70	95
60	50	85
140	36	53
270	32	42
0.002mm	3	8

- B. Maximum size shall be one inch largest dimension. The maximum retained on the #10 sieve shall be 20% by weight of the total sample.
- C. The organic content shall be between 3.0 and 8.0 percent.
- D. The pH shall be 7.5 or less.

2.2 Organic Material (Compost):

A. Organic Material (Compost) as Amendment for Soil Mediums:

1. Organic Material (Compost) for amending planting medium: stable, humus-like material produced from the aerobic decomposition of organic residues consisting of Leaf or Yard Waste Compost which shall have been composted for a minimum of one year (12 months). Compost shall be free of debris such as plastics, metal, concrete or other debris and stones larger than 1/2", larger branches and roots and wood chips over 1/2" in length or diameter. Compost shall be a dark brown to black color and be capable of supporting plant growth with appropriate management applicable, with no visible free water or dust, with no unpleasant odor, and meeting the following criteria as reported by laboratory tests.
 - a. The ratio of carbon to nitrogen shall be in the range of 12:1 to 25:1.
 - b. Stability shall be assessed by the Solvita procedure. Protocols are specified by the Solvita manual (version 4.0). The compost must achieve a maturity index of 6 or more as measured by the Solvita scale. Stability tests shall be conducted by Woods End Research Laboratory, Mt. Vernon, Maine, Soil Control laboratory of California, or approved equal.
 - c. Pathogens/Metals/Vector Attraction reduction shall meet all Massachusetts requirements for applications to soils with human activity.
 - d. Organic Content: at least 20 percent (dry weight). One hundred percent of the material shall pass a 1/2-inch (or smaller) screen. Debris such as metal, glass, plastic, wood (other than residual chips), asphalt or masonry shall not be visible and shall not exceed one percent dry weight. Organic content shall be determined by weight loss on ignition or H₂O₂ for particles passing a Number 10 sieve according

to procedures performed by the West Experiment Station at the University of Massachusetts, Amherst or equal. For loss by ignition, a 50-cc sub-sample of the screened and mixed compost is ground to pass the number 60 sieve. Two to three grams ($\pm 0.001g$) of ground sample, dried to a constant weight at 105 degrees C is placed into a muffle furnace. The temperature is slowly raised (5C/minute) to 450C and maintained for three hours. The sample is removed to an oven to equilibrate at 105C and the weight is taken. Organic matter is calculated as loss on ignition.

- e. pH: between 6.5 to 7.2 as determined from a 1:1 soil-distilled water suspension using a glass electrode pH meter American Society of Agronomy Methods of Soil Analysis, Part 2, 1986.
- f. Salinity: Electrical conductivity of a one to five soil to water ratio extract shall not exceed 2.0 mmhos/cm (dS/m).
- g. Compost: screened to 1/2 inch maximum particle size and shall contain not more than 3 percent material finer than 0.002mm as determined by hydrometer test on ashed material.
- h. Nutrient content: determined by the University of Massachusetts Soil Testing Laboratory or equivalent laboratory and utilized to evaluate soil required amendments for the mixed soils. Chemical analysis shall be undertaken for Nitrate Nitrogen, Ammonium Nitrogen, Phosphorus, Potassium, Calcium, Aluminum, Magnesium, Chromium, Iron, Manganese, Lead, Soluble Salts, Cation Exchange Capacity, soil reaction (pH), buffer pH, and micronutrients.

2.3 SAND

A. Sand as Amendment for Soil Mediums and for Drainage

- 1. Sand shall be uniformly graded medium to coarse sand consisting of clean, inert, rounded grains of quartz or other durable rock and free from loam or clay, surface coatings, mica, other deleterious materials with the following gradation. Calcitic sand is not permitted.

U.S. Sieve Size Number	Percent Passing	
	Minimum	Maximum
10	100	-
18	65	90
35	35	60
60	15	30
140	0	8
270	0	3
0.002mm	0	0.5

- 2. Maximum size shall be one inch largest dimension. The maximum retained on the #10 sieve shall be 15% by weight of the total sample.

3. The ratio of the particle size for 70% passing (D70) to the particle size for 20% passing (D20) shall be 3.0 or less. (D70/D20 <3.0)
4. Saturated hydraulic conductivity of the sand shall be not less than 30 inches per hour, according to ASTM D5856-95 (2000), when compacted to a minimum of 90% Standard Proctor, ASTM 698.
5. The pH shall be 7.5 or less.

2.4 PLANT BED SOIL

- A. Base Loam, Sand and Compost, each as specified above, shall be combined in an approximate mix ratio of one part by volume Sand to one and one half parts by volume Base Loam to one part by volume Compost (1S:1.5L:1C) to create a uniform blend which meets the following requirements.
- B. Gradation for Material Passing the Number 10 Sieve:

U.S. Sieve Size Number	% Passing by Weight	
	Minimum	Maximum
10	100	-
18	70	95
35	50	76
60	32	50
140	25	32
270	20	25
0.002mm	2.5	5

1. Maximum size shall be one inch largest dimension. The maximum retained on the #10 sieve shall be 15% by weight of the total sample.
2. Ratio of the particle size for 80% passing (D80) to the particle size for 30% passing (D30) shall be 8 or less. (D80/D30 <8)
3. Saturated hydraulic conductivity of the mix: not less than 2 inches per hour according to ASTM D5856-95 (2000) when compacted to a minimum of 84% Standard Proctor, ASTM 698.
4. Organic content: between 5.0 and 7.0 percent by weight.
5. The pH of the mix shall be between 6.5 and 7.0.

2.5 LAWN SOIL

- A. Base Loam, Sand and Compost, each as specified above, shall be combined in an approximate mix ratio of three parts by volume Sand to two parts by volume Base Loam to one and one half parts by volume Compost (3S:2L:1.5C) to create a uniform blend which meets the following requirements.

B. Gradation for Material Passing the Number 10 Sieve:

U.S. Sieve Size Number	Percent Passing	
	Minimum	Maximum
10	100	-
18	70	95
35	46	74
60	30	56
140	17	26
270	14	18
0.002mm	1	2

1. Maximum size shall be one inch largest dimension. The maximum retained on the #10 sieve shall be 15% by weight of the total sample.
2. Ratio of the particle size for 80% passing (D₈₀) to the particle size for 30% passing (D₃₀) shall be 5.0 or less. (D₈₀/D₃₀ <5.0)
3. Saturated hydraulic conductivity of the mix: not less than 3 inches per hour according to ASTM D5856-95 (2000) when compacted to a minimum of 86% Standard Proctor, ASTM 698.
4. Organic content: between 4.0 and 5.0 percent by weight.
5. The pH of the mix shall be between 6.5 and 7.2.

2.6 PRE-PLANT FERTILIZER

- A. Complete, fertilizer made from all-natural ingredients complying with State and Federal fertilizer laws. Fertilizer shall contain the following available plant food by weight, unless soils test indicate a need for different composition:

	Nitrogen	Phosphorus	Potash
Deciduous Trees and Shrubs	2%	3%	3%
Evergreen Trees and Shrubs	2%	3%	3%

- B. Fertilizer: Pro Start 2-3-3 manufactured by North Country Organics, Bradford, Vermont 05033, ph# 802.222.4277 or equal.
- C. Fertilizer to be delivered in original unopened standard size bags showing weigh, analysis ingredients and manufacturer's name.

2.7 SOIL AMENDMENTS

- A. Superphosphate: finely ground phosphate rock, commonly used for agricultural purposes and shall contain not less than 20 percent available phosphoric acid.

- B. Ground Limestone: dolomitic limestone and contain not less than 50 percent of total carbonates and 25 percent total magnesium with a neutralizing value of at least 100 percent. Material shall be ground to such fineness that 40 percent will pass 100 mesh U.S. standard sieve and 98 percent will pass through 20 mesh U.S. standard sieve.

2.8 EQUIPMENT

- A. Chisel Plow or disk harrow or bucket of backhoe: for subsoil cultivation.
- B. Rotovator or disk harrow: for planting mixture/soil cultivation.

2.9 WATER

- A. Water: furnished by Contractor, unless otherwise specified, and suitable for irrigation and free from ingredients harmful to plant life. Hose and other watering equipment furnished by Contractor.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: in the event field conditions are not as shown on Drawings and outlined in the Specifications, notify Owner's Representative in writing.
 - 1. Spot and Invert Elevations: verify field elevations of site improvements such as drainage and utility fixtures, pavements, existing plantings, and subsurface piping conform to drawings.
 - 2. Rough grade: verify specified elevations and prior earthwork operations have shaped, trimmed, and finished rough grade.
 - 3. All work shall conform to environmental requirements, including RIDEM requirements.

3.2 PREPARATION: GENERAL

- A. Protection:
 - 1. Contractor to clear working areas with Dig Net prior to doing excavation on site. If work is to be done around underground utilities, appropriate authority of utility must be notified of impending work. Hand excavate areas adjacent to utilities. Contractor shall be responsible for damages done by himself or his personnel to existing utilities, which shall be repaired or paid for by Contractor.
 - 2. Prior to installation field locate and protect from damage site improvements such as drainage and utility fixtures, pavements, and existing plantings.

3. Dust Control: upon acceptance of finish grade provide dust control.
4. Erosion Control: upon acceptance of finish grade provide erosion control.
5. Agricultural Chemicals: protect site improvements from contact with agricultural chemicals, soil amendments, and fertilizers.

3.3 PREPARATION OF PLANTING SOILS

- A. Correct deficiencies in soil as directed by soil test results. Thoroughly incorporate amendments into planting mixture to ensure even distribution.
- B. Incorporate pre plant fertilizer at a rate of 30 pounds per cubic yard of planting bed medium. Amendment rate will be 6 times square foot application rate per cubic yard of planting mixture.

3.4 DECOMPACTION OF PLANTING AREAS

- A. All subgrade areas to receive planting soils, except in-place amended drainage zones shall be loosened to a minimum depth of three inches utilizing the bucket of an excavator or approved equivalent equipment.
- C. After the soils have been loosened, inspected and written approval has been provided, Planting Soils may be spread by using a wide-track bulldozer size D-5 or smaller or may be dumped and spread with the bucket of a backhoe from the edge of the loosened area. No rubber-tired equipment or heavy equipment except for a small bulldozer shall pass over the subsoils (sub-grade) after they have been loosened. If Contractor plans to utilize such areas for use of heavy equipment, this work should be carried out prior to beginning the process of loosening soils or filling in that area, or it will have to be re-scarified and meet this specification requirement.

3.5 PLACEMENT OF PLANT BED SOIL

- A. Over Horticultural Subsoil place and spread Plant Bed Soil in lifts not greater than twelve inches and compact to a density between 80 and 84 percent Standard Proctor Maximum Dry Density.
- B. Place and spread planting medium to a depth greater than required such that after settlement, finished grade conforming to the lines, grades and elevations shown on the Drawings. Ensure proper drainage in an uninterrupted pattern free of hollows and pockets.
- C. Remove stiff clods, lumps, brush, roots, stumps, litter and other foreign material and stones over one inch in diameter and dispose of legally off site.

3.6 PLACEMENT OF LAWN SOIL

- A. After written approval of subgrade place and spread lawn soil in lifts not greater than twelve inches and compact with a minimum of three passes of the tracks of a bulldozer to a density between 83 and 86 percent Standard Proctor Maximum Dry Density.

- B. Place and spread planting medium to a depth greater than required such that after settlement, finished grade conforming to the lines, grades and elevations shown on the Drawings. Ensure proper drainage in an uninterrupted pattern free of hollows and pockets.
- C. Remove stiff clods, lumps, brush, roots, stumps, litter and other foreign material and stones over one inch in diameter and dispose of legally off site.

3.7 SHALLOW ROCK AREAS

- A. In areas where rock is within three feet of final ground surface in planting bed or tree pits areas or within two feet of final ground surface in lawn areas, including but not limited to areas shown on the plan, a minimum of six inches of sand shall be placed below planting media and the sand extended in a downgradient direction to underdrainage piping or to a minimum of five feet beyond the shallow bedrock areas.

3.8 FIELD QUALITY CONTROL

- A. Tests: after soil preparation operations are complete and prior to planting, take soil sample for testing and recommendations as established in Article 1.06 - Submittals.
- B. Confirm that the subgrade is at the proper elevation and that no further earthwork is required to bring the subgrade to proper elevations. Subgrade layer elevations shall slope parallel to the finished grade as shown on the Contract Documents. Provide a written report to the Owner's Representative and the Owner's Representative that the subgrade has been adjusted to the required elevations to provide a uniform thickness of planting media across the area. Perform no work of placing and spreading soil until elevations have been confirmed and written report has been accepted by the Owner's Representative.
- C. As provided in Article 1.09 – Project / Site Conditions, No Base Materials or Soil Medium and not subgrade materials shall be handled, planted, or seeded in any way if it is in a wet or frozen condition. A moist Soil Medium is desirable for planting.
- D. Observation: Owner's Representative to review in the field soil preparation operations:
 - 1. Preparation of Planting Mixtures
 - 2. De-compaction of subgrade
 - 3. Placement and compaction of Planting Soils

3.9 CLEANING

- A. Clean up debris generated under work of this section.
- B. Site Improvements
 - 1. Wash and sweep clean site improvements such as drainage and utility fixtures, pavements, existing plantings, and site furnishings.

2. Clean site furnishings of grout, adhesives, concrete, and other debris.

C. Waste Disposal: All removals and disposal of waste related to work of this Section shall be performed in accordance with Division 01 Section - Construction Waste Management.

3.10 PROTECTION

A. Protect work of this section until Final Acceptance.

B. Select equipment and otherwise phase the installation of the Soil Medium to ensure that wheeled equipment does not travel over prepared subsoil, placed fills or ordinary borrow or already installed soil. Movement of tracked equipment over said soils will be reviewed and considered for approval by the Owner's Representative. If it is determined by the Owner's Representative that wheeled equipment must travel over already installed soil, provide a written description of sequencing of work that ensures that compacted soil is loosened and uncompacted as the work progresses or place one-inch (25 mm) thick steel plate ballast (or equivalent ballast approved by the Owner's Representative) over the length and width of any travel way to cover Soil Medium to protect it from compaction.

C. Disturbed areas outside the limit of work shall be protected and as required, graded smooth and spread with Soil Medium to meet finished grades.

D. Soil Mediums delivered to the site shall be protected from erosion. Materials shall be spread immediately. Otherwise, materials that set on site for more than 24 hours shall be covered with tarpaulin or other soil erosion system acceptable to Owner's Representative and surrounded by silt fence

3.11 ACCEPTANCE

A. Confirm that the final grade of the Soil Mediums is at the proper finish grade elevations. Adjust grade as required to meet the contours and spot elevations noted on the Plans. Request the presence of the Owner's Representative to inspect final grade. Do not proceed with the remaining work of this Contract until the Owner's Representative has given his/her written approval of the final grade.

END OF SECTION

SECTION 32 92 00

LAWNS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Coordinate with such trades to assure the steady progress of all work under the Contract.

1.2 SUMMARY

- A. The Work of this Section includes, but is not limited to, the following:
 - 1. Seeded Lawn.
 - 2. Sodded Lawn
 - 2. Watering, fertilizing and mowing and maintenance of lawn.

1.3 RELATED SECTIONS

- A. Related Sections include the following:
 - 1. SECTION 31 20 00 – EARTH MOVING
 - 2. SECTION 31 22 19 – FINE GRADING
 - 3. SECTION 32 19 14 – PLANTING SOILS
 - 5. SECTION 32 90 00 – PLANTING
 - 6. SECTION 32 93 53 – PLANTING MAINTENANCE

1.4 REFERENCES

- A. Comply with applicable requirements of:
 - 1. State of New Hampshire, Standard Specification for Roads and Bridge Construction, Department of Transportation, latest edition.
 - 2. City of Dover, of the State of New Hampshire, and of other authorities having jurisdiction. Provide labor, materials, equipment and services to comply with requirements.
 - 3. ASTM: American Society of Testing Materials:

- a. ASTM: American Society of Testing Materials.
- b. ANSI: American National Standards Institute.
- c. AOAC: Association of Official Agricultural Chemists.
- d. USDA: United States Department of Agriculture.

1.5 SUBMITTALS

- A. Prepare and submit the following submittals in accordance with the requirements of SECTION 01 33 00 – SUBMITTAL PROCEDURES.
- B. Product Data: Submit manufacturer's information for:
 - 1. Maintenance Fertilizer
 - 2. Seed Mixture
 - 3. Protective fencing materials.
 - 4. Erosion control blanket.
- C. Certificates: Submit:
 - 1. Seed grower's certification: Submit manufacturer's certificates of compliance with each shipment of each seed type. Certificate from seed supplier shall indicate seed is true to variety indicated on packaging. Certificates shall include guaranteed percentages of purity, weed content and germination of seed, net weight and date of shipment. No seed may be sown until certificates have been submitted.
 - 2. Sod grower's certification. Submit certificate with each shipment of sod indicating certification of grass species, source, grower location, date of harvest and shipment. No sod may be placed until certificates have been submitted.
- D. Schedules: Submit:
 - 1. Seeding installation schedule for approval.
 - 2. Sod installation schedule for approval

1.6 QUALITY ASSURANCE

- A. Qualifications: contractor shall have minimum five years experience in seed and sod installation.
- B. Regulatory Requirements
 - 1. Secure permits, licenses, and pay fees including traffic control.
 - 2. Comply with laws, regulations, and quarantines for agricultural and horticultural products.
- C. Conform to provisions of SECTION 01 40 00 - QUALITY REQUIREMENTS.

1.7 DELIVERY, STORAGE AND HANDLING OF SEED, FERTILIZER AND SOIL AMENDMENTS

- A. Packing and Shipping: deliver materials in unopened containers bearing the manufacturer's name and guaranteed statement of analysis. Transport materials without damage. Protect finishes from abrasion, dirt, oils, grease, and chemicals. Pack materials to protect from weather.
- B. Acceptance at Site: verify in writing that delivered materials conform to specifications and approved submittals.
- C. Storage and Protection:
 - 1. Materials shall be uniform in composition, dry and free flowing.
 - 2. Store materials in dry place, on pallets, off the ground; protect from sun. Store materials in a manner, which does not diminish their usability and effectiveness.
 - 3. Protect materials from theft, damage, weather, dirt, oils, grease, and construction.

1.8 PROJECT CONDITIONS

- A. Environmental Requirements: do not deliver, handle or place soils when dry, wet, or frozen.
 - 1. Field Test
 - a. Form soil in palm of hand, if soil retains shape and crumbles upon touching, the soil may be worked.
 - b. If soil will not retain shape it is too dry and should not be worked.
 - c. If soil retains shape and will not crumble, it is too wet and should not be worked.
- B. Seed Planting Seasons:
 - 1. April 15 to May 15
 - 2. September 1 to October 15.
 - 3. Seeding other than within the above season shall be allowed only when ordered by Owner's Representative or when Contractor submits written request for permission to do so and permission is granted. Newly seeded areas, if seeded out of season, must be continuously watered according to good practice if seeding is done between June 1 and September 1. Seeding done outside dates established above shall be solely at Contractor's risk.
- C. Sod Planting Seasons:
 - 1. Spring (April 15 to July 15)

2. Autumn (August 15 to November 1)
3. Sodding outside of the above seasons shall be permitted when ordered by Owner's Representative or when Contractor submits written request and permission is granted. Seeding outside dates established above shall be at Contractor's risk

1.9 SEQUENCING AND SCHEDULING

- A. Perform lawn work only after planting and other work affecting ground surface has been completed.

1.10 SUBSTANTIAL COMPLETION

- A. Upon completion of seed and sod installation, request Owner's Representative's review to determine if work is substantially complete. Submit request a minimum of five days prior to anticipated inspection date. If work is substantially complete, Owner's Representative will issue a Substantial Completion letter identifying commencement of 90 day Maintenance Period.
 1. If work is not substantially complete, Owner's Representative will issue a written list of outstanding work to be done on a timely schedule agreed upon by Contractor and Owner's Representative.
 2. Contractor shall notify Owner's Representative when outstanding work is completed and ready for review. When outstanding work is complete, as determined by Owner's Representative, a letter of Substantial Completion will be issued.

1.11 90 DAY MAINTENANCE PERIOD

- A. Maintain lawn areas until Final Acceptance.

1.12 FINAL ACCEPTANCE

- A. After the 90 day maintenance period seeded lawn areas will be reviewed for final acceptance.
- B. Conditions of Final Acceptance
 1. Lawn acceptance shall be given for entire lawn area. No partial acceptance shall be given.
 2. Lawns shall exhibit uniform, thick, well- developed stand of grass. Lawn areas shall have no bare spots in excess of four inches in diameter and bare spots shall comprise no more than two percent of total area of lawn.
 3. No lawn areas shall exhibit signs of damage from erosion, washouts, gullies, or other causes.

4. Pavement surfaces and site improvements adjacent to lawn areas shall be clean and free of spills from placing or handling of loam borrow and seeding operations.

C. Inspection and Final Acceptance

1. Upon completion of 90 Day Maintenance Period, request Owner's Representative's review to determine if work is acceptable. Submit request a minimum of five days prior to anticipated inspection date. If work is acceptable, Owner's Representative will issue a Final Acceptance letter. From this date forward, lawn maintenance will be the responsibility of the Owner. Following acceptance of lawns, Owner will be given access to lawn areas for maintenance work.
 - a. If work is not accepted, Owner's Representative will issue a written list of outstanding work. Maintenance period to be extended until completion of work.
 - b. Contractor shall notify Owner's Representative when outstanding work is completed and ready for review. When work is complete, as determined by Owner's Representative, a letter of Final Acceptance will be issued.

PART 2 - PRODUCTS

2.1 LANDSCAPE SOILS AND AMENDMENTS

- A. See SECTION 32 19 14 – PLANTING SOILS.

2.2 POST PLANTING FERTILIZER

- A. Post Planting Fertilizer to be mixed with soil:

1. Complete, fertilizer made from all-natural ingredients complying with State and Federal fertilizer laws. Fertilizer shall contain the following available plant food by weight, unless soils test indicate a need for different composition:

	Nitrogen	Phosphorus	Potash
Lawns	5%	3%	4%

2. Fertilizer: Pro Start 2-3-3 manufactured by North Country Organics, Bradford, Vermont 05033. Phone: 802.222.4277.
3. Fertilizer to be delivered in original unopened standard size bags showing weigh, analysis ingredients and manufacturer's name.

2.3 WATER

- A. Water: furnished by Contractor, suitable for irrigation and free from ingredients harmful to plant life. Hose and other watering equipment furnished by Contractor.

2.4 SEED

A. Seed mixture: fresh, clean, new crop seed. Seed can be mixed by an approved method on site or can be mixed by dealer. If seed is mixed on site, each variety shall be delivered in original containers bearing dealer's guaranteed analysis. If seed is mixed by dealer, Seeding Contractor shall furnish to the Owner's Representative the dealer's guaranteed statement of composition of mixture and percentage of purity and germination of each variety.

B. Seed Mixture:

1. Tall Fescue Mix (turf-type tall fescue) by Pennington Seed, Inc., P.O. Box 290, Madison, GA 30650, Phone: 1-800-285-7333.

	<u>Proportion of mix after purity</u>	<u>Minimum germination</u>
Rebel 4 Tall Fescue	30%	85%
Justice Tall Fescue	25%	85%
Rebel Exceda Tall Fescue	25%	85%
Soprano Perennial Ryegrass	10%	85%
Wild Horse Kentucky Bluegrass	10%	85%

2. Application Rates

- a. General Lawn Areas: 350 lbs. / Acre or 8.05 lbs. / 1,000 SF
- b. Athletic Fields: 400 lbs. / Acre or 9.2 lbs. / 1,000 SF

2.5 SOD

A. Sod: nursery grown sod composed of two or more proprietary Kentucky bluegrass cultivars with a 30 percent minimum composition of fine leaf fescues (chewings, creeping red, of hard fescues). Submit cultivar names to Engineer for approval. Sod to be 1 year old minimum from time of original seeding.

1. Sod shall be grown and provided by one of the following turf farms:

- a. Tuckahoe Turf Farms Berwick Maine Fields, 305 Hubbard Road, Berwick, ME 03901. Phone: (800) 556-6985
- b. Downeast Turf Farms, 421 Alfred Road, Kennebunk, ME 04043. Phone: (207) 985-0100.
- c. Or approved equal.

2. Sod Farm Growing Medium: sod farm growing medium shall meet the following sod farm growing media requirements:

- a. Soil in which sod was grown at the Sod Farm shall be USDA classified as sand and shall conform to the following grain size distribution for material passing the #10 sieve:

U.S. Sieve Size Number	Percent Passing	
	Minimum	Maximum
10	100	-
18	85	100
35	60	85
80	25	40
140	6	26
270	4	18
0.002mm	2	5

3. The maximum particle size shall be 1/2 inch.
4. The maximum retained on the #10 sieve shall be 10% by weight of the total sample. Tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422.

- B. Provide well-rooted, healthy sod, free of diseases, nematodes and soil borne insects. Provide sod uniform in color, leaf texture, density, free of weeds, undesirable grasses, stones, roots, thatch and extraneous material; viable and capable of growth and development when planted.
- C. Machine cut sod at uniform soil thickness of 3/4 inch, plus or minus 1/4 inch at time of cutting. Thickness measurement excludes top growth and thatch. Cut individual pieces to supplier's standard width and length with maximum allowable deviation of 5%. Broken pads and torn or uneven ends are unacceptable.
- D. Install sod in the following dimensions:
 1. In linear sod strips measuring 12 inches or 16 inches in width and 4 feet to 6 feet long. Stored in rolls with grass topside inverted so topsoil is to the exterior.

2.6 TEMPORARY PROTECTIVE FENCING

- A. Protect seeded areas with snow fencing or other approved temporary fencing material. Maintain fence in place.

PART 3 - EXECUTION

3.1 LAWN WORK SCHEDULE

- A. Lawn work shall proceed on schedule in conformance with project phasing. These requirements will be strictly adhered to.
- B. Lawn work must be completed on schedule to allow at least one full growing season prior to Final Acceptance.
- C. Contractor responsible for maintenance work on installed lawn until an acceptable lawn is established for a minimum of 60 days.

3.2 EXAMINATION

- A. Verification of Conditions: in the event field conditions are not in conformance with Contract Documents, notify Owner's Representative in writing.
 - 1. Spot and Invert Elevations: verify field elevations of site improvements such as drainage and utility fixtures, pavements, existing plantings, and subsurface piping conform to Drawings.
 - 2. Finish Grades: verify specified elevations to ensure that fine grading operations have shaped, trimmed, and finished sod bed true to elevation with smooth sloped parallel to finished grade.

3.3 PREPARATION AND PLACEMENT OF PLANTING SOIL

- A. See SECTION 32 91 13 – PLANTING SOILS.

3.4 PREPARATION FOR LAWN INSTALLATION

- A. Protection:
 - 1. Dust Control: upon acceptance of finish grade provide dust control.
 - 2. Erosion Control: upon acceptance of finish grade provide erosion control.
 - 3. Agricultural Chemicals: protect site improvements from contact with agricultural chemicals, soil amendments, and fertilizers.
- B. Surface Preparation:
 - 1. Clean seed and sod bed, pavement or other site improvements prior to installation.

3.5 SOIL PREPARATION AND PLACEMENT OF PLANTING SOILS

- A. See SECTION 32 91 13 – PLANTING SOILS.
- B. Thoroughly irrigate areas to receive seed and sod.
- C. Scarification: cross rake areas to receive seed and sod so surface of soil will be receptive to holding seed.
- D. Grade seed and sod areas smooth, free draining and even surface with a loose, uniformly fine texture. Roll and rake; remove ridges and fill depressions to drain.
- E. Restore prepared areas to specified condition if eroded, settled, or otherwise disturbed after fine grading and prior to seeding and sodding.

3.6 APPLICATION OF PRE PLANTING FERTILIZER

- A. Pre-plant Fertilizer application: specified in SECTION 32 19 14 – PLANTING SOILS.

3.7 SOWING OF SEED

- A. Seeding: Seeding shall consist of soil preparation, seeding, raking, rolling, weeding, watering and otherwise providing labor and materials to secure establishment of acceptable turf.
- B. Sowing of Seed: Immediately before seed is sown, ground shall be scarified, or raked lightly until surface is smooth, friable, and of uniformly fine texture. No seeding shall be done during windy weather. Sow seed in two directions right angles to each other, applying 3 lbs. of seed per 1,000 sq. feet in each direction. Sow seed evenly using a culti-packer or approved seeding device (if culti-packer is not used, cover seed with thin layer of landscape soil by dragging, light raking or other approved method). Roll in both directions with hand roller weighing approximately one hundred pounds per foot of width, and water with fine spray. Provide protective fencing where required to keep area undisturbed until grass is established.
- C. On slopes of 3:1 or greater, Contractor can, at his option, use erosion control blanket pre-seeded with specified mixtures. Erosion control blanket shall be installed with two staples minimum per square yard.

3.7 SOD INSTALLATION

- A. Install initial row of sod in a straight line and place subsequent rows parallel to previously installed row. Lay sod edge to edge with tightly fitted joints with longest dimension parallel to contours. Stagger strips to offset joints in adjacent courses. Top of sod thatch line to be flush with surface of adjacent finished grade.
- B. On sloped areas (slopes greater than 4:1), lay sod with length perpendicular to slope, starting at base and continuing upwards with every length pegged.
- C. Immediately after laying, roll sod firmly into contact with sod bed with 100 pound per foot of width hand roller or other approved method to eliminate air pockets.
- D. Finish surface to be uniformly, smooth and even.
- E. Water sod with a fine spray at a rate of 5 gallons per square yard until the underside of new sod pad and soil below sod are thoroughly wet.

3.8 WATERING

- A. First Week: First Week: Provide labor and arrange for watering necessary to establish acceptable lawn. In absence of adequate rainfall, watering shall be performed daily and as necessary during first week and in sufficient quantities to maintain moist soil to two inch minimum depth.
- B. Second and Subsequent Weeks: Water lawn to maintain moisture in upper 5 inches of soil.

- C. Water with uniform coverage while preventing erosion due to application of excessive quantities over small areas, and prevent damage to finished surface by watering equipment. Provide sufficient watering equipment to apply one complete coverage to seeded areas in eight-hour period.

3.9 MAINTENANCE

- A. Maintenance begins immediately after seed and sod is installed and continues until Final Acceptance as follows:
 - 1. a uniform, thick, well-developed stand of turf grass is established.
 - 2. Mow turf grass at seven-day intervals.
 - a. First mowing: when grass has grown to 2" to 2 1/4" height. Cut grass to 1 3/4" height.
 - b. Subsequent mowings shall cut grass to 1 3/4" height.
 - c. Mow in Autumn until growth of grass ceases, and resume in Spring when grass grows to 2 1/4" height.
 - 3. Mow sloped areas a minimum of once during maintenance period. 90 day maintenance period shall be extended to include required cutting. Cut grass to 3" height.
 - 4. Apply uniform application of Post Planting Fertilizer at rate of 44 pounds nitrogen per acre throughout maintenance period. Initial application 3 to 4 weeks after seeding. Additional applications shall occur at four week intervals or as directed Owner's Representative.
 - 5. Lawn areas shall continue to be watered as described above.
 - 6. After grass has started, areas failing to show uniform, thick, well-developed stand of grass shall be immediately re-seeded until areas are covered with satisfactory growth of grass as determined by Owner's Representative.
 - 7. Repair damage from erosion, gullies, washouts, or other causes immediately by filling with loam borrow, tamping, re-fertilizing and re-seeding.

3.10 CLEANING

- A. Wash and sweep clean paving, site improvements and building surfaces. Clean spills and oversprays immediately. Remove and dispose off-site excess planting mixture, soil and debris.
- B. Following Final Acceptance of lawn areas, remove materials and equipment not required for other planting or maintenance work. Materials and equipment remaining on site shall be

stored in locations that do not interfere with Owner's maintenance of accepted lawns or other construction operations.

3.11 PROTECTION

- A. Protect lawn areas against damage with fencing. Fencing to remain in place for minimum 30 days or as directed by owner to ensure complete establishment of sodded lawn. Contractor to maintain fencing in upright position, stretched tightly, and neatly.

END OF SECTION

SECTION 32 93 53
PLANTING MAINTENANCE

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting, or affected by work of this Section. Coordinate with such trades to assure the steady progress of all work under the Contract.

1.2 SUMMARY

- A. The Work of this Section includes, but is not limited to, the following:
 - 1. Plant maintenance including pruning, drainage, irrigation, fertilizing, weed and pest control, and adjusting tree guys.
 - 2. Guaranty and replacement of unacceptable plants.
 - 3. Providing Owner with Maintenance Manual

1.3 RELATED SECTIONS

- A. Related Sections include the following:
 - 1. SECTION 31 20 00 – EARTH MOVING
 - 2. SECTION 31 22 19 – FINE GRADING
 - 3. SECTION 32 19 14 – PLANTING SOILS
 - 4. SECTION 32 90 00 – PLANTING
 - 5. SECTION 32 92 00 – LAWNS

1.4 REFERENCES

- A. Comply with applicable requirements of:
 - 1. State of New Hampshire, Standard Specification for Roads and Bridge Construction, Department of Transportation, latest edition.
 - 2. City of Dover, of the State of New Hampshire, and of other authorities having jurisdiction. Provide labor, materials, equipment and services to comply with requirements.

1.5 SUBMITTALS

- A. Prepare and submit the following submittals in accordance with the requirements of Section 01 33 00 – Submittal Procedures.
- B. Materials List: provide list of materials to be used in maintenance; materials shall be the same as approved in related sections:
 - 1. Fertilizers, soil amendments, testing see Section 32 19 14 – Planting Soils.
 - 2. Plant materials, mulch, and related materials, see Section 32 90 00 – Planting.
- C. Pest and Disease Treatment
 - 1. Submit plan for pest and disease treatment; identify proposed materials and methods.
 - 2. Explain why a problem does or may exist.
- D. Maintenance Manual
 - 1. Provide a maintenance manual to Owner describing operations for on-going upkeep of the installed plants. The manual shall address itself to specified types and uses of plants installed, and provide information for care of both newly installed plants and long-term maintenance.
 - 2. Provide specific information on the following items:
 - a. Watering: Watering season; diagnosis of watering need; frequency of watering; amount; time of day; methods and equipment; equipment maintenance.
 - b. Fertilization: Fertilizing seasons; analysis for fertilizer selection; application rates and methods; preparation and conditions; application times; application equipment; post-application operations and care; precautions for fertilizer use.
 - c. Liming: Liming season; analysis for liming; application rate; method and equipment for application.
 - d. Pruning: Pruning goals and purposes; methods and techniques (relate to species); equipment; season; cleanup and disposal; precautions.
 - e. Mulching of beds: Depths of mulch; refreshment and replacement of mulch.
 - f. Miscellaneous plant maintenance: Weeding and weed control; pest and disease control; leaf and litter removal; bed edging; professional assistance for plant care; and plant replacement as necessary.
 - 3. Include a month-by-month calendar of maintenance procedures, indicating operations listed above.

4. Submit a copy of maintenance manual to Landscape Architect for approval. Submit prior to planting completion. Landscape Architect may request revisions to manual to meet intent of project design.
5. Submit three copies of manual to Owner at acceptance meeting for planting work. Acceptance shall not be granted until manual has been submitted and approved.

1.6 DEFINITIONS

- A. Maintenance: consists of keeping plants in healthy growing condition including watering, weeding, cultivating, remulching, tightening and repairing of guys, removal and replacement of dead plant material, resetting plants to proper grades or upright positions and maintaining saucer.

1.7 QUALITY ASSURANCE

- A. Qualifications: contractor shall have minimum five years experience in landscape maintenance.
- B. Regulatory Requirements
 1. Secure permits, licenses, and pay fees including traffic control.
 2. Comply with laws, regulations, and quarantines for agricultural and horticultural products.
- C. Conform to provisions of Section 01 40 00 Quality Requirements.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Packing and Shipping: deliver materials in unopened containers bearing the manufacturer's name. Transport materials without damage. Protect finishes from abrasion, dirt, oils, grease, and chemicals. Pack materials to protect from weather.
- B. Acceptance at Site: verify in writing that delivered materials conform to specifications and approved submittals.
- C. Storage and Protection:
 1. Store materials in dry place, on pallets, off the ground; protect from sun.
 2. Protect materials from theft, damage, weather, dirt, oils, grease, and construction.

1.9 PROJECT/SITE CONDITIONS

- A. Environmental Requirements: do not work soils when dry, wet, or frozen.
 1. Field Test

- a. Form soil in palm of hand, if soil retains shape and crumbles upon touching, the soil may be worked.
- b. If soil will not retain shape it is too dry and should not be worked.
- c. If soil retains shape and will not crumble, it is too wet and should not be worked.

B. Planting Seasons: see Section 329000 – Planting

1.10 SUBSTANTIAL COMPLETION

- A. Upon completion of planting, request Landscape Architect's review to determine if work is substantially complete. If work is complete, Landscape Architect will issue a letter of Substantial Completion that identifies the effective dates of the start of the 90 day Maintenance Period.
 1. If work is not substantially complete, Landscape Architect will make a list of outstanding work to be done on a timely schedule agreed upon by Contractor and Landscape Architect.
 2. Contractor shall notify Landscape Architect when outstanding work is accomplished and ready for review. When outstanding work is complete, in the judgment of Landscape Architect, a letter of Substantial Completion will be issued.

1.11 90-DAY MAINTENANCE PERIOD

- A. Maintain plantings until the end of 90-day maintenance period and until the receipt of the Letter of Preliminary Acceptance. Annual and perennial planting may require additional weeding, fertilizing, watering, deadheading, or plant replacement during this time at Owner's discretion at Contractor's expense.

1.12 PRELIMINARY ACCEPTANCE

- A. After the 90-day Maintenance Period, work will be reviewed for completeness and start of 1-year Guaranty Period for plantings.
- B. Plantings shall be in thriving and vigorous condition at the time of review for Preliminary Acceptance. If plantings are acceptable, Landscape Architect will issue a Letter of Preliminary Acceptance establishing the effective date of the one-year Guaranty Period.
 1. If plantings are not thriving, in the judgment of Landscape Architect, remedial actions by Contractor will be required to repair or replace plantings.
 2. Remedial work shall be done immediately and in accordance with related work of other sections.
 3. At the conclusion of remedial work, Landscape Architect will review work and extend the Maintenance Period another 90 days to incorporate new plantings.

1.13 FINAL ACCEPTANCE

- A. After the 1-year Guaranty Period, plantings will be reviewed.
- B. Plantings shall be in thriving and vigorous condition at the time of review for Final Acceptance. If plantings are acceptable, Designer will issue a Letter of Final Acceptance.
 - 1. If plantings are not thriving, in the judgment of Designer, remedial actions by Contractor will be required to replace plantings.
 - 2. Remedial work shall be done immediately and in accordance with related work of other sections.
 - 3. At the conclusion of remedial work, Designer will review work and extend the Guaranty Period until plantings are deemed acceptable.
- D. Replace plants that are dead or, as determined by Landscape Architect, are in an unhealthy or unsightly condition, and have lost their natural shape due to dead branches, or other causes.
- E. End of Guaranty Period: one year from date of Preliminary Acceptance, Landscape Architect will review plantings. If plantings are acceptable, Landscape Architect will issue a letter of Final Acceptance. If plantings are unacceptable, plantings shall be replaced until condition of plantings are acceptable as determined by Landscape Architect.
- F. Upon receipt of letter of Final Acceptance, the project becomes responsibility of the Authority.

PART 2 - MATERIALS

2.1 MATERIALS

- A. Materials utilized during the maintenance period shall be the same specified in the work of the related sections:
 - 1. Fertilizers, soil amendments, testing, see SECTION 321914 – PLANTING SOILS
 - 2. Plants, mulch, and related materials, see SECTION 329000 – PLANTING.

2.2 BIOLOGICAL, HORTICULTURAL, HERBICIDAL AND OTHER PEST CONTROL

- A. Material Specification: shall be by a licensed pest control operator, with authority to purchase, utilize, and specify agricultural chemicals and agricultural products.
- B. Use the least hazardous, least intrusive materials and methods.

2.3 EQUIPMENT

- A. Vehicles: in good working order so oil and grease does not stain pavements and poison plantings. Signs identifying the vehicles shall be clearly displayed.
- B. Machinery: in good working order so oil and grease does not stain pavements and poison plantings.

2.4 WATER

- A. Water: Furnished by Contractor, suitable for irrigation and free from ingredients harmful to plant life, until available from on-site source. Hose and other watering furnished by Contractor.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: in the event field conditions are not as shown on Drawings and outlined in the Specifications, notify Landscape Architect in writing.

3.2 PREPARATION

- A. Protection:
 - 1. Agricultural Chemicals: protect site improvements from contact with agricultural chemicals, soil amendments, and fertilizers.

3.3 PRUNING

- A. Pruning: prune with approval of Landscape Architect.
 - 1. Remove dead branches, rubbing branches, and branch work growing towards the center of the tree.

3.4 DRAINAGE

- A. Observe drainage in plant pits with hand soil augur.
- B. Verify plant pits are draining; plant pits not draining shall be identified on the plan and brought to the attention of Landscape Architect.

3.5 PLANTS

- A. Maintain plants in vigorous condition throughout maintenance period.
- B. Replace plants that are missing, dead, not true to name or size as specified, or not in satisfactory growth, as determined by Landscape Architect. Replace plants found

unacceptable within one month or in first month of next growing season, whichever comes first.

- C. Plants must show a minimum of 75% healthy head with obvious growth since planting. Signs of disease, injury, or damage shall have been successfully treated or plant shall be rejected as determined by Landscape Architect.
- D. Replacements plants shall be same kind and size as specified in plant list. Furnish and plant. Cost of replacement borne by Contractor except where it can be shown loss resulted from vandalism, fire, theft, or other causes beyond Contractor's control. Restore areas damaged or disturbed by replacement operations to their original condition.

3.6 WATERING

- A. Refer to SECTION 32 90 00 – PLANTING, for watering requirements during the maintenance period and guaranty period.

3.7 PLANT BASINS

- A. Keep foot tamped and shaped earth dikes around plantings.

3.8 TREE GUYS

- A. Tree stakes: maintain plumb; adjust flexible ties.
- B. Guys: maintain wires taut; adjust turnbuckles; keep flags on wires.

3.9 FINISH GRADE

- A. Maintain finish grades around plantings, at pavement edges, and at irrigation fixtures.

3.10 MULCH

- A. Maintain mulch at 2" depth in planting areas with the exception of at stems and trunks of plants where mulch to be placed to a 0" depth and increasing to a depth of 2" at edge of rootballs and beyond.

3.11 TREATMENT OF PEST AND DISEASES

- A. Spray for both insect pests and diseases during maintenance period with permission of Landscape Architect. Apply herbicides, insecticides and fungicides as prescribed by their manufacturer and in accordance with The State of New Hampshire laws. Contractor shall possess from the State of New Hampshire the proper registrations and permits for application of materials or have applications made by approved, qualified firm holding registrations and permits. Furnish copies of permits in connection with materials to Landscape Architect. Spraying to be considered only after full consideration has been given to alternative pest control strategies. The least toxic approach to pest control shall be used.

3.12 ADJUSTING

- A. Re-set settled plants to proper grade and position.
- B. Restore planting saucer and adjacent material.

3.13 FIELD QUALITY CONTROL

- A. Post Plant Soil Tests: see SECTION 32 93 00 - PLANTING

3.14 CLEANING

- A. Clean up, remove and dispose of off-site excess planting mixture, soil and debris generated under work of this section.
- B. Remove and dispose of stakes, guys and other accessories at end of guaranty period.
- C. Wash and sweep clean site improvements and building surfaces. Clean spills and overspray immediately.
- D. Repair damage caused by maintenance operations.

3.15 PROTECTION

- A. Protect work of this section until Final Acceptance.
- B. Protect planted areas and soils from compaction by construction traffic and from contamination by construction materials.

END OF SECTION

SECTION 334100

STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings.
2. Manholes.
3. Catch basins.

1.2 SUBMITTALS

- A. Notarized Certificate of Compliance shall be provided to the Owner's Representative for all materials delivered to the site.
- B. Shop Drawings:
 1. Manholes and Catch Basins: Include plans, elevations, sections, details, frames, and covers.
- C. Product Data: For each type of product indicated.
- D. Product Certificates: For each type and size of pipe and fitting, from manufacturer.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of the City of Dover Construction Standards, latest edition.

B. Inspection

1. The quality of all materials, process of manufacture and finished pipe shall be subject to inspection by the Owner's Representative. Such inspection may be at the place of manufacture, and or work site after delivery. Pipe shall be subject to rejection at any time on account of failure to meet the Specification requirements, even though sample pipe may have been accepted at the place of manufacture. Pipe rejected after delivery to the site shall be marked and shall be removed from the site at once. All pipe which has been damaged after delivery will be rejected, or if already installed, shall be repaired or replaced by the Contractor, as directed by the Owner's Representative, with no additional cost to Owner. Notarized Certificate of Compliance shall be provided to the Owner's Representative for all materials delivered to the site.
2. All sections shall be inspected for general appearance, dimensions, soundness, etc. Imperfections may be repaired, subject to the approval of the Owner's

Representative, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final approval.

3. Concrete pipe shall not be shipped or subjected to interior or exterior loading until five (5) days after fabrication and/or repair and the concrete has attained a compressive strength of 3000 psi.

C. Storage and Handling of Materials:

1. Preventing damage: All materials shall be handled in a manner to prevent warping, twisting, bending, breaking, chipping, rusting or any damage whatsoever. Pipe and structures shall be lifted and moved with the appropriate apparatus without being pushed, pulled or rolled by equipment. Exercise care in moving pipe to its final position. Use slings, straps and/or other devices to support pipe when it is lifted. Transporting pipe from storage area shall be restricted to operations which will not cause damage to the pipe. Pipe shall not be dropped into the trench.
2. Storage of cement: Cement shall be stored under cover, off the ground, and shall be kept completely dry at all times.
3. Storage of reinforcing steel: All reinforcing steel shall be stored off the ground, or otherwise to prevent accumulations of dirt or grease, and in a position to prevent accumulations of standing water to minimize rusting.
4. Precast concrete handling: Precast concrete units shall be handled in a manner to prevent chipping or cracking.
5. Handling and storage of masonry products: Brick, block and similar masonry products shall be handled and stored in a manner to reduce breakage, chipping, cracking and spalling.
6. Damaged materials: All materials that have become so damaged as to be unfit for the intended use shall be promptly removed from the work site. All pipe shall be examined before laying and no pipe shall be installed which is found to be defective. Defective pipe which cannot be repaired to the satisfaction of the Owner's Representative and City's Representative (where applicable) shall be promptly removed from the project and replaced with new pipe.

1.4 PROJECT CONDITIONS

- A. Interruption of Existing Storm Drainage Service: Do not interrupt service to existing storm drainage on-site within 24 hours of an anticipated rain event, or within 24 hours following a rain event. Drainage improvement work shall be conducted in dry conditions.
- B. Notify the Owner's Representative and the City of Dover no less than one day in advance of proposed interruption of drainage service.

1.5 COORDINATION

- A. Coordinate all storm drainage system work with the City of Dover.
 1. Prior to the start of drainage utility installation, the Contractor shall contact the City's Representative, who will oversee and inspect the drainage utility construction process for compliance with City standards.
 2. The Contractor shall coordinate with the City of Dover so that a City Representative may be present for all drainage utility testing.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All products included in this section shall conform to the requirements of the standard specifications referenced herein.
- B. Pipe size and material shall be as shown on the Contract Drawings.
- C. Each length of pipe shall be marked/tagged with the nominal diameter, gauge, or class, the name of the manufacturer or his trademark, and in the case of reinforced concrete pipe, the date of manufacturer.
- D. Backfill material shall be as specified in Section 32 20 00 Earth Moving.

2.2 HDPE PIPE AND FITTINGS

- A. High Density Polyethylene Pipe (HDPE) NPS 4 to NPS 10: Pipe and Fittings shall conform to AASHTO M 252, Type S. Pipe shall have corrugated exterior surface and an interior that is smooth and even, free from roughness, projections, indentations and irregularities of any kind.
 - 1. Pipe joints shall be silt-tight bell and spigot ends meeting AASHTO M252.
 - 2. Gaskets shall conform to ASTM F477 and shall not have any visible cracking when tested according to ASTM D1149 after 72-hour exposure to 50 PPHM ozone at 104°F.
 - 3. Gaskets shall be installed by the pipe manufacturer and covered with removable wrap to ensure the gasket is free from debris.
- B. HDPE Pipe and Fittings NPS 12 to NPS 60: Pipe and Fittings shall conform to AASHTO M 294, Type S. Pipe shall have corrugated exterior surface and an interior that is smooth and even, free from roughness, projections, indentations and irregularities of any kind.
 - 1. Pipe joints shall be silt-tight bell and spigot ends meeting AASHTO M294.
 - 2. Gaskets shall conform to ASTM F477 and shall not have any visible cracking when tested according to ASTM D1149 after 72-hour exposure to 50 PPHM ozone at 104°F.
 - 3. Gaskets shall be installed by the pipe manufacturer and covered with removable wrap to ensure the gasket is free from debris.

2.3 SDR 35 PVC SEWER PIPE AND FITTINGS

- A. SDR 35 PVC Sewer Piping (solid wall and perforated) and Fittings:
 - 1. Pipe: Shall conform to ASTM D 3034 with bell-and-spigot ends for gasketed joints.
 - 2. PVC Resin Compound: Shall conform to ASTM D 1784
 - 3. Fittings: Shall conform to ASTM D 3034, PVC molded or fabricated, socket type.
 - 4. Rubber Gaskets: Shall conform to ASTM D 3212 and ASTM F 477, elastomeric seals.

2.4 CONCRETE PIPE AND FITTINGS

A. Reinforced-Concrete Sewer Pipe and Fittings:

1. Conformance to standard specifications: Pipe shall conform to the standard specifications for reinforced concrete culvert and storm drain. Pipe shall be Class V 3750D
2. Gasketed pipe joints: Gasketed pipe joints are required for all City installations and shall conform to ASTM C443 Standard Specifications for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
3. Fittings and accessories: Fittings and accessories must be approved by the Engineering Services Division prior to installation.

2.5 CATCH BASINS

- A. Precast drainage structures shall have no more than four (4) holes cast or drilled in each unit for the purpose of handling or placing unless otherwise approved by Owner's Representative. All lift holes and handling devices shall be located in accordance with plan and design requirements. Units damaged while being handled or transported will be rejected or shall be repaired in a manner approved by Owner's Representative.
- B. Precast units shall not be transported away from casting yard until concrete has reached minimum required 28-day compressive strength and a period of at least five (5) days has elapsed since casting, unless otherwise permitted by Owner's Representative.
- C. Following information shall be clearly shown on each precast member:
 1. Date of manufacture.
 2. Name of manufacturer.
- D. Joints of manhole riser sections shall be tongue and groove with rubber "O" ring joints provided on drainage manholes. Drainage inlet and outlet pipes shall be joined to the manhole with a gasketed, flexible, watertight "boot" connection or any watertight connection arrangement that allows differential settlement of the pipe and manhole wall to take place.
- E. Air-entrained concrete shall be used in the production of all units. Air content shall be maintained within the range of 5 to 7 percent.
- F. Unless otherwise specified, precast concrete catch basin lids shall have recessed pick holes.
- G. Eight inch (8-inch) walled, reinforced concrete structures are recommended when tying into existing structures and five inch (5-inch) minimum wall reinforced concrete structures are required for new construction. The structures shall be designed to handle H2O Loading.
- H. Reinforcing shall be steel or structural fibers. Steel shall conform to the requirements of NHDOT 544. Fibers shall only be used in structures with 4 feet or less inside diameter and shall be as shown on the NHDOT Qualified Products List. For five-inch thick, reinforced structures, a neoprene boot to securely seal the pipe stub in the opening is preferred. If booting cannot be done due to trench constraints, a sand stub may be utilized to provide a secure seal.

- I. Eccentric or Concentric conical top sections are required as illustrated on the standard details. Slab top sections shall be used only when the distance from top of grate to top of pipe is less than 48-inches.
- J. Every catch basin is required to have a 3-foot sump as measured from the outlet pipe invert to the floor of the structure. The sump shall be a solid precast unit. Should a center hole be cast in the base, it must be plugged with mortar.
- K. The use of barrel blocks or concrete grade rings is not permitted for new construction.
- L. Catch basins shall be accurately located one (1) foot off the curb line for 4-foot I.D. structures to ensure that the frame will be flush to the curb and centered over the structure. In no case should the frame and grate not be flush against the face of the curb.
- M. Shall the frame and grate shall not be flush against the face of curb, the Contractor will be responsible for re-setting the frame/grate and or the entire structure to achieve the proper placement.
- N. Although catch basins may not be required to be tested for water tightness, infiltration is not acceptable.
- O. Should site conditions require modifications to structure openings, only methods approved in advance by the Engineering Services Division such as core drilling or sawing will be accepted.

2.6 DRAIN MANHOLES

- A. Drain manholes shall be of similar construction to catch basins with the following exceptions:
 - 1. A 30-inch opening for a top section is required.
 - 2. The 3' sump is replaced with a brick invert as noted in the City of Dover's Construction Standards, latest edition.

2.7 FRAMES, GRATES, AND COVERS

- A. 8" cast iron catch basin frames (4" frames are not allowed) and grates shall be NHDOT Type B grate for roadway slopes less than 3%, as shown on the detail of the New Hampshire Standard Plans for Road and Bridge Construction, Standard DR-1, Plate 2.
- B. North American and India castings are allowed, provided the India castings are from SIGMA Corporation or approved equal.
- C. All castings shall be designed for H-20 Loading.
- D. 6" manhole frames and covers shall be NHDOT Standard Manhole cover and frame as shown in the New Hampshire Standard Plans for Road and Bridge Construction, Standard DR-2, Plate 2. All castings shall be designed to handle H20 Loading

2.8 MASONRY

A. Brick:

1. Brick shall be solid, sound, hard, and have plain or smooth surfaces on both ends and on the face side, and be satisfactory to the City Engineer. Brick shall comply with A.S.T.M. Standard Specifications for Sewer Brick, Designation C32, for Grade SS, Hard Red Brick. Brick samples will be required for approval prior to incorporation in the work.

B. Cement:

1. Cement shall be straight Portland Cement, Type I, II, or a Type I/II. Lime mortar or Masonry cement is not to be used on structures.

C. Mortar Sand:

1. Mortar sand shall meet the following gradation requirements:

<u>Sieve Size</u>	<u>% Passing</u>
No. 8	100
No. 16	60-100
No. 50	15-35
No. 100	2-15
No. 200	0-5

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."
- B. Excavation shall be accomplished by methods that preserve the undisturbed state of the subgrade soils.
- C. A trench may be excavated by machinery to the designated subgrade, provided that the bottom of the trench remains in the undisturbed state and provides the proper foundation for the pipe bedding.

3.2 CONTROL OF ALIGNMENT AND GRADE

- A. Easement and property and other control lines necessary for locating the work as well as elevations and bench marks used in the design of the work are shown on the Contract Drawings. The Contractor shall use this information to set line and use a level or transit to set grade.
- B. The Contractor must use laser equipment to assist in setting the pipe provided he can demonstrate satisfactory skill in its use.

- C. The use of string levels, carpenter's levels or other similar devices for transferring grade or setting pipe will not be permitted.
- D. During construction provide the Owner's Representative, at his request, all reasonable and necessary materials, opportunities, and assistance for setting stakes and making measurements, including the furnishing of one or two rodmen as needed at intermittent times.
- E. Contractor shall not proceed until he has made timely request of the Owner's Representative for, and has received from him, such controls and instructions as may be necessary as work progresses. The work shall be done in strict conformity with such controls and instructions.
- F. The Contractor shall carefully preserve bench marks, reference points and stakes, and in case of willful, careless, or accidental destruction by his own men, he will be responsible for the resulting cost to re-establish such destroyed control data and shall be responsible for any mistakes or delay that may be caused by the loss or disturbance of such control data.
- G. Maintain the proper alignment in laying pipe.

3.3 PIPING INSTALLATION

- A. General Locations and Arrangements: Contract Drawings indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
- C. Install manholes for changes in direction unless fittings are indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected.
- E. Pipe shall be laid in dry trench conditions. Provide temporary dewatering and diversion of water as needed, and as specified within the Contract Documents.
- F. Excavate a trench to required depth sufficiently wide to allow for jointing of the pipe and compaction of the material under and around the pipe. If ledge rock, rocky soil, hard pan, or other unyielding subgrade material is encountered at the normal grade of the pipe bed, excavate to 12-inches below invert grade and 12-inches on each side of the interior face of the pipe wall and refill with the appropriate compacted backfill material. Blocking is not permitted.
- G. Compact disturbed trench bottom and shape to fit pipe for a depth of not less than 10 percent of the total diameter of the pipe. The pipe shall rest firmly on the crushed stone bottom for the entire length of pipe barrels. Excavate troughs to accommodate bells or couplings to provide ample space for jointing pipe.

- H. Fill handling hole in concrete pipes with Portland cement, seal, and cover with mastic or mortar.
- I. Allow time for inspection and approval, by Owner's Representative and City Representative (where applicable), before any backfill is placed. Relay any pipe out of alignment and remove any damage pipe at no additional cost to Owner.
- J. A minimum 4' of cover shall be provided over all storm drains. Should conditions result in storm drains with less than 36-inches of cover, 2" rigid polystyrene thermal insulation with a minimum "R" value of 10 will be required two-feet each side of the utility and a distance to be specified by the City of Dover's Representative (a minimum of 8' is required). The City of Dover's Representative shall be contacted prior to the installation of the insulation.
- K. A minimum 6" of $\frac{3}{4}$ " crushed stone bedding is required under the load bearing section of all storm drain pipe from the undisturbed stable soil to the mid-diameter of the pipe.
- L. A minimum 8" of $\frac{3}{4}$ " crushed stone bedding is required under all catch basins and manholes.
- M. After placing pipe on shaped trench bottom, backfill material shall be placed and compacted to the spring (horizontal center) line of the pipe in continuous layers not exceeding 6 inches loose depth. Additional backfill material shall then be placed from the spring line to 12 inches above the crown of the pipe, allowing for installation of filter fabric wrap as shown on the Contract Drawings. This material shall be placed and compacted in continuous layers not exceeding 6 inches loose depth.
- N. After placement of material around pipe, alignment and grade of the pipe shall be checked. If the pipe has been properly installed, the Contractor may backfill the remainder of the trench in conformance with DIVISION 31 Section "Earth Moving", and the details shown on the Contract Drawings.
- O. Should unsuitable soils be encountered in the excavated trench all material will be removed and replaced with granular fill to the limits as directed by the Owner's Representative.
- P. Should storm drain pipelines or structures approach water lines or appurtenances with less than 36-inches of separation, 2" rigid polystyrene thermal insulation with a minimum "R" value of 10 will be required two-feet each side of the utility and a distance to be specified by the City of Dover's Representative (a minimum of 8' is required). The City of Dover's Representative shall be contacted prior to the installation of the insulation.
- Q. PVC pipe used in conjunction with concrete structures may require special treatment to assure a watertight seal. Manufacturer's recommendations must be followed to assure long-term performance.
- R. Install gravity-flow, nonpressure drainage piping according to the following:
 - 1. Install piping pitched down in direction of flow.
 - 2. Install piping with 48-inch minimum cover. Drainage piping with less than 36-inch cover shall be overlaid with 2-inch thick insulation.
 - 3. Install HDPE drainage piping according to ASTM D 2321.
 - 4. Install SDR 35 PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
 - 5. Install reinforced concrete piping according to ASTM C 1479.
- S. At the end of each day's work or at other intervals, the Owner's and City's Representative, with the Contractor, may inspect the pipe installation. Unsatisfactory work shall be dug up

and reinstalled to meet the requirements of the Contract Documents with no additional time for completion of the work and at no additional cost to the Owner.

3.4 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, nonpressure drainage piping according to the following:
 - 1. Join HDPE drainage piping according to ASTM D 3212 for push-on joints.
 - 2. Join SDR 35 PVC sewer piping according to ASTM D 2321 for elastomeric-seal joints.
 - 3. Join reinforced concrete piping using bell and spigot or tongue and groove type. When storm sewer is an extension of existing concrete pipe, use joint type to match. Ends of pipe are to be pushed home and the inner surfaces to be flush and even. Joints shall be made with oil resistant compression rings of an elastomeric material conforming to ASTM C443. Manufacturer's installation instructions shall be followed.

3.5 MORTAR

- A. Mortar shall consist of two parts mortar sand to one part Portland Cement.
- B. To obtain the proper ratio, one bag of Type I or Type II Portland Cement should be mixed with two-five gallon buckets of mortar sand.
- C. The mix shall be thoroughly blended only in such quantity as may be required for immediate use, and shall be used before the initial set has taken place.
- D. The mix shall be constantly worked over with hoe or shovel to keep it workable. Adding water after mixing to bring a hardened mix "back to life" will not be allowed.

3.6 BRICK MASONRY

- A. No brick masonry shall be placed until precast structure has been approved by Owner's Representative.
- B. Brick shall be wet when laid. Lay brick or concrete masonry units in mortar so as to form full bed, with end and side joints in one operation, with joints not more than three-eighths (3/8) inch wide except when bricks or concrete masonry units are laid radially, in which case narrowest part of joint shall not exceed one-quarter (1/4) inch. Lay in true line and whenever practical joints shall be carefully struck and pointed on inside.
- C. Brick masonry shall be protected from too rapid drying by approved means and shall be protected from weather and frost, as required.
- D. Brick masonry during winter conditions must be protected from freezing. A suitable heated shelter will be required to assure all materials remain above freezing for 3 days.
- E. All brickwork used to adjust manhole and catch basin frames to grade shall be sealed, plastered, and troweled smooth with one-half (1/2) inch layers of cement mortar.
- F. Backfilling around all drainage structures and inlets shall be done in such a manner so as not to damage either structure or pipes connecting to structure.

3.7 INVERTS

- A. Manhole inverts shall be constructed to provide an uninterrupted flow channel and shall correspond in shape to the lower half of the pipe.
- B. Brick shall be laid on edge. Only solid masonry construction will be accepted under the brick shelf. Mortar joints shall be tooled flush to the face of the brick to prevent minor depressions. Shelves shall be constructed to the crown of the pipe for diameters greater than 15 inches.
- C. The brick shelf shall be pitched to drain toward the through channel with one inch of difference from the structure wall to the channel edge. Puddles or undue turbulence through the manhole trough will necessitate reconstruction.

3.8 ADJUSTING FRAMES TO GRADE

- A. Frames shall be centered over the catch basin / manhole opening.
- B. Manhole frames shall be set no less than 1/8-inch lower than the finish pavement or no more than 1/4 inch lower than finish pavement.
- C. Catch basin frames shall be set no less than 1/8" lower than the finish pavement or no more than 1/2 inch lower than finish pavement.
- D. A minimum of 2 courses of brick are required under the structure frame, yet the adjusting course shall not exceed approximately one foot of brick - (normally 5 course maximum).
- E. One course of brick may be laid on edge. Brick and mortar is the only masonry material to be used between the precast structure and the cast iron frame. The use of barrel blocks and concrete grade rings is not permitted.

3.9 IDENTIFICATION

- A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tapes directly over piping and at outside edges of underground structures.
 - 1. Use warning tape or detectable warning tape over ferrous piping.
 - 2. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.10 INSPECTION REQUIREMENTS

- A. Visual Inspections
 - 1. Visual inspections of drain pipe will be performed to assure compliance with the City of Dover's Construction Standards, latest edition. Visual inspections are normally required to confirm the hydraulic integrity of Storm drains. Pipe must be sound and flawless. Cracked, chipped or deformed pipe must be replaced. Pipelines are required to be true to alignment and at a uniform slope between structures.

2. "Ponding" or deviations in alignment will be cause for rejection. The Engineering Services Division shall determine if the ponding or deviations in alignment are cause for rejection during the review of the Storm drain video prepared by the Contractor.

B. Infiltration

1. Storm drain systems are inspected for infiltration visually and by video camera. Should infiltration be observed, other than minor signs of moisture, repair or replacement will be required.

C. Observation for Uniformity of Flow

1. Water used to flush lines will be observed for uniformity of flow through each pipeline from structure to structure.

3.11 TESTING REQUIREMENTS

A. Deflection Testing

1. Deflection test will be required on all flexible pipes. Concrete and Ductile Iron are considered to be rigid pipe.
2. Deflection tests will be conducted a minimum of 30 days after installation of pipe and after the road has been constructed to subgrade and is ready for select materials.
3. Deflection tests shall be performed on the entire length of the storm drain line on a manhole-to-manhole basis.
4. The go, no-go mandrel test method shall be used and not performed before all utilities have been installed.
5. Maximum deflection shall not exceed 5% of the pipe's internal diameter.

3.12 CLEANING

- A. Clean dirt and superfluous material from interior of catch basins and piping. Flush with potable water.

END OF SECTION 33 41 00

SECTION 334600

SUBDRAINAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Perforated SDR-35 PVC pipe and fittings for use as underdrain.
2. Geotextile filter fabrics for use as underdrain.

1.2 SUBMITTALS

- A. Product Data: For geotextile filter fabrics.

PART 2 - PRODUCTS

2.1 PERFORATED SDR-35 PVC PIPE AND FITTINGS (FOUNDATION DRAIN PIPE)

- A. Perforated SDR-35 PVC pipe is specified in Division 33 Section "Storm Utility Drainage Piping".

2.2 SOIL MATERIALS

- A. Soil materials are specified in Division 31 Section "Earth Moving."

2.3 GEOTEXTILE FILTER FABRICS

- A. Geotextile Filter Fabrics are specified in Division 31 Section "Site Clearing".

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 FOUNDATION DRAINAGE INSTALLATION

- A. Lay flat-style geotextile filter fabric in trench, on suitable compacted subgrade, and overlap trench sides.

- B. Place supporting/bedding layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 6 inches.
- C. Install drainage piping as indicated in Division 33 Section "Storm Utility Drainage Piping".
- D. Add drainage course to width of at least 6 inches on either side of pipe.
- E. Cover drainage piping to at least 6 inches above top of pipe.
- F. Wrap top of drainage course over pipe with flat-style geotextile filter fabric.
- G. Install 12" wide drainage course wrapped in flat-style geotextile filter fabric, against foundation wall, from top of footing to bottom of full depth pavement section.
- H. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches.
- I. Place backfill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches. Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.

3.3 PIPING INSTALLATION

- A. Piping installation is specified in Division 33 Section "Storm Utility Drainage Piping".

3.4 PIPE JOINT CONSTRUCTION

- A. Pipe joint construction is specified in Division 33 Section "Storm Utility Drainage Piping".
- B. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

3.5 CLEANOUT INSTALLATION

- A. Cleanouts for Foundation Subdrainage:
 - 1. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
 - 2. In vehicular-traffic areas, use NPS 4 SDR-35 PVC pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 18 by 18 by 12 inches deep. Set top of cleanout flush with grade.

3.6 CONNECTIONS

- A. Comply with requirements for piping specified in Division 33 Section "Storm Utility Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where required, connect low elevations of underdrain to stormwater manholes.

3.7 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
2. Remove obstructions, replace damaged components, and repeat test until results are satisfactory, at no additional cost to Owner.

B. Drain piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.8 CLEANING

- A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 33 46 00