

SECTION 23 00 00

HEATING, VENTILATION AND AIR CONDITIONING

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SECTION 23 00 00

HEATING, VENTILATING AND AIR CONDITIONING

(Filed Sub-Bid Required)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Sub-Bid Requirements: As provided under Section 23 00 01 – Heating Ventilating and Air Conditioning Filed Sub-Bid Requirements and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - General Requirements.
1. Work of this Filed Sub-Bid includes all individual specification sections listed in Section 23 00 01.

1.2 GENERAL REFERENCES

- A. Bidding Requirements, Contract Forms, General and Supplementary Conditions and Division 1, General Requirements are hereby made a part of this Section.

1.3 SCOPE OF WORK

- A. Work Included: The scope of work consists of the installation of all materials to be furnished under this SECTION, and without limiting the generality thereof, consists of furnishing all labor, materials, equipment, plant, transportation, rigging, staging, appurtenances and services necessary and/or incidental to properly complete all heating, ventilating and air conditioning work as shown on the Drawings, as described in the Specifications, or as reasonably inferred from either, in the opinion of the Architect as being required, and includes:
1. Variable refrigerant flow system comprised of indoor evaporator and outdoor condensers.
  2. Heat pump roof top unit w/ Energy recover.
  3. Supply ductwork with associated terminal boxes, and supply registers and diffusers.
  4. Return and exhaust ductwork with associated grilles and registers.
  5. Refrigerant piping systems and accessories.
  6. Electric cabinet unit heaters, Electric horizontal unit heaters.
  7. Toilet exhaust and general exhaust systems.
  8. Kitchen hood exhaust system.
  9. Piping and ductwork insulation.
  10. Balancing, air
  11. Automatic temperature controls.
  12. Furnish, erect and maintain staging and scaffolding, including mechanical hoisting and rigging equipment required for the performance of the heating, ventilating and air conditioning work.
- B. The HVAC Subcontractor shall be responsible for all cutting and patching related to the work of this Section except in finished surfaces. Patching is the responsibility of the trade effected.
1. For coordination of cutting and patching, refer to Section 01 31 00, PROJECT MANAGEMENT AND COORDINATION.

2. For cutting and patching specifications, refer to Section 001700, EXECUTION REQUIREMENTS.
- C. Items to be Furnished Only: Furnish the following items for installation by the designated Sections:
  1. Access Panels
    - a. Access panels for access to heating, ventilating and air conditioning equipment shall be furnished under this Section for installation by the General Contractor or appropriate Subcontractor.
- D. Items to be Installed Only: Install the following items as furnished by the designated Sections:
  1. SECTION 26 00 00 - ELECTRICAL
    - a. Duct mounted smoke detectors.
- E. Related Work: The following items of work are not included in this Section and are specified under the designated SECTIONS:
  1. DIVISION 1 - GENERAL REQUIREMENTS  
SECTION 01 31 00 PROJECT MANAGEMENT AND COORDINATION
    - a. Coordination of cutting and patching.
  2. SECTION 01 73 00 - CUTTING AND PATCHING
  2. DIVISION 2 - SITE CONSTRUCTION
    - a. Excavation, backfill, pumping and shoring.
  3. DIVISION 3 - CONCRETE
    - a. Concrete bases and supports.
  4. DIVISION 7 - THERMAL AND MOISTURE PROTECTION  
SECTION 07 00 02 - ROOFING AND FLASHING
    - a. Flashing for all roof penetrations.
  5. DIVISION 8 - DOORS AND WINDOWS
    - a. Door louvers and undercut doors.
  6. DIVISION 9 - FINISHES  
SECTION 09 00 09 - PAINTING
    - a. Field painting, except as noted otherwise. Field painting of radiation shall be done using the electrostatic method.
  7. DIVISION 8 - OPENINGS  
SECTION 08 90 00 - LOUVERS AND VENTS
    - a. Exterior wall louvers.
  8. DIVISION 11 - EQUIPMENT  
SECTION 11 40 00 - FOOD SERVICE EQUIPMENT
    - a. Kitchen equipment.
  9. DIVISION 21 - FIRE SUPPRESSION  
SECTION 21 00 00 FIRE SUPPRESSION
    - a. Sprinklers and equipment.
  10. DIVISION 22 - PLUMBING  
SECTION 22 00 00 - PLUMBING
    - a. Domestic water heaters.
    - b. Town water make-up.
  11. DIVISION 26 - ELECTRICAL  
SECTION 26 00 00 - ELECTRICAL
    - a. Power wiring except power wiring to variable air volume terminal units
    - b. Starters and disconnects where not furnished integral with equipment.

- c. Emergency generator and related equipment.
- d. Wiring of smoke detectors.
  - e. Wiring of Solid State Controller and wiring to associated destratification fans.
- f. Wiring of Solid State Controllers to respective exhaust fans.

F. The work of this Section is shown on Drawings numbered, M0.01 through M7.06”

#### 1.4 DEFINITIONS

- A. “HVAC” as used hereinafter in this SECTION shall mean “Heating, Ventilating and Air Conditioning.”
- B. “HVAC Subcontractor” as used hereinafter in this SECTION shall mean the “Heating, Ventilating and Air Conditioning Subcontractor,” i.e., the filed bid subcontractor under this Section 23 00 00.
- C. “Concealed” shall be defined as areas where piping is located in chases, shafts, pipe tunnels, and above furred ceilings.
- D. “Underground” shall mean piping exterior to or within the building that is buried. All other piping shall be considered “exposed.”
- E. “Piping” shall mean, in addition to pipe, all fittings, valves, hangers, and other accessories relating to such piping systems.
- F. “Provide” shall mean “provided complete in place,” that is, “furnished and installed.”

#### 1.5 VALVE TAGS, NAMEPLATES AND CHARTS

- A. Furnish and install on each gate and globe valve, and on all automatic control valves used in this contract, a two-inch diameter brass tag with stamped numeral a minimum height of one-half inch painted white. The tags shall be attached to the valve handles or stem necks with brass hooks or chains and properly secured.
- B. These numbers shall correspond to numbers indicated for valves on the Record Drawings and on two printed detailed lists. These printed lists shall state the numbers and locations of each valve and control and the section, fixture or equipment 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 or closed.
- C. These printed lists shall be prepared in form to meet approval of the Architect and shall be framed under glass.
- D. Nameplates, catalog numbers and rating identification shall be securely attached to electrical and mechanical equipment with screws or rivets. Adhesives or cements will not be permitted.

#### 1.6 SHOP DRAWINGS

- A. General: Refer to Division 1, General Requirements, Section 01 33 00, Submittal Procedures, for submittal provisions and procedures.

- B. In accordance with Division 1, General Requirements, submit to the Architect for approval complete sets of detailed information consisting of manufacturers' bulletins, capacities, shop drawings, and parts lists of all material to be provided for this project.
- C. Any 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. Unless noted otherwise, this is NOT a proprietary specification and it should be noted that "Or approved 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 "approved equal". It is the intent of this specification to encourage open and competitive involvement from multiple manufacturers that are able to supply similar products.

#### 1.7 CODES, REGULATIONS AND PERMITS

- A. All work done under this SECTION shall conform to the codes and regulations governing such work as set forth by the Massachusetts Department of Public Safety, the Massachusetts State Building Code and all local codes having jurisdiction.
- B. Give notices, file plans, obtain permits and licenses, and obtain necessary approvals from authorities having jurisdiction. Deliver certificates of inspection to Architect. No work shall be covered before examination and approval by Architect, inspectors and authorities having jurisdiction. Imperfect or condemned work shall be replaced with work conforming to requirements, without extra cost to Owner, subject to the approval of the Architect. If work is covered before due inspection and approval, the HVAC Subcontractor shall pay costs of uncovering the installed work, whether it meets contract requirements or not.
- C. Refer to Supplementary General Conditions 00 80 00 for payment fees.
- D. Refer to Division 1, Section 01 41 00, Regulatory Requirements.

#### 1.8 INTENT

- A. It is not intended that the Drawings show every pipe, fitting, and appurtenance. All such parts necessary for the complete execution of the work, in accordance with the best practices of the trade and to the satisfaction of the Architect shall be provided whether these parts may have been specifically mentioned or not, or indicated on the Drawings.

#### 1.9 DRAWINGS AND SPECIFICATIONS

- A. The Drawings and Specifications are complementary each to the other, and any labor or material called for by either, whether or not by both, or necessary for the successful operation of any components shall be furnished and installed.
- B. Before installing any work, verify that it does not interfere with the clearances required for other work. Installed work which interferes with existing necessary services shall be modified as directed by the Architect, at no additional cost to the

Owner.

- C. Be familiar with the Drawings and Specifications of all other trades to prevent interferences and assure complete coordination.

#### 1.10 GIVING INFORMATION

- A. Keep fully informed as to the shape, size and position of all openings and foundations required for all apparatus furnished under this SECTION and give full information to the General Contractor sufficiently in advance of the work, so that all such openings and foundations may be built in advance. Furnish all sleeves and supports herein specified, so the General Contractor may build same in place.
- B. In the case of failure to give proper information as noted above, assume the cost of having necessary changes to the work made by the General Contractor.

#### 1.11 OBTAINING INFORMATION

- A. Obtain detailed information from the manufacturers of apparatus which is to be provided, for the proper methods of installation. Obtain all information from the General Contractor and other Subcontractors which may be necessary to facilitate the work and the completion of the whole project.

#### 1.12 MATERIALS AND EQUIPMENT

- A. All materials and equipment furnished under this SECTION shall be new and of the best grade for the service intended. The manufacturers mentioned in the specifications are intended to indicate the quality desired. Any substitutions shall be as approved by the Architect as herein provided by the "or equal" clause, in addition to meeting the limitations of space and capacity shown or specified. Re-built materials and equipment will not be accepted.

#### 1.13 REFERENCES

- A. National standards referenced herein are included to establish recognized quality only. Equivalent quality and testing standards will be acceptable subject to their timely submission, review and acceptance by the Designer.
- B. Refer to SECTION 01420 - REFERENCES for schedule of references.
- C. Reference Standards:
  - 1. Reference herein to any technical society, organizations, group or body are made in accordance with the following abbreviations:

ADC	Air Diffusion Council
AMCA	Air Moving and Conditioning Association
ANSI	American National Standards Institute
ARI	Air Conditioning & Refrigeration Institute
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing Materials
AWG	American Wire Gauge

AWS	American Welding Society
FS	Federal Specifications
IEEE	Institute of Electrical and Electronic Engineers
NEC	National Electrical Code
NEMA	National Electrical Manufacturer Association
NFPA	National Fire Protection Association
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
UL	Underwriters Laboratories, Inc.

#### 1.14 COORDINATION DRAWINGS

- A. Before materials are purchased or work is begun, the HVAC Subcontractor shall prepare and submit to the Designer, Coordination Drawings showing the size and location of his equipment, ductwork 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.
- B. Coordination drawings are for the Contractor's and the Designer's use during construction and shall not be construed as replacing any shop or record drawings required elsewhere in these Contract Documents.

#### 1.15 MOTORS AND STARTERS

- A. Motors for all equipment under this SECTION shall be quiet in operation and shall be guaranteed to run without objectionable noise or vibration.
- B. Motors smaller than one-half (1/2) horsepower shall be wound for 120 volts, single phase, 60 hertz.
- C. Motors one-half (1/2) horsepower and larger shall be wound for 480 volt, 3 phase, 60 hertz.
- D. Starters provided for all other equipment shall be provided by the Electrical Subcontractor.
- E. Starters shall have properly calibrated thermal overload, compensating type thermal heaters in accordance with motor characteristics. Starters shall be magnetic for remote control and be equipped with auxiliary contacts.
- F. Voltages shown in Paragraphs B and C are typical unless otherwise noted.
- G. All motors one horsepower and over shall be premium efficiency type.

#### 1.16 TEMPORARY HEATING

- A. Special reference is made to "Heating during Construction", Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS.

#### 1.17 OPERATIONS AND MAINTENANCE MANUALS

- A. Refer to SECTION 01 78 00 - CLOSEOUT SUBMITTALS, for submittal procedures pertaining to operating and maintenance manuals.



- B. At least two (2) months prior to the time of turning over this contract to the Owner for Use & Occupancy or substantial completion, secure and deliver to the Architect three (3) complete indexed files containing approved operating and maintenance manuals, shop drawings, and other data as follows:
  - 1. Operating manuals and operating instructions for the various systems.
  - 2. Catalog data sheets for each item of mechanical or electrical equipment actually installed including performance curves, rating data and parts lists.
  - 3. Catalog sheets, maintenance manuals, and approved shop drawings of all mechanical or electrical equipment controls and fixtures with all details clearly indicated.
  - 4. Names, addresses and telephone numbers of repair and service companies for each of the major systems installed under this Contract.
  - 5. Copies of all service contracts provided for the guarantee period.
  - 6. Copies of all equipment and system warranties.
- C. Non-availability of operating and maintenance manuals or inaccuracies therein may be grounds for cancellation and postponement of any scheduled final inspection by the Owner until such time as the discrepancy has been corrected and/or retainage of sufficient monies to prepare same.
- D. Provide qualified trained personnel to insure proper operation of the systems and to train the Owner's operating and maintenance personnel in the proper operation and maintenance of the systems. Instruction period shall be a minimum of two (2) eight-hour days. Coordinate with Commissioning Agent per specification section 01 91 00.
- E. Refer to SECTION 01 75 00, Starting and Adjusting. Coordinate all start-up, operation, and testing activities with the Project Manager, General Contractor and the Commissioning Agent per specification section 019100.

#### 1.18 RECORD DRAWINGS

- A. General: Refer to Division 1, General Requirements, SECTION 017800, Close-out Submittals for Requirements.
- B. The work of this Section is shown on Drawings numbered, M0.01 through M7.06

#### 1.19 CONTRACT COST BREAKDOWN

- A. Within 30 days of commencing the work, submit to the Architect a complete breakdown of the Contract price to aid in determining the value of the installed work during the construction period. The form shall correspond to the construction schedule with a percentage of progress to complete breakdown with progress description by month.

#### 1.20 GUARANTEE AND SERVICE

- A. Attention is directed to the provisions of the CONTRACT AND GENERAL CONDITIONS regarding guarantees/warranties for the Work.
- B. Manufacturers shall provide their standard guarantees/warranties for work under this Section. However, such guarantees/warranties shall be in addition to and not in lieu of all other liabilities which the manufacturer and the Contractor may have

by law or by other provisions of the Contract Documents.

#### 1.21 DEBRIS REMOVAL AND CLEAN-UP

- A. The HVAC Subcontractor shall, at the end of each day's work, remove waste materials and debris resulting from the installation of the heating, ventilating and air conditioning system. The HVAC Subcontractor shall deposit such waste and debris in a dumpster on-site. Dumpster shall be provided by the General Contractor. The General Contractor shall be responsible for the emptying of dumpster when required.

The HVAC Subcontractor shall, at the completion of his work, remove from the school property all tools, equipment and surplus materials resulting from the installation of the heating, ventilating and air conditioning system.

#### 1.22 COMMISSIONING REQUIREMENTS

- A. An independent Commissioning Agent (CA) will be retained for this project. The commissioning process will be implemented in accordance with the LEED for Schools v2009 and Commissioning Credits EAp1 – Fundamental Commissioning of Building Energy Systems and EAc3 – Enhanced Commissioning.
- B. This contractor shall assist and support the CA as necessary in accordance with the requirements of specification section 019100 – COMMISSIONING.
1. "Commissioning of a system or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Tenant's and Building Owner's operation and maintenance personnel, is required in cooperation with Tenant's and Building Owner's Representatives and the Commissioning Agent. Project Closeout is dependent on successful completion of all commissioning procedures, documentation and issue closure. Refer to Commissioning Specification, Section 019100, for detailed commissioning requirements."

### PART 2 - PRODUCTS

#### 2.1 ACCESS PANELS

- A. All work shall be installed so that all parts requiring inspection, operation, maintenance and repair are readily accessible. Minor deviations from the drawings may be made to accomplish this, but changes of magnitude shall not be made prior to written approval from the Architect.
- B. Furnish access panels for installation in walls and ceilings at locations indicated on the drawings or as required to permit access.
- C. All access panels shall be located in closets, storage rooms and/or other non-public areas, in a workmanlike manner, positioned so that junction can be easily reached and the size shall be sufficient for this purpose (minimum 12 inches x 16 inches). When the access panels are required in corridor, lobbies or other habitable areas, they shall be located as directed by the Architect.
- D. Access panels shall be as manufactured by Inland Steel Products Company "Milcor", Walsh-Hannon-Gladwin, Inc., "Way-Loctor" or approved equal. Types

shall be as follows:

- |    |                 |                  |
|----|-----------------|------------------|
| 1. | Masonry or Tile | “Milcor” Type M  |
| 2. | Drywall         | “Milcor” Type DW |
| 3. | Fire-Rate       | “Milcor”         |

- E. Units shall have 16 gauge steel frame and 14 gauge steel hinged door panel. Door shall have concealed spring hinges allowing door to be opened to 175 degrees.
- F. Provide flush screwdriver operated camlocks in accordance with manufacturer’s schedule of panel sizes and number of locks.
- G. Units shall be factory primed for field painting by Section 09 00 09.
- H. Install U.L. rated 1-1/2 hour Class B access panels where required to comply with applicable code requirements.

## 2.2 DUCTLESS SPLIT FANCOIL SYSTEM

- A. Provide a complete split system type ductless fancoil air conditioning system consisting of compact mounted packaged evaporator sections with matching air cooled outdoor condensing unit. The units shall be listed by the Electrical Testing Laboratories (ETL) and bear the ETL label. All wiring to be in accordance with the National Electrical Code (NEC). The units shall be rated in accordance with ARI Standard 210 and bear the ARI label. A full charge of R-410a for 25 feet of refrigerant tubing shall be provided in the condensing unit. System SEER shall meet or exceed 1992 Federal Standards.
  - 1. The system components shall be provided by a single manufacturer to provide for an integrated, 100% compatible installation. System shall be as manufactured by Mitsubishi Company, Sanyo Company or Trane.
- B. The units shall have a manufacturer’s warranty for a period of one (1) year from date of installation. The compressor shall have a warranty of six (6) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the site of installation.
- C. The indoor unit shall provide a total minimum cooling capacity as scheduled on the drawings with an SEER of 10.0 or an EER of 9.9 at ARI Standard conditions. The system net minimum total cooling capacity shall be rated at 67 degrees FDB indoor and 95 degrees FDB air entering the outdoor coil.
- D. The indoor unit shall be completely factory assembled and wired. The casing shall be of galvanized sheet steel, phosphatized, bonderized and finished in a baked enamel white finish.
  - 1. The evaporator fan shall be a high performance forward curve line flow fan direct driven by a single motor. The fan shall be statically and dynamically balanced and shall run on permanently lubricated bearings.
  - 2. An adjustable change vane shall be provided with the ability to direct the air flow from horizontal to vertical. An adjustable guide vane shall be provided to manually change the air direction from left to right.
  - 3. The evaporator coil shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phoscopper or silver alloy. The coils shall be pressure tested to 450 psig at the factory.

4. An insulated condensate pan with drain shall be provided under the coil.
- E. The control system shall consist of multiple microprocessor sections. One microprocessor shall be factory wired and located within each indoor unit. It shall have the capability of sensing room temperature and indoor coil temperature; receive and process commands from the remote controller; and control the outdoor unit. The Contractor shall be responsible for required interlock wiring.
1. The microprocessor within the wall mounted remote controller shall display setpoint; provide two (2) manually selected modes of cooling, normal and economy operation at 2 degrees above setpoint; night set back operation of 4 degrees above setpoint; and manual or automatic fan speed control.
  2. The optimum temperature shall be memorized for immediate recall as the system default setpoint whenever the system is used again.
  3. The system shall be capable of automatic restart when power is restored after power interruption.
  4. Automatic fan speed control shall be based upon the temperature difference between setpoint and room temperature maintaining lowest speed possible.
  5. A remote control unit shall be wireless, using infrared, line of sight for control of system and shall include automatic ON/OFF timer; liquid crystal display, and temperature reset capability. Furnish and install, in the field, on the wall, a remote control unit holder.
- F. The outdoor unit shall be completely factory assembled, piped and wired. The casing shall be fabricated of galvanized steel, phosphatized, bonderized and finished with baked enamel. The unit shall be furnished with direct drive, propeller type fans arranged for horizontal discharge.
1. The motor shall have inherent protection, be of the permanently lubricated type and resiliently mounted for quiet operation.
  2. The fans shall be provided with a raised guard to prevent contact with moving parts.
  3. Multiple compressors shall be provided, one for each indoor evaporator fancoil unit. The compressors shall be of the high performance rotary type with accumulator and internal thermal overloads. The compressors shall be mounted so as to avoid the transmission of vibration.
  4. The refrigeration system shall have the capability to operate with maximum height difference of 25 feet and overall refrigerant tubing length of 160 linear feet between indoor and outdoor sections without the need for line size changes, traps, or additional oil. Refrigerant flow from the condenser to be controlled by means of capillary tubes.
  5. The condenser coil shall be non-ferrous construction with smooth plate fins bonded to copper tubing. The coil shall be protected with an internal metal guard finish to match unit panels.
  6. The unit shall be controlled by the microprocessor located in the matching indoor units.

### 2.3 FANS (CENTRIFUGAL)

- A. Centrifugal fans mounted in ceiling, wall or with inline duct configuration shall be of the sizes and capacities indicated on the drawings. Fans shall be centrifugal type manufactured by Cook, Greenheck, Acme or Penn Ventilator Company.
- B. Fans shall be provided with damper and adapter kit for installing fan with an inline arrangement, where applicable a wall vent, or roof vent cap for installation on an

insulated curb provided by the HVAC Contractor.

- C. Provide solid state controller to allow full range control of fan speed.

#### 2.4 FANS (ROOF)

- A. Roof exhaust fans shall be of the centrifugal belt-driven or direct-drive type as indicated on drawings. Fans shall be of capacities and characteristics as scheduled on drawings and specified herein. Fans shall be as manufactured by Greenheck, Cook or Penn Ventilator Company.
- B. Construction of the fan housing shall be of heavy-gauge aluminum.
- C. All spun parts shall have a rolled bead for added rigidity and shall be specially spun so as to seal the pores of the aluminum providing greater resistance against oxidation and deterioration.
- D. The fan wheel shall be all-aluminum of the centrifugal blower type featuring backward-inclined blades and a tapered inlet shroud. Wheels shall be statically and dynamically balanced. Inlet cone shall be aluminum and of the centrifugal blower type. Motor and drives shall be enclosed in a weathertight compartment, separate from the exhaust air stream. Air for cooling the motor shall be supplied to the motor compartment by way of an air passage from an area free of contaminated exhaust fumes. Motors shall be of the duty, permanently lubricated, sealed ball-bearing type. Drives shall be sized for 165 percent of motor horsepower capabilities and of the cast-iron type, keyed to the fan and motor shafts. Variable pitch drives shall be standard. Fan shall be of steel construction, turned, ground, and polished to precise tolerances in relationship to the hub and bearings. Drive belts shall be of the oil-resistant, non-static, non-sparking type with life expectancy of 24,000 hours.
- E. Bearings shall be flanged and of the permanently lubricated, permanently sealed, ball-bearing type capable of over 200,000 hours bearing life. The entire drive assembly and wheel shall be removable as a complete unit, from the support structure without disassembling the external fan housing. The complete drive assembly shall be mounted on rubber vibration isolation.
- F. Direct drive units shall be of identical construction as belt drive units, except for drives, belts, and fan shaft bearings.
- G. Fans shall be licensed to bear the AMCA ratings seal for air and sound performance.
- H. Fans shall be furnished with pre-fabricated 18 inch high roof curbs. Roof curbs shall have 2 inch raised cant strip and wood nailer. Curb shall be aluminum construction with all seams continuously welded the entire length. Curbs shall meet the one "G" acceleration criteria. Fans shall be furnished with automatic motor operated damper.
- I. Provide solid state speed controller as a disconnect for direct drive fans, pre-wired and mounted. Provide pre-wired and mounted disconnect switch on belt drive fans.

2.5 ELECTRIC CEILING UNIT HEATER

- A. The heating equipment shall include an electric, ceiling-mounted type CDF Series 500 fan-forced air heater suitable for large area heating as manufactured by QMark, a Marley Engineered Products Brand, Bennettsville, SC or approved manufacturer. Heater shall be UL listed. The heater shall be designed for surface, recess, or T-Bar mounting. For surface mounting, a QMark CDF-SE surface enclosure shall be used. For T-Bar mounting, a QMark CDF-RE recess enclosure shall be used. For recessed mounting in a permanent ceiling, a QMark CDFRE recess enclosure and CDF-TK trim kit shall be used. The heaters shall be factory wired for single-phase operation and field convertible to three-phase operation by removing one jumper wire. The heaters should be factory wired for full wattage and field convertible to 75% or 50% wattage by the removal of one or two wires respectively.
- B. HEATER SECTION - The heater section shall consist of a 20 gauge steel chassis on which are mounted the heating elements, fan motor and blade, fan control, thermal cutout, and 3-pole contactor. Heater section shall be completely prewired.
- C. HEATER ELEMENTS - The heating elements shall be guaranteed for five years and shall be of non-glowing design consisting of 80/20 NiCh resistance wire, enclosed in a steel sheath, to which steel plate fins are brazed. The elements shall cover the entire air intake area to ensure uniform heating of all discharged air.
- D. MOTOR AND CONTROLS - The fan motor shall be impedanceprotected, permanently lubricated, and with totally-enclosed rotor. Fan control shall be bi-metallic, snap-action type and shall activate the fan immediately and continue to operate the fan after the thermostat is satisfied and until all heated air has been discharged. Thermal cutout shall be bi-metallic snap-action type designed to automatically shut off the heater in the event of overheating and reactivate the heater when temperature returns to normal.
- E. OPERATIONAL CONTROLS - Thermostat, disconnect switch, and all interlock relays shall be installed within the heater enclosure.
- F. RECESS ENCLOSURE - The back box shall be designed for duty as a recessed rough-in box in masonry, T-Bar, or frame ceiling construction. The back box shall be 20 gauge galvanized steel and shall contain knockouts through which field wiring leads are brought. Enclosures to recess into a maximum 7 inches of ceiling space. The louvered recess faceplate shall be of 20 gauge cold rolled steel, phosphatized, then electrostatically painted Navajo white by a baked enamel process.
- G. SURFACE ENCLOSURE - The surface mounting plate shall be designed for duty as a rough-in box on masonry, T-Bar, or frame ceiling construction. The surface mounting plate shall be 20 gauge galvanized steel and shall contain knockouts through which field wiring leads are brought. Enclosure to extend a maximum of 6 inches into the heated space. The louvered surface wrapper shall be contoured aluminum extrusion and 20 gauge sheet metal combination with rounded corners. The surface wrapper shall be electrostatically painted Navajo white by a baked enamel process.

2.6 ELECTRIC UNIT HEATER

- A. Unit mounts either horizontally or vertically. Totally versatile. For factories, warehouses, garages, stores, shipping rooms, power stations. Can be used for primary, supplementary, spot, or dual-system heating.
- B. Wide range of optional control kits are field installable, increasing the MUH adaptability to the specification market.
- C. Forced air unit heater with 10 power ratings; from 3KW to 50 KW heating output; 208, 240, 277 and 480V, 10,230 to 170,500 BTU/hr.
- D. 32 compatible models (no need to try to assemble a heating system from 70 or 80 models!)
- E. Heavy gauge die-formed steel housing. Two-toned, smartly styled with stainless steel louvers.
- F. Advanced pull-through air flow design draws air across heating element for more even air distribution and cooler element operation.
- G. Specially designed venturi outlet to meet that added throw as required in vertical position.
- H. Branch circuit fusing (when required).
- I. Completely enclosed fan motor.
- J. 1- or 3-phase wiring on 5 through 10 KW 208/240V and 15 KW 208V units (field interchangeable).
- K. Aluminum-finned, copper clad steel sheath heating element has longer useful life, because of cooler sheath temperature and faster heat dissipation.
- L. 24V control transformer standard on most models, providing a safer and more accurate means of temperature control. 3KW and 5KW, 208-277V, have line voltage controls as standard (24V control available on made-to-order basis).
- M. Automatic reset linear thermal cut-out, capillary type, provides protection over entire length of element areas (Manual reset protection available on made-to-order basis).
- N. 2-speed fan selector switch (25 to 50 KW models).
- O. Fan delay feature eliminates cold drafts. Element heats up before fan cuts in, then fan continues to distribute heat after element shuts off.
- P. Ruggedly built, yet lighter weight for easier installation. No piping flutes, valves, or traps.
- Q. Individually adjustable discharge louvers to control air flow.
- R. Choice of optional diffusers for variety of air patterns, maximizing heat concentration and coverage in the vertical position.
- S. Meets all UL, NEC, and OSHA requirements.

2.7 ELECTIC WALL HEATER

- A. The heating equipment shall include electric, automatic fan forced air heater suitable for large area heating, as manufactured by QMark®, A Marley Engineered Products Brand, Bennettsville, SC or approved equal. The heater shall be designed for wall recess or surface mounting. Heaters shall be UL listed or equivalent (ETL).
- B. HEATER ASSEMBLY: The heater assembly which fits into the back box shall consist of a fan panel upon which is mounted all of the operational parts of the heater.
- C. HEATING ELEMENT: The heating element shall be of the non-glowing design consisting of a special resistance wire enclosed in a steel sheath to which steel plate fins are copper brazed. It shall be warranted for 5 years.
- D. FAN AND MOTOR: Fan shall be five-bladed aluminum. Fan motor shall be totally enclosed.
- E. FAN DELAY SWITCH: Fan control shall be of bi-metallic, snap-action type and shall activate fan after heating element reaches operating temperature. The fan shall continue to operate after the thermostat is satisfied and until the heating element is cool.
- F. THERMOSTAT: The tamper-proof thermostat shall be of the bi-metallic snap-action type with enclosed contacts. It shall be completely concealed behind the front cover to become tamper proof.
- G. THERMAL CUTOUT: A manual-reset thermal cutout shall be built into the system to shut off the heater in the event of overheating.
- H. POWER ON/OFF SWITCH: A double-pole, single throw ON/OFF switch shall be mounted on the back box for positive disconnect of power supply. It will be completely concealed behind the front grille panel.
- I. LOW VOLTAGE RELAYS: 24-volt and 120 volt low voltage relays shall be available as optional equipment to control 208, 240 or 277 volt heaters in conjunction with central energy control systems. The built-in thermostat can then be used as one of the thermostats in an automatic night set back operation.
- J. BACK BOX: The back box shall be designed for duty as a recessed rough-in box in either masonry or frame installations, and is also used with the surface mounting frame in surface mounting installations. The back box shall be 20-gauge galvanized steel and shall contain knockouts through which power leads are brought.
- K. FRONT PANEL: The front panel shall be of the bar grille type and shall be constructed of 16-gauge cold-rolled steel, welded into a uniform grille to direct the warmed air toward the floor. The front grille shall be surrounded by a decorative satin-finish aluminum "picture" frame.
- L. THREE PIECE DESIGN: The heater shall be made up of a back box, a heater assembly and a front panel.



2.8 EXHAUST FANS (INLINE TUBULAR CENTRIFUGAL)

- A. Inline centrifugal fans shall be of the sizes and capacities indicated on the drawings. Fans shall be tubular centrifugal as manufactured by American Air Filter Model Centriline as manufactured by Greenheck, Cook, Penn Ventilator or Tubular Acoustafoil.
- B. Fan housings, fan wheels and all other fan parts shall be aluminum construction. Fans shall include inlet and outlet flanges, straightening vanes, mounting brackets. Fan bearings shall be grease lubricated ball bearing type with grease nipples extended outside fan casings. Fans shall be provided with motor drives on adjustable motor base, adjustable drive sheaves and belt drive with belt guards.
  - 1. (Fans shall be belt driven inline tubular centrifugal type AMCA rated. Housings shall be of heavy welded steel construction with inlet and outlet flanges, straightening vanes, variable inlet vanes and mounting bases or brackets to suit fan position.)
- C. Fan wheels shall be centrifugal type, statically and dynamically balanced. Fan bearings shall be grease lubricated ball bearing type with grease nipples extended outside fan casing. Fan casing shall have raised type removable access doors. Fans shall be provided with motor drive sheaves and belt drive with belt guards. Fans shall receive factory applied primer on clean bare metal followed by enamel finish coats. Where fans are mounted without inlet or outlet duct connections, protective screening shall be provided. Where non-sparking construction is indicated, all fan parts shall be field grounded and inlet cones and rubbing plates shall be non-ferrous.

2.9 FILTERS

- A. **MERV 8**
  - 1. Air Filters shall be Model Pre Pleat 62RM8 panel filters, as manufactured by Flanders Precisionaire or approved equal.
  - 2. Each filter shall consist of an electrostatically charged synthetic only media, with corrosion-resistant expanded metal backing and moisture resistant enclosing frame. The filter shall be 1", 2" or 4" nominal depth. The grid shall be 100% bonded to the media on the air exiting side to eliminate media vibration and pull away.
  - 3. The grid shall be formed to provide a uniform V-wedge shaped pleat with the open area on the air exiting side for maximum utilization of the media and low airflow resistance. The filter shall be classified for flammability by Underwriters Laboratories, Standard 900 as Class 2.
  - 4. The filter shall have a Minimum Efficiency Reporting Value of 8 by ASHRAE Standard 52.2.
- B. **MERV 13**
  - 1. Air Filters shall be Model Dominator High Efficiency Rigid Cell Extended Surface Filter, as manufactured by Purolator or approved equal.
  - 2. Each filter shall consist of 100% synthetic media. The cell sides shall be high strength, high impact polystyrene plastic and the entire filter shall be completely incinerable. The filter shall be 4" nominal depth.
  - 3. The filter shall be classified by Underwriters Laboratories, Standard 900 as Class 1.
  - 4. The filter shall have a Minimum Efficiency Reporting Value of 13 by

ASHRAE Standard 52.2.

2.10 FOUNDATIONS AND SUPPORTS

- A. All mechanical equipment and systems shall be substantially supported without distortion or excessive vibration. The methods of support shall be as hereinafter described, except as otherwise noted on the drawings. This Contractor shall locate all equipment bases and shall provide all anchor bolts and templates to the General Contractor who shall form and set all concrete work and shall set all anchor bolts. Anchor bolts and nuts shall be galvanized.
- B. Concrete housekeeping pads shall follow equipment plan shape and be 6 inches in height. Where equipment is set directly on housekeeping pads the space between equipment base and pad top shall be filled by the General Contractor with non-shrinking grout. Where equipment shape or mounting is such as to require an air space between equipment bases and pad, the pad shall then be furnished with a smooth troweled surface. All equipment shall be anchored to housekeeping pads or all intervening vibration isolator bases shall be anchored to the structure.
- C. Where steel frame floor supports are indicated to be provided, such framing shall be all-welded type with two coats of red primer. The framing system shall be substantial type with members sized to prevent equipment distortion or excessive vibration. Framing shall be simple post and beam box type with diagonal bracing to prevent lateral movement. Beam members shall be positioned to align with equipment support points for proper bolting and posts shall be positioned to prevent excessive beam cantilevering. Posts shall be provided with baseplate anchored to the structure.
- D. Where steel framing supports are indicated to be provided for roof mounted equipment (those without integral curbs for setting into roof structure) the same framing system as described above shall be used, except members shall be galvanized and bolted together. Posts shall be positioned to align both framing and roof structural members with pitch pockets at roof penetrations.
- E. Ground-mounted equipment shall be supported with framing system similar to roofing application described above except that posts shall be set on poured-in-place concrete piers with galvanized anchor bolts. Concrete piers shall be provided by the General Contractor.

2.11 GRAVITY VENTILATORS

- A. Gravity ventilators shall be roof mounted air intake louver houses as manufactured by Cook, Greenheck, or Penn Ventilator Company.
- B. Louver houses shall have heavy gauge extruded 6063-T5 aluminum blade of the storm blade style with corners metered and welded. Roof and curb caps shall be formed of minimum 0.051 gauge aluminum unit base to be minimum 0.080 gauge. The entire assembly braced by heavy mill gauge galvanized steel interior upright angles at the corners and along the sides. Manufacturer's catalog ratings shall be based upon tests conducted in an industry approved testing laboratory with air volumes and losses as shown.
- C. Per ANSI-A58.1 testing standards, each ventilator must be rated for 100 MPH wind load and 101.5 lbs. per square foot snow load.

- D. Furnish 1/2" thick sprayed on plastic coating to eliminate condensation on underside of roof. Intake ventilators to be 200% free area. Relief vents to be 150% free area.
- E. All seams to be continuously welded. Equip all ventilators with aluminum bird screen.
  - 1. Provide a roof curb of matching construction details, coordinated with the roof construction within which it is to be installed. Curb shall be equipped with a two position, electrically driven damper at the integral utility shelf within the curb, for each gravity ventilator.
- F. Provide entire aluminum assemblies in three-coat, fluoropolymer color, to be selected by the Architect from manufacturer's standard range of colors and gloss.
  - 1. Surfaces to be acid chromate-fluoride-phosphate pre-treated.
  - 2. Provide manufacturer's standard three-coat, thermo-cured system composed of specially formulated inhibitive primer, fluorocarbon color coat and clear fluorocarbon topcoat, with both color coat and clear topcoat containing not less than 70 percent polyvinyl resin by weight; complying with AAMA 605.2.
  - 3. Provide with five (5) year warrantee.

2.12 INSULATION MATERIALS (GENERAL REQUIREMENTS)

- A. All insulation materials to be furnished for installation under this section shall be as manufactured by Owens-Corning, Certaineed, Knauf, or Schiller Company.
- B. Shop drawings shall be submitted for all insulation system materials to be furnished for installation under this section. Submittals shall include descriptions of the application of all materials to be used for each insulation class and catalog cuts of all materials furnished.
- C. All insulation materials to be furnished for installation under this section shall conform to fuel contributed flame spread and smoke developed limits set forth in NFPA Standard 90A as determined by NFPA 255, ASTM E84 or UL723 tests.

2.13 INSULATION (PIPING)

- A. Piping systems shall be insulated as specified herein and as indicated on the drawings.

Piping System Types	Fluid Temp. Range F.	Runouts Up to 2"	Insulation Materials In Inches for Pipe Sizes					Class
			1" & Less	1 1/4" – 2"	2 1/2" – 4"	5" to 6"	8" & Larger	
Coil Drains	Any	3/4	3/4	3/4	3/4	3/4	3/4	Inside 104 Outside 107

Runouts not exceeding twelve (12) inches in length.

Note: Provide 0.016 inch thickness embossed aluminum protective jacketing on all insulated piping within mechanical rooms within 6 feet of floors.

- B. Insulation shall be omitted from the following piping:
1. Equipment vent piping.
  2. Equipment drain piping beyond shut off valve.
  3. Piping within fintube covers.

Class 104

Piping: Insulation shall consist of high density (minimum #4) molded fiberglass sectional pipe insulation with a minimum R value of 4.0 H. degrees F. ft.<sup>2</sup>/BTU per inch, with factory applied all-service jacket with vapor barrier, butt and lap end strips shall be self-sealing or secured with vapor seal adhesive. Mechanical Room piping shall be covered with PVC Piping Insulation Cover

Fittings, Valves and Flanges: 2 inch size and smaller shall be insulated with 1 pound density and secured with 20 gauge annealed steel wire. Then apply insulating and finish cement to match the adjacent pipe insulation thickness and then have two (2) 1/8 inch thick smoothing and finishing coats of vapor seal adhesive applied using intermediate glass fabric reinforcing. Vapor seal adhesive shall lap adjacent pipe cover. Fittings may be insulated with two layers of fiberglass with PVC covers. Mechanical Room fittings, valves and flanges shall be covered with PVC Piping Insulation Cover.

Valves, Fittings and Flanges: 2½ inch size and larger shall be insulated using sections of high density fiberglass molded sectional pipe insulation cut to fit, secured with 20 gauge annealed steel wire. All voids and pockets shall then be filled with insulating cement and finish cement. Finish shall be two 1/8 inch thick smoothing and finishing coats of vapor seal adhesive applied using intermediate glass fabric reinforcing. Vapor seal adhesive shall lap adjacent pipe cover. Mechanical Room fittings, valves and flanges shall be covered with PVC Piping Insulation Cover.

Class 107

Tubing and Piping: Insulation shall consist of flexible type foamed plastic pipe insulation with flame spread rating of 25 or less and smoke development rating of 50 or less per ASTM E84-75 test, integral vapor barrier. Insulation shall be slit type, field sealed with companion adhesive.

Fittings, Valves and Flanges: Tubing Systems – Fittings shall be made by miter cutting of adjacent straight piping runs and sealing joints with companion adhesive. Valves shall be insulated by using a combination of nested pipe insulation and sheets to form a complete enclosure with all joints sealed with companion adhesive. Flanges shall be insulated by using sheets cut to fit pipe side of flange and wrapping sheets around flange perimeter. All joints shall be sealed using companion adhesive. Piping Systems – Fittings shall be insulated using nested sections of pipe insulation mitered to form a square corner and sealing joints with companion adhesive. Valves and flanges shall be insulated as described for tubing systems.

- C. PVC Piping Insulation Cover:
1. Piping insulation cover shall be of nominal thirty (30) mil UV stabilized PVC preformed to appropriate shapes for straight piping, fittings, valves and accessories. Solvent welding type adhesive shall form a permanent chemical bond between surfaces and shall present a continuous vapor barrier across the joint.

2. Mechanical Room piping insulation cover shall be of nominal thirty (30) mil colored PVC preformed to appropriate shapes for straight piping, fittings, valves and accessories. Solvent welding type adhesive shall form a permanent chemical bond between surfaces and shall present a continuous vapor barrier across the joint. The following color coding shall be utilized:
3. PVC piping insulation cover shall incorporate the following characteristics.

<u>Typical Properties</u>	<u>Test Method</u>	<u>Value</u>
Service Range	N.A.	0°F. to 150°F
Specific Gravity	ASTM D-792	1.48
Flame Spread	ASTM E-84-97a	25
Smoke Developed	ASTM E-84-97a	50
<u>Typical Properties</u>	<u>Test Method</u>	<u>Value</u>
Flexural Strength	ASTM D-638	11,500 psi
Tensile Modulus	ASTM D-638	470,000 psi
Elongation at Yield	ASTM D-638	3% MD
Flexural Modulus	ASTM E-790	460,000 psi
Electrical Conductance	D-257	Non-conductor
Gardner-SPI Impact	D-3679	8 lb/mil (30 mil sample)
Abrasion	Taber Method	10,000 revolutions, CS-17 wheel, 1,000 gr weight
Water Vapor Transmission	ASTM E96-95	0.009 perms

2.14 INSULATION (SHEET METAL)

- A. Sheet metal work shall be insulated as specified herein and as indicated on the drawings.
- B. Insulation shall be applied to the following:
  1. All air conditioning systems ductwork and associated equipment exposed to view; all systems outside air plenums, ducts and louver boxes; all system exhaust air plenums, ducts and louver boxes from louver connections back to automatic dampers. All portions of heating and ventilating and air conditioning unit casings not internally insulated, all air conditioning systems return air fans and all equipment shall have Class 131 insulation.
  2. All concealed air conditioning system supply and return air ductwork and associated equipment including terminal box reheat coil casings, shall have Class 135 insulation.
  3. Insulation liner shall be provided where indicated on the drawings. Refer to sheet metal work.
  4. All sound attenuators in insulated system ductwork shall be insulated. Sound attenuator sections furnished with Rooftop air handling units shall be insulated in field when not furnished insulated by the unit manufacturer.
- C. Kitchen grease ductwork shall have 3-inch Class 130 insulation.
- D. Insulation shall be omitted from the following sheet metal work:
  1. Toilet, locker and storage exhaust ductwork except where noted on

drawings.

- E. All louver plenums, louver blank-off plates and ductwork which will conduct air shall have insulation thickness increased to a minimum of 2 inches or as indicated on drawings.
- F. All supply and return ductwork located outside shall have rigid board insulation with thickness increased to a minimum of 3 inches and be provided with a weatherproof cover in addition to the vapor barrier.

1. Class 130

- a. Insulation shall consist of a UL listed duct wrap system complying with UL 1978 and ASTM E-119. Blanket material shall be in alumina (45% ±) composite incorporating the following characteristics.
- b. Service Range: 0°F to 2300°F
- c. Melting Point: 3200°F
- d. R Value @ 70°F:  $4.5 \frac{\text{Hr.Sq.Ft.}^\circ\text{F.Inch}}{\text{BTU}}$
- e. R Value @ 283°F:  $9.9 \frac{\text{Hr.Sq.Ft.}^\circ\text{F.Inch}}{\text{BTU}}$
- f. Flame Spread: 5 (ASTM E84/UL-723)
- g. Smoke Developed: 5 (ASTM E84/UL-723)
- h. The blanket shall have a foil facing, adhered to the blanket mat, incorporating the following characteristics:
- i. Tensile Strength: M.D. 40#/IN (ASTM D-828)  
C.D. 40#/IN (ASTM D-828)
- j. Puncture Resistance: 100 Units (Min) (ASTM D-781)
- k. Self adhesive filament tape shall be of the high performance type equal to 3M Company \*898.
- l. Banding material, 3/4" wide, minimum 0.015" thick, carbon steel for construction requirements of zero clearance to combustibles or 1 hour ratings. Stainless steel banding shall be used for 2 hour requirements (SS wire ties or 1/4" SS hose clamps may be substituted for hanger insulation only).
- m. Tensioning tool for banding material manufactured by Okle or by Signode Company; seals such as those manufactured by Okle or by Signode Company; and crimping tool such as those manufactured by Okle or Signode.
- n. 10 gauge, 4" to 5" long, copper coated steel pins; 1½" x 1½" galvanized steel speed clips; capacitor discharge stud gun (110/115) such as that manufactured by AGM.
- o. Grease duct access door hardware; 4½" x 5" long, 1/4" wing nuts and 1/4" metal washers; 4" long steel hollow tubing to fit threaded rods.

2. Class 131

- a. Insulation shall consist of 1½ inch thick minimum 4 pound density rigid fiberglass board with reinforced foil vapor barrier cut to fit duct shape and applied by impaling insulation on pins attached to duct surface. Pins shall be located approximately 1 per square foot of surface. Insulation shall be secured on pins using metal washers with excess pin length trimmed. Seal seams and all vapor barrier penetrations using 4 inch wide reinforced foil tape self-sealing type or secured using vapor seal adhesive.

- b. Note: Flanges protruding from sheet metal shall be covered with 4 inch wide insulation board strips and sealed with 4 inch wide reinforced tape secured with vapor seal adhesive.
  - c. Finish shall consist of pre-sized glass fabric jacket applied to insulation surface and secured with lagging adhesive. All plenums and ducts within 5 feet of floors shall have edges reinforced with metal corner beads applied to insulation and sealed with 4 inch reinforced foil tape secured with vapor seal adhesive prior to finish.
3. Class 135
- a. Insulation shall consist of minimum 1½ inch thick flexible fiberglass blanket with reinforced foil vapor barrier. Insulation shall be tightly wrapped around duct and secured using bonding adhesive covering not less than 50 percent of sheet metal surface. Seams and penetrations shall be sealed by using 4 inch wide reinforced foil tape self-sealing type or secured with vapor seal adhesive. The bottom of ducts over 24 inches wide shall have additional support for blanket consisting of pins attached to duct surface at a rate of 1 per 2 square feet, evenly spaced. Insulation shall be impaled on pins and secured using mechanical washers with excess pin length trimmed.
- G. Ductwork Weatherproof Insulation Cover:
- 1. Weatherproof insulation cover shall be a self-adhering roll-type roofing membrane consisting of a laminated assembly of aluminum facing, two (2) layers of styrene-butadiene-styrene and a nominal forty (40) mil layer of rubberized asphalt adhesive. Asphalt adhesive compound shall be pressure sensitive, protected by a release paper until installation. Composite assembly shall incorporate the following characteristics.

<u>Typical Properties</u>	<u>Test Method</u>	<u>Value</u>
Service Range	N.A.	-25°F. to 150°F.
Heat Aging	ASTM D-794	No visible blistering, delamination or deterioration
Flame Spread	ASTM E-84-97a	0 (NFPA Class "A")
Smoke Density	ASTM E-84-97a	5
Tear Strength	ASTM D-1424	680 gr MD 640 gr CD
Tensile Strength	ASTM D-1000	500 p si MD 625 psi CD
Elongation	ASTM D-1000	296% MD 228% CD
Static Uplift	ASTM E-907	No damage or failure evident @ 75 psf for 1 minute
Wind Driven Rain	South Florida Test 5683	No leakage, damage or failures evident @ 100 MPH
Lap Joint Tensile Strength	MFM Method	Exceeds material strength
Lap Joint Peel Strength	MFM Method	11 lb/in (180° angle)
Abrasion	Taber Method	10,000 revolutions, CS-17

<u>Typical Properties</u>	<u>Test Method</u>	<u>Value</u>
Low Temperature Flexibility	MFM Method	wheel, 1,000 gr weight 100,000 cycles @ 10°F with no cracking
Q-U-C Accelerated Weathering	Q Panel Co. UV Chamber per Rubber Manufacturer's Association	4,000 hr exposure surface and lap joints, no effect
Reflectivity	Photo-volt meter	129 (black surface ≈ 29)
Water Vapor Transmission	ASTM E96-95	0.009 perms

2.15 INSULATION MATERIALS (MECHANICAL)

- A. Summary:
1. Extent of mechanical insulation required by this section is indicated on the drawings, by the requirements of this section, and Section 15B.03, "General Requirements – Mechanical Work".
  2. Types: Types of mechanical insulation specified in this section include the following:
    - a. Flexible unicellular pipe insulation.
    - b. Fiberglass duct insulation.
    - c. Fiberglass equipment insulation.
    - d. Insulation jackets.
    - e. Insulation accessories.
  3. Related Sections: Refer to other sections of Division 15 for the following:
    - a. Refrigerant piping and specialties
    - b. Sheet metal ductwork
- B. Quality Assurance:
1. Codes and Standards: Provide insulation conforming to the following standards:
    - a. American Society for Testing and Materials (ASTM)
    - b. American Society of Heating, Refrigerating and Air Conditioning (ASHRAE)
    - c. National Fire Protection Association (NFPA)
- C. Submittal:
1. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each mechanical system requiring insulation. Also furnish necessary test data certified by an independent testing laboratory.
- D. Insulation – General Requirements:
1. General: Provide insulation conforming with the referenced publications and the specified temperature ranges and densities in pounds per cubic foot (pcf).
  2. Insulation Exterior: Provide insulation exterior that is cleanable, grease resistant, non-flaking, and non-peeling.
  3. Physical Changes: Provide insulation that shows no physical changes that adversely affect its qualities under normal use at the intended use



temperature.

- E. Flexible Unicellular Pipe Insulation:
  - 1. General: Provide 1 inch thick flexible unicellular pipe insulation conforming to ASTM C534, Type 1 (tubular). Provide flexible unicellular pipe insulation for temperatures of minus 40 degrees F. to 210 degrees F.
  - 2. Fittings, Flanges, and Valves: Provide insulation for fittings, flanges and valves premolded, precut, or job fabricated of the same thickness and conductivity as used on adjacent piping.
  
- F. Fiberglass Duct Insulation:
  - 1. General: Provide fiberglass duct insulation for concealed spaces as follows:
    - a. For concealed insulation, provide 1½ inch thick flexible fiberglass duct insulation with minimum 1½ pound per cubic foot density and with factory applied vapor-proof jacket ASTM C921, Type I.
  
- G. Fiberglass Equipment Insulation:
  - 1. General: Provide fiberglass equipment insulation for concealed spaces as follows:
    - a. For concealed insulation, provide 1½ inch thick flexible fiberglass equipment insulation conforming to (ASTM C553, Type I {Resilient, Flexible}, Class B5 {up to 400 degrees F., 2.0 pcf nominal}) (ASTM C592, Class I {up to 850 degrees F., one side metal-mesh covered, 8 pcf average minimum}).
  
- H. Insulation Jackets:
  - 1. General: Provide insulation jackets in accordance with ASTM C921. Test insulation jacket as a composite with the insulation.
  
- I. Insulation Accessories:
  - 1. General: Provide insulation accessories compatible with materials to which applied and suitable for the service. Provide insulation accessories that do not corrode, soften or otherwise attack the insulation or jacket in either the wet or dry state.
  
- J. General Insulation Installation: Install insulation material with smooth and even surfaces. Unless otherwise specified, install insulation materials, accessories and finishes in accordance with the manufacturer's published recommendations.
  
- K. Insulation for Low Temperature Piping:
  - 1. General: Unless otherwise specified, insulate low-temperature piping.
  - 2. Locations Insulated: Install insulation in the following locations and as indicated:
    - a. Refrigerant suction piping.
  
- L. Flexible Unicellular Insulation: Install flexible unicellular insulation as follows:
  - 1. Slip flexible unicellular pipe insulation on the pipe prior to connection wherever possible, and seal the butt joints with adhesive.
  - 2. Where the slip-on technique is not possible, slit the insulation and apply to the pipe, seal the seams and butt joints with adhesive.
  - 3. Protect flexible unicellular insulation from compression at all pipe hanger locations by the use of compression resistant inserts and protective metal shields. Provide inserts of the same thickness and outside contour as the

- adjoining insulation, mold or shape to fit at least 90 degrees of the pipe circumference, and seal into adjoining pipe insulation with adhesive.
4. Insulate all fittings, flanges and valves (except valve stems, hand wheels and operators) in piping insulated with flexible unicellular insulation with similar pipe or sheet insulation of the same thickness.
  5. Seal all joints at fittings and valves with adhesive.
  6. Insulate screwed fittings with sleeved fitting covers fabricated from miter-cut pieces of pipe insulation according to the manufacturer's sleeving size recommendations and overlap and seal to the adjacent pipe insulation.
  7. Insulate all valves and welded fittings with fitting covers fabricated from similar pipe insulation or sheet insulation.
- M. Insulation for Air Handling and Air Distribution Equipment and Ducts:
1. General: Unless otherwise specified insulate air handling and air distribution equipment.
  2. Ventilation System Locations Insulated: Install insulation for ventilation systems with leaving temperature less than 90 degrees F. in the following locations and as indicated:
    - a. Ducts and apparatus in concealed spaces.
  3. Air Conditioning System Locations Insulation: Install insulation for air conditioning systems of all types, velocities and pressures, in the following locations and as indicated:
    - a. All supply ductwork.
- N. Concealed Duct Flexible Insulation: Secure the flexible insulation for concealed ducts with long sides or diameters less than 24 inches tightly and smoothly with a bonding adhesive, Category 3, applied in 6 inch wide transverse strips on 12 inch centers. Secure the flexible insulation for ducts with long sides or diameters of 24 inches or more tightly and smoothly with metal or nylon anchors or pins, cemented or welded to the ducts, spaced not more than 13 inches apart each way. Do not permit sagging of the insulation and provide sufficient bonding adhesive or fasteners to prevent this.
- O. Insulation Jackets: Provide insulation for air handling and air distribution equipment and ducts with jackets as specified under "Insulation Jackets" article, of this section. Install the jackets at all joints with a 2 inch wide lap drawn tight and secured with staples on 4 inch centers and 1 inch from edges of laps.

## 2.16 MOTORS

- A. This section identifies basic requirements for motors. It includes motors that are factory-installed as part of equipment and appliances as well as field-installed motors.
- B. Quality Assurance:
1. Comply with NFPA 70 "National Electrical Code".
  2. NRTL Listing: Provide NRTL listed motors.
    - a. Term "Listed": As defined in "National Electrical Code", Article 100.
    - b. Listing Agency Qualifications: "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
  3. Comply with NEMA MG 1: "Motors and Generators".
  4. Comply with UL 1004: "Motors, Electric".

- C. All motors provided for this project shall comply with the requirements of this section, except as otherwise indicated.
1. Motors 1/2 HP and Larger: Polyphase
  2. Motors Smaller than 1/2 HP: Single phase.
  3. Frequency Rating: 60 Hz.
  4. Voltage Rating: Determined by voltage of circuit to which motor is connected for the following motor voltage ratings (utilization voltages):
    - a. 120V Circuit: 115 V – motor rating.
    - b. 208V Circuit: 200 V – motor rating
    - c. 240V Circuit: 230 V – motor rating.
    - d. 480V Circuit: 460 V – motor rating.
  5. Service factors indicated for motors are minimum values and apply at frequency and utilizing voltage at which motor is connected. Provide motors which will not operate in service factor range when supply voltage is within 10 percent of motor voltage rating.
  6. Capacity: Sufficient to start and operate connected loads at designated speeds in indicated environment, and with indicated operating sequence, without exceeding nameplate ratings. Provide motors rated for continuous duty at 100 percent of rated capacity.
  7. Temperature Rise: Based on 40 degree C. ambient except as otherwise indicated.
    - a. Enclosure: Totally Enclosed Air Over
- D. Polyphase Motors:
1. General: Squirrel-cage induction type conforming to the following requirements except as otherwise indicated.
    - a. NEMA Design Letter Designation: "A" or "B"
  2. Multi-Speed Motors: Separate winding for each speed.
  3. Premium Efficiency Motors: Nominal efficiency equal to or greater than that stated in NEMA Standard Publication MG 1-2003, Tables 12-12 and 12-13 respectively.
  4. Variable speed motors for use with solid-state drives: Energy efficient, squirrel-cage induction, design B units with ratings, characteristics, and features coordinated with and approved by drive manufacturer.
  5. Internal thermal overload protection for motors: For motors so indicated, protection automatically opens control circuit arranged for external connection. Protection operates when winding temperature exceeds safe value calibrated to the temperature rating of the motor insulation.
  6. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading of the application.
  7. Rugged Duty Motors: Totally enclosed with 1.25 minimum service factor. Provide motors with regreasable bearings and equipped with capped relief vents. Insulate windings with nonhygroscopic material. External finish shall be chemical resistant paint over corrosion resistant primer. Provide integral condensate drains.
  8. Motors for reduced in-rush starting: Coordinate with indicated reduced in-rush controller type and with characteristics of driven equipment load. Provide required wiring leads in motor terminal box to suit control method.
- E. Single-Phase Motors:
1. General: Conform to the following requirements except as otherwise indicated.
  2. Energy Efficient Motors: One of the following types as selected to suit the starting torque and other requirements of the specific motor application:

- a. Permanent Split Capacitor
- b. Split-Phase Start, Capacitor-Run
- c. Capacitor-Start, Capacitor-Run
3. Shaded-Pole Motors: Use only for motors smaller than 1/20 HP.
4. Internal Thermal Overload Protection for Motors: For motors so indicated, protection automatically opens the power supply circuit to the motor, or a control circuit arranged for external connection. Protection operates when winding temperature exceeds a safe value calibrated to the temperature rating of the motor insulation. Provide device that automatically resets when motor temperature returns to normal range except as otherwise indicated.
5. Bearings, belt connected motors and other motors with high radial forces on motor shaft shall be ball bearing type. Sealed, prelubricated sleeve bearings may be used for other single phase motors.

#### 2.17 MULTI INDOOR UNIT, VARIABLE REFRIGERANT FLOW SYSTEM

- A. The variable capacity, heat pump heat recovery air conditioning system shall be a Mitsubishi Electric or approved equal CITY MULTI VRFZ (Variable Refrigerant Flow Zoning) System. The CITY MULTI VRFZ systems shall be the R2-Series (simultaneous cooling and heating) split system heat pump.
- B. The R2-Series system shall consist of a PURY outdoor unit, BC (Branch Circuit) Controller(s) (Single, Main, or Main with Sub(s), multiple indoor units (-E models), and M-NET DDC (Direct Digital Controls). The PURY outdoor unit shall be a vertical discharge, 208 volt, three phase unit
  1. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label.
  2. All wiring shall be in accordance with the National Electrical Code (N.E.C.).
  3. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
  4. A full charge of R-410A for the condensing unit only shall be provided in the condensing unit.
- C. Warranty:
  1. The units shall be covered by the manufacturer's limited warranty for a period of one (1) year from date of installation provided the systems are:
    - a. Designed by a certified CITY MULTI Diamond Designer
    - b. Installed by a certified CITY MULTI Diamond Dealer
    - c. Verified with a completed commissioning report submitted to Mitsubishi Electric Service Department
  2. The units shall be covered by an extended manufacturer's limited warranty for a period of five (5) years from date of installation.
    - a. In addition, the compressor shall have a manufacturer's limited warranty for a period of six (6) years from date of installation.
    - b. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer.
    - c. This warranty shall not include labor.
- D. Quality Assurance:
  1. Manufacturer shall have a minimum of twenty-five years of HVAC experience in the U.S. market.

2. The CITY MULTI VRFZ system shall be installed by a Mitsubishi authorized CITY MULTI Diamond Dealer with extensive CITY MULTI install and service training. The mandatory contractor service and install training should be performed by the manufacturer.
- E. R2-Series Outdoor Unit:
1. General:
    - a. The R2-Series PURY outdoor unit shall be used specifically with CITY MULTI VRFZ components. The R2-Series shall consist of the PURY outdoor unit, Branch Circuit (BC) Controller, indoor units (-E models), and M-NET DDC (Direct Digital Controls). The PURY outdoor units shall be equipped with multiple circuit boards that interface to the M-NET controls system and shall perform all functions necessary for operation. The outdoor unit shall have a powder coated finish. The outdoor unit shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory.
    - b. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of outdoor rated capacity.
    - c. Outdoor unit shall have a sound rating no higher than 63 dB(A).
    - d. Both refrigerant lines from the outdoor unit to the BC (Branch Circuit) Controller (Single or Main) shall be insulated.
    - e. The outdoor unit shall have an accumulator with refrigerant level sensors and controls.
    - f. The outdoor unit shall have a high pressure safety switch, over-current protection and DC bus protection.
    - g. The outdoor unit shall have the ability to operate with a maximum height difference of 164 feet and have total refrigerant tubing length of 984-1312 feet. The greatest length is not to exceed 492 feet between outdoor unit and the indoor units without the need for line size changes or traps.
    - h. The outdoor unit shall be capable of operating in heating down to -4°F ambient temperature without additional low ambient controls.
    - i. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained.
  2. Unit Cabinet:
    - a. The casing(s) shall be fabricated of galvanized steel, bonderized and finished with a powder coated baked enamel.
  3. Fan:
    - a. The P240YSHMU outdoor unit shall be furnished with two direct drive, variable speed propeller type fans.
    - b. All fan motors shall have inherent protection, have permanently lubricated bearings, and be completely variable speed.
    - c. All fan motors shall be mounted for quiet operation.
    - d. All fans shall be provided with a raised guard to prevent contact with moving parts.
    - e. The outdoor unit shall have vertical discharge airflow.
  4. Refrigerant
    - a. R410A refrigerant shall be required for PURY-P-TGMU-A outdoor unit systems.
  5. Coil:
    - a. The outdoor coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.

- b. The coil fins shall have a factory applied corrosion resistant blue-fin finish.
  - c. The coil shall be protected with an integral metal guard.
  - d. Refrigerant flow from the outdoor unit shall be controlled by means of an inverter driven compressor.
  - e. The outdoor coil shall include 4 circuits with two position valves for each circuit, except for the last stage.
6. Compressor:
- a. The PURY-240YSHMU outdoor unit shall be equipped with TWO (2) inverter driven scroll hermetic compressors.
  - b. A crankcase heater(s) shall be factory mounted on the compressor(s).
  - c. The outdoor unit compressor shall have an inverter to modulate capacity. The capacity shall be completely variable down to 16% of rated capacity.
  - d. The compressor will be equipped with an internal thermal overload.
  - e. The compressor shall be mounted to avoid the transmission of vibration.
7. Electrical:
- a. The outdoor unit electrical power shall be 460 volts, 3-phase, 60 hertz.
  - b. The outdoor unit shall be controlled by integral microprocessors.
  - c. The control circuit between the indoor units, BC Controller and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.
- F. Branch Circuit (BC) Controllers:
- 1. General:
    - a. The BC (Branch Circuit) Controllers shall be specifically used with R410A R2-Series systems. These units shall be equipped with a circuit board that interfaces to the M-NET controls system and shall perform all functions necessary for operation. The unit shall have a galvanized steel finish. The BC Controller shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of rated capacity.
  - 2. BC Unit Cabinet:
    - a. The casing shall be fabricated of galvanized steel.
    - b. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.
    - c. The unit shall house two tube-in-tube heat exchangers.
  - 3. Refrigerant:
    - a. R410A refrigerant shall be required.
  - 4. Refrigerant valves:
    - a. The unit shall be furnished with multiple two position refrigerant valves.
    - b. Each circuit shall have one (54,000 Btu/h or smaller indoor unit section) two-position liquid line valve and a two-position suction line valve.
    - c. When connecting a 54,000 Btu/h or larger indoor unit section, two branch circuits shall be joined together at the branch controller to

- deliver an appropriate amount of refrigerant. The two refrigerant valves shall operate simultaneously.
- d. Linear electronic expansion valves shall be used to control the variable refrigerant flow.
5. Integral Drain Pan:
    - a. An integral condensate pan and drain shall be provided.
  6. Electrical:
    - a. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
    - b. The unit shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253V (230V/60Hz).
    - c. The BC Controller shall be controlled by integral microprocessors.
    - d. The control circuit between the indoor units and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.
- G. PLFY-P\*\*NBMU-E (4-Way Ceiling-Recessed Cassette with Grille) Indoor Unit:
1. General:
    - a. The PLFY shall be a four-way cassette style indoor unit that recesses into the ceiling with a ceiling grille. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.
  2. Unit Cabinet:
    - a. The cabinet shall be space-saving ceiling-recessed cassette.
    - b. The cabinet panel shall have provisions for a field installed filtered outside air intake.
    - c. Branch ducting shall be allowed from cabinet.
    - d. Four-way grille shall be fixed to bottom of cabinet allowing two, three or four-way blow.
    - e. The grille vane angles shall be individually adjustable from the wired remote controller to customize the airflow pattern for the conditioned space
  3. Fan:
    - a. The indoor fan shall be an assembly with a turbo fan direct driven by a single motor.
    - b. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
    - c. The indoor fan shall consist of five (5) speed settings, Low, Mid1, Mid2, High and Auto.
    - d. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set-point and space temperature.
    - e. The indoor unit shall have an adjustable air outlet system offering 4-way airflow, 3-way airflow, or 2-way airflow.
    - f. The indoor unit shall have switches that can be set to provide optimum airflow based on ceiling height and number of outlets used.
    - g. The indoor unit vanes shall have 5 fixed positions and a swing feature that shall be capable of automatically swinging the vanes

- up and down for uniform air distribution.
    - h. The vanes shall have an Auto-Wave selectable option in the heating mode that shall randomly cycle the vanes up and down to evenly heat the space.
    - i. If specified, the grille shall have an optional i-see sensor that will measure room temperature variations and adjust the airflow accordingly to evenly condition the space.
  - 4. Filter:
    - a. Return air shall be filtered by means of a long-life washable filter
  - 5. Coil:
    - a. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
    - b. The tubing shall have inner grooves for high efficiency heat exchange.
    - c. All tube joints shall be brazed with phos-copper or silver alloy.
    - d. The coils shall be pressure tested at the factory.
    - e. A condensate pan and drain shall be provided under the coil.
    - f. The unit shall include a condensate lift mechanism that will be able to raise drain water 33 inches above the condensate pan.
    - g. Both refrigerant lines to the PLFY indoor units shall be insulated.
  - 6. Electrical:
    - a. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
    - b. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).
  - 7. Controls:
    - a. This unit shall use controls provided by Mitsubishi Electric to perform functions necessary to operate the system. Please refer to Part 5 of this guide specification for details on controllers and other control options.
- H. PDFY (Ducted) Indoor Unit:
  - 1. General:
    - a. The PDFY shall be a ceiling-concealed ducted indoor fan coil design that mounts above the ceiling with a 2-position, field adjustable return and a fixed horizontal discharge supply and shall have a modulating linear expansion device. The PDFY shall be used with the R2-Series outdoor unit and BC Controller, Y-Series outdoor unit, or S-Series outdoor unit. The PDFY shall support individual control using M-NET DDC controllers
  - 2. Indoor Unit.
    - a. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.
  - 3. Unit Cabinet:
    - a. The unit shall be space saving, ceiling-concealed, ducted.
    - b. The cabinet panel shall have provisions for a field installed filtered outside air intake.
  - 4. Fan:
    - a. The indoor unit fan shall be an assembly with one or two Sirocco



- fan(s) direct driven by a single motor.
- b. The indoor fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings.
- c. The indoor unit shall have a ducted air outlet system and ducted return air system.
- 5. Filter:
  - a. Return air shall be filtered by means of a standard factory installed return air filter.
  - b. Optional return filter box (rear or bottom placement) with high-efficiency filter shall be available for all PDFY indoor units.
- 6. Coil:
  - a. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
  - b. The tubing shall have inner grooves for high efficiency heat exchange.
  - c. All tube joints shall be brazed with phos-copper or silver alloy.
  - d. The coils shall be pressure tested at the factory.
  - e. A condensate pan and drain shall be provided under the coil.
  - f. The condensate shall be gravity drained from the fan coil.
  - g. Both refrigerant lines to the PDFY indoor units shall be insulated.
- 7. Electrical:
  - a. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
  - b. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).
- 8. Controls:
  - a. This unit shall use controls provided by Mitsubishi Electric to perform functions necessary to operate the system. Please refer to Part 5 of this guide specification for details on controllers and other control options.
- I. Controls (General):
  - 1. The CITY MULTI Controls Network (CMCN) shall be capable of supporting remote controllers, schedule timers, system controllers, centralized controllers, an integrated web-based interface, graphical user workstation, and system integration to Building Management Systems via BACnet® and LonWorks®. VRF systems shall be integrated into Building management system. Mechanical contractor shall coordinate with ATC contractor.
  - 2. The CMCN shall operate at 24VDC. Controller power and communications shall be via a common non-polar communications bus.
  - 3. Control wiring shall be installed in a system daisy chain configuration from indoor unit to ME remote controller to indoor unit, to the BC controller (main and subs, if applicable) and to the outdoor unit. Control wiring to remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.
  - 4. Control wiring for schedule timers, system controllers, and centralized controllers shall be installed in a daisy chain configuration from outdoor unit to outdoor unit, to system controllers, to the power supply.
  - 5. Control wiring for the Deluxe MA, Simple MA, and Wireless MA remote controllers shall be from the remote controller to the first associated indoor unit (TB-15) then to the remaining associated indoor units (TB-15) in a daisy chain configuration...
  - 6. The G-50A and GB-50A system controller shall be capable of being networked with other G-50A and GB-50A system controllers for web based

- control.
7. Wiring shall be 2-conductor (16 AWG or 18 AWG), twisted shielded pair, stranded wire, as defined by the Design Tool AutoCAD output.
  8. Network wiring shall be CAT-5e with RJ-45 connection.
  9. Network Controls
    - a. The CITY MULTI Controls Network (CMCN) consists of remote controllers, schedule timers, system controllers, centralized controllers, and/or integrated web based interface communicating over a high-speed communication bus. The CITY MULTI Controls Network shall support operation monitoring, scheduling, error email distribution, personal browsers, tenant billing, online maintenance support, and integration with Building Management Systems (BMS) using either LonWorks® or BACnet® interfaces.
    - b. CMCN: Remote Controllers
      - 1) Deluxe MA Remote Controller (PAR-21MAA) shall be capable of controlling up to 16 indoor units (defined as 1 group). The Deluxe MA Remote Controller shall be approximately 5" x 5" in size and white in color with a light-green LCD display. The PAR-21MAA shall support a selection from multiple languages (Spanish, German, Japanese, Chinese, English, Russian, Italian, or French) for display information. The Deluxe MA supports temperature display selection of Fahrenheit or Celsius. The Deluxe MA Remote Controller shall control the following grouped operations: On/Off, Operation Mode (cool, heat, auto (R2-Series only), dry, and fan), temperature set point, fan speed setting, and airflow direction setting. The Deluxe MA Remote Controller shall support timer settings of on/off/temperature up to 8 times in a day in 1-minute increments. The Deluxe MA Remote Controller shall support an Auto Off timer. The Deluxe MA Remote Controller shall be able to limit the set temperature range from the Deluxe MA. The room temperature shall be sensed at either the Deluxe MA Remote Controller or the Indoor Unit dependent on the indoor unit dipswitch setting. The Deluxe MA Remote Controller shall display a four-digit error code in the event of system abnormality/error.
      - 2) The Deluxe MA Remote Controller shall only be used in the same group with other Deluxe MA Remote Controllers (PAR-21MAA), with up to two remote controllers per group.
      - 3) The Deluxe MA Remote Controller shall require no addressing. The Deluxe MA Remote Controller shall connect using two-wire, stranded, non-polar control wire to TB15 connection terminal on the indoor unit. The PAR-21MAA shall require cross-over wiring for grouping across indoor units.

<b>PAR-21MAA (Deluxe MA Remote Controller)</b>			
<b>Item</b>	<b>Description</b>	<b>Operation</b>	<b>Display</b>
ON/OFF	Run and stop operation for a single group	Each Group	Each Group

<b>PAR-21MAA (Deluxe MA Remote Controller)</b>			
<b>Item</b>	<b>Description</b>	<b>Operation</b>	<b>Display</b>
Operation Mode	Switches between Cool/Dry/Auto/Fan/Heat. Operation modes vary depending on the air conditioner unit. Auto mode is in the R2-Series only.	Each Group	Each Group
Temperature Setting	Sets the temperature for a single group. Range of temperature setting Cool/Dry: 67°F-87°F (57°F-87°F for PEFY/PDFY/PFFY-E) Heat: 63°F-83°F (63°F-83°F for PEFY/PDFY/PFFY-E) Auto: 67°F-83°F (63°F-83°F for PEFY/PDFY/PFFY-E)	Each Group	Each Group
Fan Speed Setting	Models with 4 air flow speed settings: Hi/Mid-2/Mid-1/Low Models with 3 air flow speed settings: Hi/Mid/Low Models with 2 air flow speed settings: Hi/Low	Each Group	Each Group
Air Flow Direction Setting	Air flow direction angles 100%-80%-60%-40%, Swing, Louver ON/OFF. Air flow direction settings vary depending on the model.	Each Group	Each Group
Weekly Scheduler	ON/OFF/Temperature setting can be done up to 8 times one day in the week. The time can be set by the 1-minute interval.	Each Group	Each Group
Permit / Prohibit Local Operation	Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter). *1: Centrally Controlled is displayed on the remote controller for prohibited functions.	N/A	Each Group *1
Prohibition / Permission of Specified Mode	Setting via the System Controller, the operation for the following modes is prohibited: Cooling Prohibited: Cool, Dry, Auto Heating Prohibited: Heat, Auto Cooling-Heating Prohibited: Cool, Heat, Dry, Auto	N/A	Each Group
Display Indoor Unit Intake Temp	Measures and displays the intake temperature of the indoor unit when the indoor unit is operating.	N/A	Each Group
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed	N/A	Each Unit
Test Run	Operates air conditioner units in test run mode.	Each Group	Each Group
Ventilation Equipment	Up to 16 indoor units can be connected to an interlocked system that has one LOSSNAY unit. LOSSNAY items that can be set are "Hi", "Low", and "Stop". Ventilation mode switching is not available.	Each Group	Each Group
Set Temperature Range Limit	The range of room temperature setting can be limited by the initial setting. The lowest limit temperature can be made higher than the usual (67°F) in cool/dry mode, while the upper limit temperature lower than the usual (83°F) in heat mode. *Function does not work in auto mode setting	Each Group	Each Group
Auto Lock Out Function	Setting/releasing of simplified locking for remote control buttons can be performed. <ul style="list-style-type: none"> <li>• Locking of all buttons</li> <li>• Locking of all buttons except ON/OFF button</li> </ul>	Each Group	Each Group

10. Input/Output (IO) Boards:

- a. Digital Input Digital Output (DIDO) Board: The DIDO IO board shall be capable of providing On/Off control for non-Mitsubishi equipment via the G-50A/GB-50A Centralized Controller's licensed web browser functions and the TG-2000A software. Each DIDO board shall have two digital inputs and two digital outputs and shall be capable of expanding to a total of six digital inputs and six digital outputs. Each digital output shall be capable of supporting an independent schedule via the G-50A/GB-50A Centralized Controller's licensed web browser functions and the TG-2000A software. Status indication of the On/Off state of the non-Mitsubishi equipment shall be either via the On/Off status of the digital output or by receipt of a digital input to the DIDO board.
  - b. The DIDO IO board shall be capable of receiving a digital input for interlock settings with the CITY MULTI indoor units or digital outputs on the DIDO board. Based on the digital input status the DIDO board shall be capable of setting the following parameter on the indoor unit On/Off, Mode, and Set Temperature to predefined settings. The DIDO board shall also be capable of interlocking the On/Off state of a digital output on the DIDO board based on a digital input status.
  - c. Analog Input (AI) Board: The AI IO board shall be capable of monitoring temperature or humidity via the G-50A/GB-50A Centralized Controller's licensed web browser functions and the TG-2000A software. Each AI board shall have two analog inputs. Each input shall be capable of receiving a 4/20mA, 0/10 VDC, or 1/5 VDC signal for monitoring temperature or humidity. The AI board shall be capable of monitoring the temperature or humidity input and shall be capable of displaying graphical trending of the temperature or humidity values via the G-50A/GB-50A Centralized Controller's licensed web browser functions and the TG-2000A software. Notification of user adjustable high and low level alarms shall be capable of being emailed to distribution list or outputted via a digital output.
  - d. The AI IO board shall be capable of setting the following parameters on the indoor unit On/Off, Mode, and Set Temperature to predefined settings based on the input value of the temperature or humidity. The AI board shall also be capable of interlocking the On/Off state of a digital output on the input value of the temperature or humidity.
11. GB-50A Centralized Controller
- a. The GB-50A Centralized Controller shall be capable of controlling via a PC a maximum of 50 indoor units across multiple CITY MULTI outdoor units. A field supplied PC shall be required for the GB-50A Centralized Controller. The GB-50A Centralized Controller shall be approximately 5"x11" in size and shall be powered from a Power Supply Unit (PAC-SC50KUA). The GB-50A Centralized Controller shall support operation superceding that of the remote controllers, system configuration, daily/weekly/annual scheduling, monitoring of operation status, error email notification, online maintenance tool and malfunction monitoring. The GB-50A Centralized Controller shall have basic operation controls which can be applied to an individual indoor unit, a group of indoor units (up to 50 indoor units), or all indoor

units (collective batch operation). This basic control set of operation controls for the GB-50A Centralized Controller shall include on/off, operation mode selection (cool, heat, auto (R2-Series only), dry, and fan), temperature setting, fan speed setting, airflow direction setting, error email notification, and online maintenance. Since the GB-50A provides centralized control it shall be able to enable or disable operation of local remote controllers via the PC. In terms of scheduling, the GB-50A Centralized Controller shall allow the user to define daily, weekly, and annual schedules with operations consisting of ON/OFF, mode selection, temperature setting, and permit/prohibit of remote controllers.

<b>GB-50A (Centralized Controller)</b>			
<b>Item</b>	<b>Description</b>	<b>Operation</b>	<b>Display</b>
ON/OFF	Run and stop operation for a single group	Each Group or Collective	Each Group or Collective
Operation Mode	Switches between Cool/Dry/Auto/Fan/Heat. (Group of Lossnay unit: automatic ventilation/vent-heat/interchange/normal ventilation) Operation modes vary depending on the air conditioner unit. Auto mode is in the CITY MULTI R2-Series only.	Each Group or Collective	Each Group
Temperature Setting	Sets the temperature for a single group. Range of temperature setting: Cool/Dry: 67°F-87°F (57°F-87°F for PEFY/PDFY/PFFY-E) Heat: 63°F-83°F (63°F-83°F for PEFY/PDFY/PFFY-E) Auto: 67°F-83°F (63°F-83°F for PEFY/PDFY/PFFY-E) * Range of temperature setting varies depending on the model.	Each Group or Collective	Each Group
Fan Speed Setting	Models with 4 air flow speed settings: Hi/Mid-2/Mid-/Low Models with 3 air flow speed settings: Hi/Mid/Low Models with 2 air flow speed settings: Hi/Low	Each Group or Collective	Each Group
Air Flow Direction Setting	Air flow direction angles 100%-80%-60%-40%, Swing, *1. Louver cannot be set. Air flow direction settings vary depending on the model.	*1 Each Group or Collective	Each Group
Permit / Prohibit Local Operation	Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter). *2: Centrally Controlled is displayed on the remote controller for prohibited functions.	Each Group or Collective	*2 Each Group
Indoor Unit Intake Temp	Measures the intake temperature of the indoor unit when the indoor unit is operating.	N/A	Each Group

<b>GB-50A (Centralized Controller)</b>			
<b>Item</b>	<b>Description</b>	<b>Operation</b>	<b>Display</b>
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed *3 When an error occurs, the LED flashes. The operation monitor screen shows the abnormal unit by flashing it. The error monitor screen shows the abnormal unit address, error code and source of detection. The error log monitor screen shows the time and date, the abnormal unit address, error code and source of detection	N/A	*3 Each Unit or Collective
Ventilation Equipment	This interlocked system settings can be performed by the master system controller. When setting the interlocked system, use the ventilation switch the free plan LOSSNAY settings between "Hi", "Low" and "Stop". When setting a group of only free plan LOSSNAY units, you can switch between "Normal ventilation", "Interchange ventilation" and "Automatic ventilation".	Each Group	Each Group
External Input / Output	By using accessory cables you can set and monitor the following. Input By level: "Batch start/stop", "Batch emergency stop" By pulse: "batch start/stop", "Enable/disable remote controller" Output: "start/stop", "error/Normal" *4: Requires the external I/O cables (PAC-YG10HA-E) sold separately.	*4 Collective	*4 Collective

\*GB-50A needs a PC (field supplied) connected together to monitor and operate the air conditioner system.

- b. Standard software functions shall allow the building manager to securely log into each GB-50A via the PC's web browser to support operation monitoring, scheduling, error email, and online maintenance diagnostics. Standard software functions shall not expire. Additional optional software functions shall be available of personal browser for PCs and MACs, Tenant Billing that requires TG-2000 Integrated System software in conjunction with GB-50A Centralized Controllers. BACnet® interface shall be available through software operating on a dedicated PC and a GB-50A license. Optional software functions shall require advance purchasing and can only be activated upon receipt of a license number from Mitsubishi Electric HVAC.
12. Web-based User Interface:
  - a. Licenses per function, per G-50A/GB-50A shall be required.
  - b. All PCs shall be field supplied.
  - c. PC-Monitoring (SW-Mon): The CMCN shall be capable of monitoring and operating all indoor units from a networked PC's web browser for up to 50 units per G-50A/GB-50A centralized controller.
  - d. PC Scheduling (SW-Sch): The CMCN shall be capable of

- creating customized daily, weekly, and annual schedules from a network PC's web browser for up to 50 units per G-50A/GB-50A. Schedules shall be applied to a single indoor unit, a group of indoor units, or collectively (batch) to all indoor units controlled by the G-50A/GB-50A.
- e. Online Error Email (SW-Email): The CMCN shall be capable of sending detailed alerts to customizable distribution lists based on user defined error types.
  - f. Personal Web Browser (SW-Pweb): The CMCN shall be capable of allowing up to 50 individual users to monitor and control user defined zones via a network PC or MAC's web browser.
  - g. Online Maintenance Diagnostics (SW-Maint): The CMCN shall be capable of performing maintenance diagnostics via a network PC and G-50A/GB-50A centralized controller using Maintenance Tool Software.
  - h. Tenant Billing (SW-Charge): The CMCN shall be capable of calculating CITY MULTI energy usage in kWh and in a monetary amount based on the energy consumption of the outdoor unit(s) divided among the associated indoor units. This software is used in conjunction with the TG-2000 software a networked PC, and Watt Hour Meters (WHM).
13. CMCN: System Integration
- a. The CMCN shall be capable of supporting integration with Building Management Systems (BMS) via our LonWorks® and BACnet® interfaces.
14. PAC-YTG31CDA: BACnet® Interface
- a. The Mitsubishi Electric HVAC BACnet® interface, PAC-YG31CDA, shall be compliant with BACnet®/IP (ANSI/ASHRAE 135-1995, 135a) and UDP/IP of Ethernet (ANSI/ASHRAE 135-1995, 135b). The BACnet® interface shall require a dedicated network computer and activated BACnet® software function via Mitsubishi Electric HVAC issued license. The BACnet® software license shall be on a per G-50A/GB-50A basis for a maximum of 50 indoor units controlled by one G-50A/GB-50A Centralized Controller. The BACnet® interface shall support a maximum of ten G-50A/GB-50A Centralized Controllers for a maximum of 500 indoor units. Operation and monitoring points include, but are not limited to, on/off, operation mode, fan speed, prohibit remote controller, filter sign reset, alarm state, error code, and error address.
15. Power Supply (PAC-SC50KUA)
- a. The power supply shall supply 12VDC (TB 3) for the G-50 centralized controller and 24VDC (TB 2) voltage for the central control transmission.
  - b. The power supply can power a maximum of 2 G-50A/GB-50A centralized controllers.
16. Mr. Slim M-Series and P-Series Control
- a. The CMCN shall have the capability of controlling and monitoring the Mitsubishi Electric Mr. Slim MSY and MSZ units through the use of an adaptor to allow the MSY and MSZ units to communication on the M-Net communication bus.
  - b. The CMCN shall have the capability of controlling and monitoring the Mitsubishi Electric Mr. Slim PUY and PUZ units through the use of an adaptor to allow the PUY and PUZ units to

communication on the M-Net communication bus.

## 2.18 PIPE, HANGERS, SUPPORTS AND ANCHORS

- A. Provide all necessary labor, supervision, materials, equipment and services required to furnish and install all pipe supports, hangers, anchors and other suitable supporting appliances necessary to support firmly and substantially all parts of the apparatus described in this specification. Equipment shall be as manufactured by B-Line, Uni-Strut, Grinnell or Carpenter & Patterson.
  - 1. Pipe shall be adequately supported by pipe hanger and supports and restrained by anchors. Hangers, etc. for insulated pipes shall be sized to accommodate insulation thickness.
- B. Steel pipe hangers, anchors and supports shall have the manufacturer's name, part number, and applicable size stamped into each part for identification.
- C. Hangers, anchors and supports shall be designed and manufactured in conformance with the following standards as appropriate.
  - 1. ASTM B633: Specification for Electro-deposited Coatings of Zinc on Iron and Steel.
  - 2. ASTM A123: Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars and Strip
  - 3. ASTM A653 G90: Manufacturers Standardization Society: Pipe Hangers and Supports – Materials, Design and Manufacture
  - 4. MSS SP69: Manufacturers Standardization Society: Pipe Hangers and Supports – Selection and Application
- D. Hangers:
  - 1. Uninsulated pipes 2 inches and smaller:
    - a. Adjustable steel swivel ring (band type) hanger.
    - b. Adjustable steel swivel J-hanger.
    - c. Malleable iron ring hanger or hinged ring hanger.
    - d. Malleable iron split-ring hanger with eye socket.
    - e. Adjustable steel clevis hanger.
  - 2. Uninsulated pipes 2½ inches and larger.
    - a. Adjustable steel clevis hanger.
    - b. Pipe roll with sockets.
    - c. Adjustable steel yoke pipe roll.
- E. Pipe Anchors:
  - 1. Provide a complete system of accessories as required to transmit thermal expansion forces to the building structure for redirection to the piping expansion compensation system. Anchors shall consist of structural attachments, framing members for translating forces to and from the building structure and plates welded to the appropriate piping sections.
  - 2. Structural attachments shall be as appropriate for the point of connection intended. Verify anchor connection points with Project Structural Engineer prior to fabrication.
  - 3. Framing members shall be sized to accept the forces associated with the Contractor's proposed piping system arrangement with a minimum factor of safety of 3.0.
  - 4. Framing point of attachment to the appropriate piping section shall be of a



minimum thickness of 1/4" and shall increase by 1/16" in thickness for each two-pipe size increases above three inches in diameter (3"Φ). Framing point of attachment to the appropriate piping section shall be of a minimum length of 16" and shall increase by 2" in length for each two pipe size increases above three inches in diameter (3" Φ).

17. Welds to connect framing point of attachment to the appropriate piping section shall be full penetration fillet welds parallel to the central axis of the piping. All welding processes, including but not limited to procedures and welding operator qualifications, shall be in strict accordance with the requirements of Section IX of the ASME and Pressure Vessel Code (edition, including any addenda, in effect at the time of the contract execution).
- F. Pipe Clamps:
1. Provide pipe clamps with weld-less eye nuts to allow flexibility in the hanger assembly as required to adjust for horizontal movement. Provide double bolted pipe clamps for insulated lines.
- G. Multiple or Trapeze Hangers:
1. Trapeze hangers shall be constructed from 12 gauge roll formed ASTM A570 Gr. 33 structural steel channel, 1½ x 1½" minimum, or stronger as required.
  2. Mount pipes to trapeze with 2 piece pipe straps sized for outside diameter of pipe.
  3. For pipes subjected to axial movement:
    - a. Strut mounted roller support. Use pipe protection shield or saddles on insulated lines.
    - b. Strut mounted pipe guide.
- H. Wall Supports:
1. Pipes 4 Inches and Smaller:
    - a. Carbon steel hook.
    - b. Carbon steel J-hanger.
  2. Pipes Larger than 4 Inch:
    - a. Welded strut bracket and pipe straps.
    - b. Welded steel brackets, with roller chair or adjustable steel yoke pipe roll. Use pipe protection shield or saddles on insulated lines.
- I. Floor Supports:
1. In mechanical spaces where weight of piping or other apparatus makes it impractical to support same suspended only from structure above, flanged pipe standards shall be installed to support the weight of the piping, valves and fittings. Main passageways and access space must not be obstructed.
  2. Hot piping under 6 inch and all cold piping:
    - a. Carbon steel adjustable pipe saddle and nipple attached to steel base stand sized for pipe elevation. Pipe saddle shall be screwed or welded to appropriate base stand.
  3. Hot piping 6 inches and larger:
    - a. Adjustable roller stand with base plate.
    - b. Adjustable roller support and steel support sized for elevation.
- J. Vertical Supports:
1. Steel riser clamp sized to fit outside diameter of pipe.

- K. Copper Tubing Supports:
1. Hangers shall be sized to fit copper tubing outside diameters.
    - a. Adjustable steel swivel ring (band type) hanger.
    - b. Malleable iron ring hanger, or hinged ring hanger.
    - c. Malleable iron split-ring hanger with eye socket.
    - d. Adjustable steel clevis hanger.
  2. For supporting vertical runs use epoxy painted or plastic coated riser clamps.
  3. For supporting copper tube to strut use epoxy painted pipe straps sized for copper tubing, or plastic inserted vibration isolation clamps.

Note: Copper plating of hangers is for purposes of identification only. This superficial coating shall not be designed to provide significant protection in corrosive areas.

- L. Plastic Pipe Supports:
1. V-bottom clevis hanger with galvanized 18 gauge continuous support channel.

- M. Supplementary Structural Supports:
1. Design and fabricate supports using structural quality steel bolted framing materials as manufactured by B-Line or Uni-Strut.
  2. Channels shall be roll formed, 12 gauge, ASTM A570 Grade 33 steel, 1 $\frac{5}{8}$ " x 1 $\frac{5}{8}$ " or greater as required by loading conditions. Submit designs for pipe tunnels, pipe galleries, etc., to Engineer for approval.
  3. Clamps and fittings shall be specifically designed and listed for use with the strut system.

- N. Upper Attachments:
1. Beam clamps shall be used where piping is to be suspended from building steel. Clamp type shall be selected on the basis of load to be supported, and load configuration.
    - a. C-Clamps shall have locknuts and cup point set screws. Top flange c-clamps shall be used when attaching a hanger rod to the top flange of structural shapes. Refer to manufacturer's recommendations for setscrew torque. Retaining straps shall be used to maintain the position on the beam where required.
    - b. Center loaded beam clamps shall be used where specified. Steel clamps, malleable iron or forged steel beam clamps with cross bolt shall be as required to fit beams.
  2. Concrete Inserts:
    - a. Cast in place spot concrete inserts shall be used where applicable, either steel or malleable iron body. Spot inserts shall allow for lateral adjustment and have means for attachment to forms. Select inserts to suit threaded hanger rod sizes.
      - 1) Arrange pipe hangers, and auxiliary framing if required, to limit the maximum pipe load, with pipes fully insulated and filled with water, to not exceed 1500 pounds on any one slab insert.
      - 2) Inserts shall be spaced not closer than 4 feet o.c. in either direction. Where pipe inserts are closer together than 4 feet o.c. notify the Architect for review.
    - b. Continuous concrete inserts shall be used where applicable.

Channels shall be 12 gauge, ASTM A570 Grade 33 structural quality carbon steel, complete with Styrofoam inserts and end caps with nail holes for attachment to forms. The continuous concrete insert shall have a minimum load rating of 2,000 lbs/ft. in concrete. Select channel nuts suitable for strut and rod sizes.

- c. Provide inserts for placement in form-work before concrete is poured.
- d. Provide inserts for suspending hangers from reinforced concrete slabs and sizes of reinforced concrete beams.
- e. Where concrete slabs form finished ceilings, provide inserts to be flush with slab surface.
- f. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.

O. Vibration Isolation and Supports:

1. Refer to Section "Vibration Isolation and Seismic Restraints" for vibration isolation requirements.
2. All horizontal runs of pipe in all mechanical equipment rooms, and for a distance of fifty (50) equivalent pipe diameters beyond the respective mechanical equipment rooms, shall be isolated from building structure by means of units designed for insertion of rids. Selection of correct isolators for each application shall be made by the vibration isolation manufacturer subject to approval of the Architect.

P. Accessories:

1. Hanger rods shall be threaded both ends, or continuous threaded rods of circular cross section. Use adjusting locknuts at upper attachments and hangers. No wire, chain or perforated straps shall be allowed.
2. Shields shall be 180° galvanized sheet metal, 12" minimum length, 18 gauge minimum thickness, designed to match outside diameter of the insulated pipe.
3. Pipe protection saddles shall be formed from carbon steel, 1/8 inch minimum thickness, sized for insulation thickness. Saddles for pipe sizes greater than 12 inches shall have a center support rib.

Q. Finishes:

1. Hangers not in direct contact with copper pipe shall be zinc plated in accordance with ASTM B633, SC3 or have an electro-deposited epoxy finish.
2. Strut channels shall be pre-galvanized in accordance with ASTM A653 G90 or Strut channels shall be electro-deposited epoxy finish.
3. Hangers and strut located outdoors shall be hot dip galvanized after fabrication in accordance with ASTM A123.
4. Hangers and strut located in corrosive areas shall be Type 316 stainless steel with matching stainless steel hardware.
5. Hangers and clamps for support of bare copper piping shall be painted with electro deposited copper colored epoxy.

R. Support Spacing:

1. Horizontal steel piping shall be supported in accordance with MSS SP-69 Tables 3 and 4, excerpts of which follow below:

NOMINAL PIPE SIZE	ROD DIAMETERS	MAX. SPACING
1/2" - 1 1/2"	3/8"	7'0"
1 1/2"	3/8"	9'0"
2"	3/8"	10'0"
2 1/2"	1/2"	11'0"
3"	1/2"	12'0"
4"	5/8"	14'0"

2. Horizontal copper tubing shall be supported in accordance with MSS SP-69 Tables 3 and 4, excerpts of which follow below:

NOMINAL TUBE SIZE	ROD DIAMETERS	MAX. SPACING
1/2" – 3/4"	3/8"	5'0"
1"	3/8"	6'0"
1 1/4"	3/8"	7'0"
1 1/2"	3/8"	8'0"
2"	3/8"	9'0"
2 1/2"	1/2"	10'0"
3"	1/2"	11'0"
4"	1/2"	12'0"

- S. Provide means of preventing dissimilar metal contact such as plastic coated hangers, copper colored epoxy paint, or non-adhesive isolation tape. Galvanized felt isolators sized for copper tubing may also be used.
- T. Install hangers to provide a minimum 1/2 inch space between finished covering and adjacent work.
- U. Place a hanger within 12 inches of each horizontal elbow.
- V. Support vertical piping independently of connected horizontal piping. Support vertical pipes at every other floor. Wherever possible, locate riser clamps directly below pipe couplings or shear lugs.
- W. Where several pipes can be installed in parallel and at the same elevation, provide trapeze hangers as specified herein above. Trapeze hangers shall be spaced according to the smallest pipe size, or install intermediate supports according to schedule herein above.
- X. Do not support piping from other pipes, ductwork or other equipment which is not building structure.

2.19 PIPING MATERIALS

- A. All piping materials installed under this section shall be new and shall consist of the following materials of construction:

<u>System of Section</u>	<u>Piping Class</u>
Refrigerant Piping	12

- B. Class 12 Piping System

	<u>All Pipe Sizes</u>
Construction	Hard brazed joints.
Piping	Copper tubing, Type ACR, hard drawn; cleaned, dehydrated and capped for refrigeration service, ANSI B70.1, ASTM A280.
	<u>All Pipe Sizes</u>
Fittings	Wrought copper, brazed joint type, ANSI B16.22.
Couplings	Same as "Fittings" above.
Brazing Alloy	East Flo, Sil Fos, Phos. Co. minimum 1100 °F melting temperature ASTM B260.

## 2.20 REFRIGERANT PIPING AND SPECIALTIES

- A. Summary:
1. Extent of refrigeration piping, fittings, valves and accessories is indicated (on the drawings and by the requirements of this section and section 15B.03 "General Requirements – Mechanical").
    - a. Refrigeration piping is specified on a performance basis and the Contractor is responsible for the design and preparation of shop drawings covering all refrigeration piping work.
  2. Related Sections: Refer to other Division 15 sections for the following:
    - a. Mechanical Insulation
- B. Quality Assurance:
1. Codes and Standards: Provide refrigeration piping conforming to the requirements of the following:
    - a. Air Conditioning and Refrigeration Institute (ARI).
    - b. American National Standards Institute (ANSI).
    - c. American Society for Testing and Materials (ASTM).
    - d. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
    - e. Manufacturer's Standardization Society of the Valve and Fittings Industry, Inc. (MSS).
- C. Submittal:
1. Refer to Section 15B.02, "Submittals" for basic information relating to submittal requirements.
  2. Product Data: Submit manufacturer's technical product data on the following:
    - a. Refrigerant Valves
    - b. Refrigerant Specialties
- D. Refrigerant Piping:
1. Refrigerant Piping: Dimensions and material requirements for pipe, pipe fittings and components shall conform to ASHRAE 15 and ANSI B31.5 and

shall be compatible with fluids used and capable of withstanding the pressures and temperatures of the service.

- a. Tubing used for refrigerant service shall be cleaned, sealed, capped, or plugged prior to shipment from the manufacturer's plant.

E. Valves and Accessories:

1. Valves: Provide valves designed, manufactured and tested specifically for refrigerant service.
  - a. Internal parts shall be removable for inspection or replacement without applying heat or breaking pipe connections. Threaded ends of valves shall conform to ANSI B2.1.

F. Execution – General:

1. Installation: Install piping components to ensure proper and efficient operation of the equipment and controls and in accordance with manufacturer's printed instructions.
  - a. Provide proper supports for the mounting of vibration isolators, stands, guides, anchors, clamps and brackets.
  - b. Provide piping connected to equipment with vibration isolators with flexible connections which shall conform to vibration and sound isolation requirements for the system.
  - c. Conform to ASHRAE 15 and ANSI B31.5.

## 2.21 REGISTERS, GRILLES AND DIFFUSERS

- A. Registers, grilles and diffusers shall be of model, size and capacity and furnished as scheduled on the drawings. Equipment shall be as manufactured by Titus, Tuttle & Bailey, Krueger or Metal-Aire and shall be supplied with white baked enamel finish except where noted otherwise.
- B. All supply registers shall be furnished with individually adjustable face louvers. Registers and grilles shall be supplied with white baked enamel finish except where noted otherwise.
- C. Diffusers, registers and grilles for installation in walls or plastered ceilings shall be provided with sponge rubber frame gaskets and Phillips head screws for attachment of device frame to building construction.
- D. The diffuser shall be provided with a removable core permitting easy access to core sections. Diffuser neck shall extend no less than 1 inch above the core to accommodate an internal duct connection to prevent leakage to ceiling space. Diffusers shall be assembled in patterns which provide one, two, three or four-way air discharge with each side delivering a quantity of air proportional to the area served.
- E. When indicated by manufacturer's model number on the equipment schedule, the ceiling diffusers shall be of the restricted multi-orifice 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 ensure rapid mixing of primary and room air. Each individual diffusing vane shall be welded in place and mechanically fastened to adjacent louver sections to make a rigid unit. The vanes shall extend to the discharge edges of the louvers. Where louver sections join core frame, the louver ends shall be

welded to core frame. The leaving edge of each louver shall be hemmed and the louver ends shall be rounded and hemmed before welding the core frames.

- F. All duct connections to registers, grilles and diffusers shall have all interior surfaces with the line of sight or within 4 feet of the opening painted with dull black paint.

## 2.22 PACKAGED ENERGY RECOVERY UNITS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Valent, Annex Air, Munters, Semco, Venmar
  2. Or approved equal
- B. Unit Construction:
1. Base: Manufacturer's standard base shall be constructed of minimum 10 gage galvanized steel with 16 gage integral floor pan. Floor pan shall be insulated with minimum 1/4" closed cell neoprene liner. All floor seams shall have a raised rib joint. Penetrations through the floor shall have a minimum 3/8" raised rib around each opening. Base shall have a minimum 4" overhang over the top of a roof curb to prevent water infiltration.
  2. Panels: Manufacturer's standard casing shall be constructed of minimum 2-inch, foam-injected, double-wall panels.
    - a. Individual panels shall be constructed so that there is no metal-to-metal contact between the interior and exterior sheet metal of each panel.
    - b. Interior side of panel shall be 22 gage G-90 galvanized steel. Exterior side of panel shall be 22 gage pre-painted steel rated for 1000 hours of salt spray exposure in accordance with ASTM B117 and ASTM D1654.
    - c. Insulation shall be 2 lb/ft<sup>3</sup> injected foam insulation with a minimum R-value of 12. Foam sheet or fiberglass insulation are not acceptable due to reduced durability of panel and increased chance for rust forming between the panels. Insulation water absorption must be no more than 0.038 lb/ft per ASTM D2842 and show "no growth" per ASTM G21 biocide testing. Interior sheet metal shall encase insulation so that it is not exposed to the airstream.
  3. Access doors shall be provided for access to all internal components requiring regular maintenance or inspection. Access door construction and materials shall be identical to unit casing. Access doors shall have galvanized hinges and a minimum of two quarter-turn compression latches with adjustable catches. Access doors shall be sealed with a full-perimeter D-shaped gasket constructed of EPDM sponge rubber.
  4. Roof shall be pitched away from access doors and include a minimum 1/2" overhang around the perimeter of the unit.
  5. Outdoor Air Inlet: Outdoor units shall be provided with a factory provided, field-assembled weather hood with protective bird screen on the outdoor air inlet. Indoor units shall be provided with duct connections at the outdoor air inlet.
  6. Unit shall include lifting eyes on top of unit for use during rigging.
  7. Motorized dampers – Outside Air and Return Air
    - a. Frame shall be constructed of a 16 gage galvanized steel hat-channel.

- b. Blades shall be constructed of 16 gage galvanized steel strengthened by three longitudinal 1 inch deep “vee” grooves.
  - c. Blades shall be symmetrical relative to its axle pivot point.
  - d. Axle bearings shall be synthetic sleeve-type and rotate inside extruded holes in the damper frame.
  - e. Blade seals shall be extruded vinyl permanently bonded to the appropriate blade edges.
  - f. Frame shall include flexible stainless steel compression-type jamb seals.
  - g. Modulating spring-return actuators shall be provided by the factory, installed on the damper, and wired to the control center. Each damper shall have a dedicated actuator. Single actuators with gear trains are not acceptable.
  - h. Damper leakage shall be no more than 3 cfm/sq.ft. at 1 in.wg static pressure.
8. Exhaust: Gravity backdraft damper with internal bird screen. Indoor units shall have duct flanges for connection to exhaust ductwork.
- C. Heat Recovery Device: Heat Wheel – Polymer substrate with silica gel desiccant.
- 1. Energy recovery shall be an integral part of unit from the manufacturer. No field assembly, ducting, or wiring shall be required with the energy recovery option.
  - 2. Energy recovery media shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.
  - 3. Energy recovery shall be provided through a total enthalpy wheel providing sensible and latent energy transfer per the scheduled performance.
  - 4. Energy recovery wheel shall be constructed of lightweight polymer substrate with permanently-bonded silica gel desiccant.
  - 5. Energy recovery wheel cassette shall be mounted perpendicular (90°) to the base of the unit.
  - 6. A VFD shall be required to modulate the speed of the wheel and to provide soft start to extend the life of the belt.
  - 7. Individual pie-shaped wheel sections shall be removable from wheel cassette for maintenance.
  - 8. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours.
  - 9. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.
  - 10. Energy wheel cassette shall include seals, drive motor, and urethane drive belt.
  - 11. Latent energy shall be transferred entirely in the vapor phase with no condensation.
  - 12. The energy recovery cassette and wheel drive motor shall be an Underwriters Laboratories Recognized Component for electrical and fire safety.
  - 13. Thermal performance shall be certified by the wheel manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment.
- D. DX Cooling Coil:
- 1. Coil shall be rated in accordance to AHRI standards, designed to withstand 250 psig working pressure at 300 degrees F, and pressure tested to 600 psig.



2. Coil shall be a minimum of 4 rows deep with maximum fin density of 10 fins per inch.
  3. Refrigeration systems with more than one circuit shall have interlaced evaporator coils.
  4. Coil casing shall be constructed of 304 stainless steel.
  5. Coil tubes shall be constructed of 1/2" diameter, 0.016" thick seamless copper tubing.
  6. Coil fins shall be constructed of 0.0060" thick aluminum.
  7. Drain pan
    - a. Drain pan shall be constructed of a minimum of 18 gage 201 stainless steel.
    - b. Drain pan shall be double-sloped to ensure condensate removal from unit.
    - c. Drain pan shall extend a minimum of 8" past the evaporator coil to ensure condensate retention.
- E. Refrigeration – Air Source Heat Pump:
1. Unit shall be provided with factory piped, charged, and tested packaged air-cooled direct expansion refrigeration system.
  2. Unit shall be factory charged with R-410A refrigerant
  3. Refrigeration systems 10 nominal tons and above shall be equipped with two stages of capacity control, each stage on an independent refrigerant circuit.
  4. Refrigeration systems 30 nominal tons and above shall be equipped with four stages of capacity control, two stages per independent circuit.
  5. Refrigeration system shall include microprocessor-based defrost cycle which shall enable a defrost cycle based on ambient dry-bulb temperature and ambient relative humidity.
  6. Refrigeration system shall be provided with thermal expansion valve (TXV) incorporating adjustable superheat.
- F. Compressors:
1. Compressors shall be hermetic scroll type and include the following items:
    - a. Suction and discharge service valves.
    - b. Suction and discharge isolation valves.
    - c. Reverse rotation protection.
    - d. Oil level adjustment.
    - e. Oil filter.
    - f. Filter drier
    - g. Short cycling control.
    - h. High and low pressure limits.
    - i. Crankcase heaters.
  2. Compressors shall be installed in a separate compartment, above the unit floor, and isolated from the surrounding environment by double wall foam injected panels and access doors.
  3. Compressors shall be installed using manufacturer's recommended rubber vibration isolators.
  4. Capacity control shall be provided through the use of a single Digital Scroll™ compressor. Additional compressors, if required, shall be fixed stage scroll compressors.
- G. Hot Gas Reheat:
1. Hot-gas reheat coil shall be separated from the evaporator coil by a minimum of 6" in the direction of airflow to prevent the re-evaporation of

- condensate, provide room for coil cleaning, and allow control system to monitor evaporator coil leaving dew point temperature.
2. Coil shall be rated in accordance to AHRI standards, designed to withstand 250 psig working pressure at 300 degrees F, and pressure tested to 600 psig.
  3. Coil casing shall be constructed of 16 gage galvanized steel.
  4. Coil tubes shall be constructed of 5/16" diameter, 0.012" thick seamless copper tubing.
  5. Coil fins shall be constructed of 0.0060" thick aluminum fins.
  6. Hot-gas reheat shall be controlled through a factory-supplied and controlled modulating 3-way valve.
  7. Coil shall be hydrogen or helium leak tested.
- H. Air Cooled Condenser:
1. Air cooled condenser coil shall be unit mounted.
  2. Provide condenser coils with galvanized casing, seamless copper tubes, and aluminum fins.
  3. Coil shall be rated in accordance to AHRI standards, designed to withstand 250 psig working pressure at 300 degrees F, and pressure tested to 600 psig.
  4. Coil casing shall be constructed of 16 gage galvanized steel.
  5. Coil tubes shall be constructed of 5/16" diameter, 0.012" thick seamless copper tubing.
  6. Coil fins shall be constructed of 0.0060" thick aluminum fins.
  7. Condenser coils shall be mounted at a minimum 30 degree angle from vertical to help prevent hail damage.
  8. Coil shall be hydrogen or helium leak tested.
  9. Condenser coils shall include factory provided and installed condenser coil guards.
- I. Condensing Fans – Low ambient and Low sound (EC Fans):
1. Condensing section shall be equipped with high-performance 1200 rpm condensing fans.
  2. Condensing fan blades shall be constructed out of a polymer, sickle-shaped blades with serrated trailing edges for sound reduction. Individual fans shall be capable of an Lw(A) of 75 dB as tested to ISO 5801.
  3. All condensing fan motors shall be electrically-commutated and capable of modulation without the need of an external variable frequency drive.
  4. All condensing fans shall modulate in unison to maintain the head pressure set point.
- J. Direct Drive Supply and Exhaust Airflow Blowers:
1. Fan assemblies shall be direct-drive without the use of belts or adjustable sheaves.
  2. A variable frequency drive (VFD) shall be provided for each fan section. VFD shall be mounted, wired, and programmed by the equipment manufacturer. VFD shall be located in an enclosed compartment outside of the supply or exhaust air stream.
  3. Fan wheel shall be tested in accordance to AMCA 210. Fan speed shall not exceed 2400 RPM.
  4. Fans may be full width or partial width. Fans modified to partial width through the use of banding or other blade reduction method are not acceptable.
  5. Fans shall be mounted on minimum 1" tall neoprene isolators.

6. Fan motor shall be VFD rated, ODP type, EPACT compliant, and shall be of premium efficiency (PE).
- K. Electric Heat (Main heating coil):
1. Unit shall be provided with SCR controlled open-coil electric heater. Staged heaters are not acceptable.
  2. Electric heater elements shall be high grade nickel-chrome alloy, insulated by floating ceramic bushings.
  3. Electric heater shall be equipped with fail-safe, automatic reset and manual reset disc-type thermal cut-outs, magnetic contactors, 24VAC transformer, and airflow proving sensor.
  4. Electric heater shall be provided with a separate power connection from main unit disconnect.
- L. Electric Preheat
1. Electric preheater: Shall be provided for frost control of the energy wheel. Preheater shall comply with UL 1995 and be constructed on a galvanized steel frame. See schedule for KW sizing of electric preheat.
- M. Filters:
1. Outdoor air filters (energy recovery only)
    - a. Outdoor air filter rack shall accommodate factory-provided 2" aluminum or 2" MERV8 filters.
    - b. Filter sections shall be accessible through a 2" foam-injected, double-wall, hinged access door with quarter-turn latches.
  2. Return air filters (energy recovery only)
    - a. Return air filter rack shall accommodate factory-provided 2" MERV8 filters.
    - b. Filter sections shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.
  3. Supply air filters
    - a. Supply air filter rack shall accommodate factory 4" MERV 14 with leading 2" MERV 8 filters.
    - b. Filter sections shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.
    - c. Filter section shall include magnehelic gauge and/or dirty filter pressure switch.
- N. Electrical:
1. Unit shall be constructed with an integral electrical and control center isolated from supply airflow, exhaust airflow, compressors, and heating elements. The control center shall control all aspects of the unit operation. VFDs with overload protection shall be provided for each fan bank.
  2. Units shall be wired according to NEC and listed per ETL. ETL listing shall cover all components of the ventilator and not be limited to the control panel. All major electrical components shall be UL or ETL listed.
  3. Unit shall have a single point of connection with integral unit mounted disconnect. Panel shall have an SCCR rating of 5 kV.
  4. Units shall be factory wired with a dual point power connection.
  5. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 7% out of balance on voltage, the voltage is more than 7% under design voltage,

- or on phase reversal.
6. The following items shall be provided and wired within the control center by the factory:
    - a. Non-fused disconnect.
    - b. Sub-circuit fusing.
    - c. Low voltage transformers.
    - d. Controls as specified in this section.
    - e. Control circuit fusing.
    - f. Terminal block.
    - g. Supply and Exhaust Fan motor Variable Frequency Drives (VFDs).
  7. Electrical panel must house all high voltage components such as terminal blocks, variable frequency drives, and fuse blocks.
  8. All electrical power and controls wiring shall run in chase located between unit ceiling and roof to minimize interior wall penetrations and allow for ease of access.
  9. *Need to add clarification on how the dual power and the electric coil power*
  10. Options
    - a. Control panel shall include a factory supplied and mounted 115V GFCI convenience outlet receptacle with a 12A circuit breaker. Outlet shall be powered by the main power.
    - b. Unit shall include a factory supplied, mounted, and wired electric heating element in the control panel to maintain a minimum of 0F in the panel.
- O. Controls:
1. Units shall be furnished with a Controls Lite or similar option. The concept of Controls Lite is that the Refrigeration Control, Gas Heating Control, and VFD's are wired to terminal strip where the ATC can control via hard wired points with their field installed controller. The unit controller and all other controls are provided by ATC. The following points will be factory furnished, installed, and wired to a terminal strip for the ATC:
    - a. OA, RA, EA Damper Actuators
    - b. Start/stop and modulating of Fans
    - c. Enable/disable, stagin and modulating gas heat
    - d. Heat wheel start/stop and modulation
    - e. Enable/disable and modulating signal for cooling
    - f. Enable/disable and modulating signal for Hot Gas Reheat
    - g. Supply Fan Air Flow Measuring Station
    - h. Exhaust Fan Air Flow Measuring Station
    - i. Outside Air Flow Measuring Station
  2. The refrigeration controller shall control the entire refrigeration portion of the unit and accept the signals from the BMS listed above. The refrigeration controller shall also monitor and control all refrigerant safeties and alarms. The refrigerant controller shall include an interface (Bacnet, etc) for monitoring only of all alarms, pressures, and functionality.
  3. VFD's shall be controlled via hardwired signals from the ATC controller for enable/disable, modulation and feedback.
- P. FACTORY VERIFICATION TESTING
1. Unit shall be thoroughly run tested prior to shipment from the factory.
  2. Factory run test report shall be provided at the request of the engineer, contractor, or owner.
  3. Testing Procedures (the non-applicable devices should be removed from

this list)

- a. Unit shall be subjected to and pass a dielectric (hipot) test.
  - b. All motorized dampers shall be cycled one full stroke while installed in the unit using the factory-provided motorized actuators.
  - c. Supply fan
    - 1) Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.
    - 2) Verify fan pressure proving switch operation.
    - 3) Measure and record current draw through supply fan motor(s).
  4. Exhaust fan
    - a. Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.
    - b. Verify fan pressure proving switch operation.
    - c. Measure and record current draw through exhaust fan motor(s).
  5. Energy recovery wheel
    - a. Visually inspect energy recovery wheel cassette is free to rotate within cassette.
    - b. Visually inspect energy recovery belt drive mechanism.
    - c. Enable energy recovery wheel motor and ensure proper rotation.
    - d. Measure and record current draw through energy recovery wheel motor.
  6. Condensing fans
    - a. Ensure fans rotate freely without obstruction.
    - b. Energize fans and ensure proper rotation.
    - c. Measure and record the amount of current draw through each condensing fan.
  7. Refrigeration system
    - a. Measure and record subcooling and superheat on circuit A with hot-gas reheat valve closed (0%) after 15 minutes of steady-state operation.
    - b. Measure and record subcooling and superheat on circuit A with hot-gas reheat valve open (100%) after 15 minutes of steady-state operation.
    - c. Measure and record subcooling and superheat on circuit B after 15 minutes of steady-state operation.
  8. Test report shall be provided prior to unit startup and available from the factory upon request.
- Q. CAPACITIES AND CHARACTERISTICS
1. As indicated on the drawing schedules.

## 2.23 SHEET METAL WORK

- A. General: Ductwork systems shall be fabricated and installed in accordance with recommendations contained in the SMACNA "HVAC Duct Construction Standards", Second Edition 1995, and as herein specified. Tables and figures referred to hereinafter are taken from the SMACNA publication.
- B. Duct Pressure Classes: As shown on drawings. Where no specific duct pressure class designations are provided on drawings, the 2 inch water gauge pressure class is the basis of compliance with the standards, regardless of velocity in the duct, except when the duct is variable volume supply or designated exhaust. All

variable volume ducts upstream of VAV boxes have a 3 inch WG basis of compliance when the drawings do not give pressure class. All AC unit discharge plenums of VAV systems shall have a 6 inch WG basis and the ductwork to the first branch take-off a 4 inch WG basis of compliance when the drawings do indicate a pressure class. Negative pressure ductwork between lab hoods and exhaust fan inlet shall be 5 inch water gauge pressure class. Snaplock construction is not permitted. Refer to NFPA for Smoke Exhaust Ductwork Gauge Requirements.

- C. Casings and Plenums: Casing and plenum sheet metal gauges, reinforcing and construction details shall be in accordance with Figures 6-1 through 6-12. Intake and exhaust plenums shall be sealed liquid tight and drained. Where through-louver drainage can not be achieved, a 1 inch drain connection with serviceable 3 inch deep trap, shall be provided within a heated space to prevent freezing, and piped to the nearest floor drain. Bottom of plenums shall pitch toward drainage openings.
- D. Hangers and Supports: Ductwork sheet metal supports shall be in accordance with Chapter IV, including all plenum and casing sheet metal which is suspended.
- E. Sealing: All duct joints and air device connections shall be sealed in accordance with Table 1-2 except that all supply systems shall be sealed Class A. The sealant shall be Hardcast 550 with imbedded fabric, except for joints with dissimilar metals then a lead gasket shall be provided. Louver plenums shall be sealed water tight to a height of 12 inches above the plenum bottom.
- F. Branch Take-Offs: Branch main take-offs for round ductwork shall be 45 degree lateral tap and where terminal boxes occur, shall be 45° angle entry in accordance with Figure 2-6.
- G. Elbows: Elbows for round ducts shall be stamped type elbows with centerline radius equal to 1.5 times duct diameter. Where space is limited, the centerline radius may be reduced to 1.0 times the diameter for only those ducts entering into corridor ceiling spaces from vertical duct shafts. Elbows for rectangular and oval ductwork shall have a centerline radius equal to 1.5 times the duct width.
  - 1. Where space is restricted and as approved in writing by the Engineer, square throat elbows with single or double thickness turning vanes, as required, may be used. Elbows shall be in accordance with Figure 2-2 except that throat types RE-4, RE-6, RE-7, RE-9 and RE-10 are specifically prohibited. Provide an access door upstream of all square throat elbows with single (or double) thickness turning vanes.
- H. Transitions and Offsets: Transitions in round ducts shall be conical reducers. Transitions in rectangular ducts shall be in accordance with Figure 2-7 except that offset type 1 and offset type 2 are specifically prohibited.
- I. Flexible Connections: Flexible connections shall be in accordance with Figure 2-17. Flexible connectors shall be installed to provide alignment of equipment and devices with ducts in operating positions. Provide on the inlet and outlet side of all air moving equipment incorporating rotating elements. Connections shall be of glass fiber reinforced neoprene captured by a fingered metal band at each edge. Maintain a maximum three inch (3") separation and a minimum 1½ inch separation between the connected devices such that a standard four inch (4") connector will be installed slack.

- J. Access Doors: Access doors in sheet metal ducts shall be provided with sash locks. Access doors in casings and plenums shall be provided with Type 2 locks (handles). All doors shall be hinged. Door insulation shall match adjacent casings. Doors shall be provided on all plenum and mixing sections, fire dampers, smoke dampers, combination fire/smoke dampers, reheat coils (inlet side), air valves and terminal filter equipment.
- K. Volume Dampers: Volume dampers shall be in accordance with SMACNA except that, in addition to those indicated on drawings, each branch main and branch shall be provided with damper typical to locations indicated in Figure 2-1. Additional dampers shall be provided where shown on plans, details and where specified elsewhere. Damper gauge to be two (2) gauges heavier than the duct in which they are mounted. Provide with locking quadrants or push rods and pillow blocks as appropriate. Dampers shall be sufficiently large to extend the full width of the branch duct to which it is attached. Provide scooped profile as required.
- L. Fire Dampers and Smoke Dampers: Fire and smoke dampers shall be in accordance with National Fire Code NFPA 90A Standard requirements and bear an Underwriters label. Dampers shall be installed in accordance with manufacturer's installation instructions. Dampers shall be UL listed, labeled, and shall be dynamic-static designed in accordance with UL Standard 555. Dampers shall be listed to support the appropriate fire rating required for wall and/or floor penetrations served. Dampers in lined ducts shall be in accordance with Figure 2-22. Where required as a condition of damper listing, provide slip joint. To permit breakaway, no screws, rivets, bolts or other fasteners shall be used; each joint shall have an access door as applicable. Provide an access door in the duct to service fusible link. Access doors for insulated ducts shall be double wall insulated sandwich type. Fire dampers shall be out of air stream Type B or C. Combination fire/smoke dampers may be used in lieu of separate dampers. All smoke dampers and combination fire/smoke dampers shall be furnished with pneumatic or electric actuators as required, and appropriate UL label. Provide 10 gauge welded sleeve where dampers can not be placed directly into the fire and/or smoke wall.
1. All smoke dampers and fire/smoke dampers shall be supplied with electric/electronic actuators, 165 degree F. "McCabe Link" (for use in general HVAC ductwork), 185 degree F. "McCabe Link" (for use in smoke control exhaust ductwork). All fire/smoke dampers shall be capable of being reset remotely. All fire/smoke dampers shall be supplied with one (1) end switch that will indicate both full closed and full open. All fire/smoke dampers shall fail open upon loss of control signal. All smoke dampers shall fail closed upon loss of control signal.
  2. Except where specifically noted otherwise, the maximum permissible pressure drop for any fire damper at air flow quantity required by Design Documents shall not exceed 0.1 inches of water.
  3. Except where specifically noted otherwise, the maximum permissible pressure drop for any smoke damper assembly at air flow quantity required by design documents shall be as follows:
    - a. Up to 1,000 FPM 0.05 Inches of Water
    - b. 1,000 to 2,000 FPM 0.10 Inches of Water
    - c. Over 2,000 FPM 0.20 Inches of Water
  4. Damper sizes shall be adjusted accordingly where required to reduce pressure drop.
  5. Installed dampers found to have pressure drops in excess of specified values shall be replaced at no additional cost to the Owner.

- M. All fire, smoke and combination fire/smoke dampers shall be dynamically rated for the following conditions:
- |    |                                       |           |
|----|---------------------------------------|-----------|
| 1. | Fan (VAV) Discharge to Terminal Units | 3,500 FPM |
| 2. | Fan (CV) Discharge to Reheat Coils    | 1,500 FPM |
| 3. | Terminal Box/Reheat Coil Discharge to |           |
| a. | Terminal Device (Diffuser, etc.)      | 1,000 FPM |
| 4. | Return/Exhaust Terminal Device        |           |
| a. | (Register, etc.) to fan inlet         | 1,800 FPM |
- N. Exposed Ductwork: All ductwork exposed to view, except in mechanical rooms, shall not be cross-broken or beaded. Where reinforcement can not be eliminated by using heavy duty gauge, it shall be internal. Seams shall be of non-standing type and duct shall be cleaned and degreased to accept application of paint.
- O. Flexible Ductwork: Shall be manufactured in accordance with UL-181, Class 0 and the amended Standards of NFPA 90A. The flexible ductwork shall be tested and listed by UL under these standards.
1. Ductwork shall be fabricated of minimum 0.0065" thick, grade 3003 aluminum alloy incorporating a "O" temper.
  2. Spiral construction shall incorporate a continuous grooved seam, flat pipe lock, doubled over, to create an effective triple locking joint. Double locking seams shall not be accepted.
  3. Corrugations formed into the spiral tape impart rigidity and shall support duct flexibility. Corrugations shall not exceed 3% of the nominal duct diameter.
  4. Joints for securing to ductwork and/or equipment collars shall incorporate a reinforcing band around the circumference of the flexible duct and its connection point. Self-tapping sheet metal screws shall extend through the reinforcing band through the connecting collar, sandwiching the flexible ductwork between. Final air sealant shall be provided by Hardcast 550 with imbedded fabric.
  5. Where associated ductwork is specified to be insulated, matching thickness insulating jacket, complete with vapor barrier, shall be used.
  6. Length of flexible duct shall not exceed 48 inches except where specifically noted otherwise on drawings.
  7. Flexible ductwork shall not be used in conjunction with ductwork rated for 6 inches WG and higher. Flexible duct shall not be installed to penetrate any walls, ceilings, roofs, floors, etc.
  8. The intent of this specification section is to allow the use of flexible ductwork as a final connection to a terminal device. Bends shall not exceed 90 degrees or have a radius less than inside diameter of duct.
- P. Exhaust systems serving bathrooms, shower rooms and similar rooms where the exhaust air may contain a high moisture content shall be constructed of aluminum and shall be sealed watertight and pitched to prevent any accumulation of moisture. Provide a trapped drain at all low points and at the base of each riser.
- Q. Exhaust systems serving laboratory exhaust hoods shall be constructed of Type 316 stainless steel with externally welded, liquid tight joints, unless indicated otherwise on the drawings.
- R. Provide 24 gauge piping sheet metal protective covers, shields or saddles to protect piping insulation. Protective covers shall totally encapsulate any and all



exposed HVAC piping within six feet (6') of finished floor. Shields and saddles shall extend a minimum of six inches (6") ahead and behind the projected footprint of the pipe support addressed and shall completely cover the lower 180° arc of the insulated piping.

S. Acoustic Liner:

1. All ductwork noted on plans to be acoustically lined, shall have one-inch (1") thick "ToughGard R" duct liner with enhanced surface. Acoustical liner shall be composed of rotary-type glass fibers for superior acoustic performance. The fibers shall be bonded together with a thermosetting resin into a insulation blanket which is overlaid with a durable, water repellent, fire-resistant black composite air stream surface.
2. Acoustic liner shall comply with ASTM C1071 for air velocities up to 6000 FPM.
3. Acoustic liner shall comply with ASTM C1104 for vapor sorption.

Note: Duct dimensions shown are of clear inside dimensions after application of liner.

2.24 SOUND ATTENUATORS

- A. Silencers shall be of the size, configuration, capacity and acoustic performance as scheduled on the drawings. All silencers shall be factory fabricated and supplied by the same manufacturer. Silencers shall be manufactured by VAW, Kinetics, Commercial Acoustics or approved equal.
- B. Alternate manufacturers must request and obtain written approval by the Engineer to bid the project at least 10 days prior to the bid due date. As a condition of pre-approval, alternate manufacturers must submit to the Engineer a minimum of twenty (20) different HVAC silencer test reports. Each report shall be for a silencer tested in full accordance with the ASTM E-477-99 silencer test standard in an aero-acoustic test facility which is NVLAP accredited for the ASTM E477-99 standard. Each test shall have been conducted within the last 12 month period. A copy of the laboratory's NVLAP accreditation certificate must be included with the submitted reports. Any changes to the specifications must be submitted and approved in writing by the Engineer at least 10 days prior to the bid due-date.
- C. Silencer inlet and outlet connection dimensions must be equal to the duct sizes shown on the drawings. Duct transitions at silencers are not permitted unless shown on the contract drawings.
- D. Elbow Silencers: All elbow silencers, including models REFL shall be constructed with an 18 gauge galvanized steel outer casing (unless HTL casing is specified) and 22 gauge galvanized perforated steel. All acoustical splitters shall be internally radiused and aerodynamically designed for efficient turning of the air. Half and full splitters are required as necessary to achieve the scheduled insertion loss. All elbow silencers with a turning cross-section dimension greater than 48" shall have at least two half splitters and one full splitter.
- E. Rectangular Silencers:
  1. All rectangular silencers shall be constructed with a 22-gauge galvanized steel outer casing and 26 gauge galvanized perforated steel liner.
- F. Acoustic Media:

1. Media shall be of acoustic quality, shot-free glass fiber insulation with long, resilient fibers bonded with a thermosetting resin. Glass fiber density and compression shall be as required to insure conformance with laboratory test data. Glass fiber shall be packed with a minimum of 15% compression during silencer assembly. Media shall be bacteria and fungus resistant, resilient such that it will not crumble or break, and conforming to irregular surfaces. Media shall not cause or accelerate corrosion of aluminum or steel. Mineral wool will not be permitted as a substitute for glass fiber.
- G. Media Protection;
1. Media shall be encapsulated in glass fiber cloth to help prevent shedding, erosion and impregnation of the glass fiber.
- H. Silencer materials, including glass fiber, shall have maximum combustion ratings as noted below when tested in accordance with ASTM E84, NFPA 255 or UL 723.
1. Flamespread Classification: 15
  2. Smoke Development Rating: 5
- I. Silencers shall have high transmission loss (HTL) walls externally applied and completely sealed to the silencer casing by the silencer manufacturer to assure quality-controlled transmission loss. The HTL walls shall consist of media, airspace, mass and 10-gauge outer protective metal skin, as required, to obtain the specified room noise criteria. Standard acoustical panels will not be accepted as HTL walls. If requested by the Engineer, breakout noise calculations for each air handling and fan system shall be provided with the silencer submittal to insure compliance with the room noise criteria. Breakout noise calculations shall be based on the sound power levels of the specified equipment.
- J. Silencers shall be constructed in accordance with ASHRAE and SMACNA Standards for the pressure and velocity classification specified for the air distribution system in which it is installed. Material gauges noted in "Section B Materials" are minimums. Material gauges shall be increased as required for the system pressure and velocity classification. The silencers shall not fail structurally when subjected to a differential air pressure of 8 inches water gauge.
1. Casings shall be lock formed and sealed, except as noted in Section B Materials, to provide leakage resistant construction. Airtight construction shall be achieved by use of a duct-sealing compound supplied and installed by the Contractor at the job site.
  2. All perforated steel shall be adequately stiffened to insure flatness and form. All spot welds shall be painted.
- K. Acoustic Performance:
1. Silencer dynamic insertion loss shall not be less than that listed in the silencer schedule.
  2. Silencer generated noise shall not be greater than that listed in the silencer schedule.
  3. Acoustic performance shall include dynamic insertion loss and generated noise for forward flow (air and noise in same direction) or reverse flow (air and noise in opposite direction) in accordance with the project's air distribution system requirements.
  4. All silencer ratings shall be determined in a duct-to-reverberant room test facility which provides for airflow in both directions through the test silencer in accordance with the ASTM E-477-99 test standard. The test set-up, procedure and facility shall eliminate all effects due to flanking, directivity,

end reflection, standing waves and reverberation room absorption.

- L. Silencer pressure drops shall not exceed those listed in the silencer schedule. Silencer pressure drop measurements shall be made in accordance with the ASTM E-477-99 test standard. Tests shall be conducted and reported on the identical units for which acoustical data is presented.
- M. The manufacturer shall supply certified test data for each scheduled silencer. The data shall include dynamic insertion loss, generated noise and pressure drop for forward or reverse flow, matching the project's air distribution system requirement. All ratings shall be conducted in the same facility and shall utilize the same silencer.
  - 1. Test facilities and test reports shall be open to inspection upon request from the Engineer. Silencer performance must have been substantiated by laboratory testing according to ASTM E477-99 and so certified when submitted for approval. The aero-acoustic laboratory must be NVLAP accredited for the ASTM E477-99 test standard. A copy of the accreditation certificate must be included with the submittals. Data from non-NVLAP accredited test facilities will not be accepted.

## 2.25 SUPPLEMENTAL SUPPORT SYSTEM

- A. This Contractor shall provide all supplemental supports required to direct equipment and materials support loads to approved structural load bearing points. All mechanical equipment and systems shall be substantially supported without distortion or excessive vibration. The methods of support shall be as hereinafter described, except as otherwise noted on the drawings.
- B. The supplemental support system shall be substantial type with members sized to prevent equipment distortion or excessive vibration. The HVAC Subcontractor shall provide support components as required such that all equipment shall operate without objectionable noise or vibration being transmitted to the structure.
- C. The supplemental support system shall conform to requirements of this specification. Manufacturer's published characteristics referenced are intended as a guide only. The supplier shall verify support elements submitted are in accordance with specified materials and construction and are appropriately sized to accept and direct the proposed loading.
- D. All supplemental support elements shall be by one (1) manufacturer: Unistrut, B-Line or Telestrut. The acceptable standard or quality shall be as follows:
  - 1. Framing Members:
    - a. Nominal Size: 1 $\frac{5}{8}$ " x 1 $\frac{5}{8}$ " "U" channel
    - b. Body: Mild Carbon Steel, ASTM A570 Grade 33
    - c. Gauge: 12 Gauge (0.105" thick)
    - d. Slot Width: 7/8" nominal
    - e. Pre-Punching: 9/16" Diameter, 1 $\frac{7}{8}$ " on center, 3 sides
    - f. Finish: Hot-Dipped Galvanizing, G90 weight, ASTM A123
    - g. Conformance: Metal Forming Manufacturers Association (MFMA) Standard Publication MFMA-1.
  - 2. Fittings:
    - a. Nominal Size: 1 $\frac{5}{8}$ " (length per device)
    - b. Shape: Per Service from Manufacturer's Standard Catalog
    - c. Body: Hot Rolled Mild Carbon Steel, ASTM A570, Grade 33

- d. Gauge: 1/4" Nominal Thickness
  - e. Hole Size: 9/16" Nominal
  - f. Finish: Hot Dipped Galvanizing, G90 weight, ASTM A123
  - g. Conformance: Metal Forming Manufacturer's Association (MFMA) Standard Publication MFMA-1
3. Accessories:
- a. Nominal Size: Per Service from Manufacturer's Standard Catalog
  - b. Shape: Per Service from Manufacturer's Standard Catalog
  - c. Body: Hot Rolled Mild Carbon Steel, ASTM A570, Grade 33
  - d. Gauge: 1/4" Nominal Thickness
  - e. Hole Size: 9/16" Nominal
  - f. Conformance: Metal Forming Manufacturer's Association (MFMA) Standard Publication MFMA-1.
  - g. Rollers: Gray Cast Iron
4. Nuts and Bolts:
- a. Nominal Size: 1/2" diameter x (Size per device)
  - b. Body: Mild carbon steel, ASTM A570, Grade 33, and Case Hardened
  - c. Threading: Coarse, Unified & American, UNC Classes 2A and 2B
  - d. Mounting: Spring or non-spring
  - e. Finish: Electro-Galvanized, G90 weight, ASTM A123
  - f. Conformance: Metal Forming Manufacturer's Association (MFMA) Standard Publication MFMA-1
- E. Supplemental support system members shall be positioned to align with equipment support points for proper bolting.

## 2.26 TERMINAL BOXES

- A. Single duct type:
- 1. Terminal Casing  
Furnish and install Titus, Enviro-Tec or Metal-Aire, single duct terminals of sizes and capacities (CFM) indicated on the drawings. Terminals shall be constructed of not less than 24 gauge zinc-coated steel, mechanically assembled and sealed to form an air-tight casing; maximum air leakage of 2 % at 3" w.g. Spot-welded casings are not acceptable. Interior walls of the terminal casing shall be lined with 1/2 -inch dual-density fiberglass with 4 pounds per cubic foot skin density, rated for a maximum air velocity of 4500 fpm. Insulation must meet all requirements of UL 181 and NFPA 90-A. Raw edges exposed to the airstream shall be coated and sealed. Sound power data shall be submitted with no corrections or noise reduction factors applied.
  - 2. Air Control Valve Assembly  
Terminal air control valve shall be dual-wall construction, consisting of two (2) metal thicknesses with 1/2-inch dual-density insulation sandwiched between, creating an effective radiated sound barrier. Insulation shall be as specified for terminal casing. The control blade of the air valve shall be 16-gauge, designed to operate through a 45-degree arc. Multi-blade dampers and single blade volume controllers (operating through 90°) are not acceptable. The control blade shall be bolted or welded to a continuous shaft which rotates in self-lubricating nylon bearings. Blade shall close against a closed-cell gasket seat; it shall be preloaded to insure a tight seal. Blade shall not deflect at inlet pressures up to 6" w.g. Elliptical or oval dampers are not an acceptable substitution.

3. Controls  
Terminal unit control shall be furnished by the ATC Contractor and factory installed by the terminal box manufacturer. See ATC Specification Paragraph 2.51. The terminal box manufacturer shall bear all costs associated with mounting the controls. Terminal boxes shall be provided with a sheetmetal control enclosure. Provide a factory-applied typed label unique to each VAV terminal box indicating DDC address, TAG, maximum flow setting, minimum flow setting.
4. Pressure-Independent Models with Pressure Differential Controller  
Pressure differential reset controller shall maintain setpoint (CFM) within 5%, regardless of system pressure change. CFM limiting devices are not acceptable. The reset controller shall constantly monitor thermostat input, air flow (CFM), and system static and total pressures in a manner as to minimize under-or over-controlling in relation to the space temperature requirements. The reset controller shall be capable of field adjustment of minimum and maximum CFM settings without the use of tools. Flow curve for field balancing shall be affixed to terminal casing. Differential flow taps and factory-set CFM shall be provided is so noted at terminal schedule on the drawings. Controller shall maintain pressure independence to as low as .03" w.g. Averaging sensor shall be mounted in the inlet of the terminal and shall provide a minimum of one air pickup point for each 2-1/2" of inlet diameter. Single-point differential sensors are not acceptable.
5. Acceptable Alternate Manufacturers:
  - a. Nailor and Price

## 2.27 VALVES

- A. All valves shall conform to requirements of this specification for the services indicated. Manufacturer's numbers referenced are intended as a guide only. The supplier shall verify valves submitted are in accordance with specified materials and construction.
- B. All valves of a given type shall be by one (1) manufacturer. The acceptable standard of quality shall be as follows.

## 2.28 VARIABLE FREQUENCY DRIVES

- A. General
  1. The Contractor shall provide a complete adjustable frequency controller as indicated on the drawings.
  2. The Contractor shall be responsible for the installation and start-up of the equipment covered by this specification.
  3. The adjustable frequency controller shall be furnished by a single vendor who has actively been manufacturing adjustable frequency controllers for a period of at least five (5) years.
  4. Complete drawing shall be furnished for approval and shall consist of master wiring diagrams, elementary or control schematics, including coordination with other electrical control devices operating in conjunction with the adjustable frequency controllers. Suitable outline drawings showing details necessary to located conduit stubups and field wiring shall be furnished for approval before proceeding with manufacture.
  5. The adjustable frequency controller shall be UL and CSA certified and shall comply with the latest applicable standards of ANSI, IEEE, NEMA and national Electrical Code.

6. Adjustable frequency controller manufacturer shall maintain and staff engineering service, within one hundred (100) actual miles of the site, to provide start-up service, emergency service calls, repair work, service contracts, maintenance and troubleshooting training of customer personnel.
- B. Construction
1. The adjustable frequency controller shall be rated 460 volt, 3 phase, with feature and options as specified.
  2. The adjustable frequency controller shall be rated for the motor HP as shown on the drawings. The controllers shall provide digitally-based speed adjustment of three phase motors. The adjustable frequency and voltage output shall provide constant volts per hertz excitation of the motor up to 60 hertz.
  3. The adjustable frequency controllers shall have a 110% overload rating for one (1) minute, every ten (10) minutes and a 140% overload rating for two (2) seconds, every fifteen (15) seconds.
  4. The controller shall be capable of converting incoming 3 phase, 460 volt (+10%) and 60 hertz (+/- 2 hertz) power to a fixed potential DC bus level. The DC voltage shall be inverted by a full wave diode bridge rectifier or a pulse width modulated (PWM) inverter to an adjustable frequency output. The controller shall maintain power factor at .95 or greater at any speed or load. The controller shall have a minimum efficiency of 95% at rated load. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan (variable torque) control.
  5. The adjustable frequency AC controller shall employ a full wave rectifier to prevent line notching, for conversion of AC power to DC power. The inverter section shall use Insulated Gate Bipolar Transistors (IGBT) (p -n substrate) as switching devices. The IGBT, operating as a MOS-gated, input inverted Darlington transistor with a MOSFET (n -n substrate in n-channel enhancement mode) input shall support high input impedance, low drive power and fast (40+k/sec) switching speeds. The bipolar output stage shall enable low conduction losses with high currents. A DC bus choke and DC capacitors shall control internal harmonic generation.
    - a. Silicon controller rectifies (SCR's), current source inverters and paralleling of devices are unacceptable.
  6. Sine wave approximation and voltage vector control shall be used to allow operation at rated motor shaft output at nominal speed with no derating. This voltage vector control shall be designed to minimize harmonics to the motor to maximize motor efficiency and life.
  7. The inverter shall operate in an ambient temperature of 0°C to 40°C for elevations up to 3,300 feet above seal level and humidity of 0% to 95% non-condensing.
  8. The controller enclosure shall be NEMA 1, wall-mounted. The controller shall have easily removable assemblies and shall be front accessible. No side clearance shall be required for cooling of wall mount units and all power and control wiring shall be done from the bottom.
  9. All enclosures shall be not less than 16-gauge steel with surfaces to be thoroughly cleaned and phosphatized prior to painting. They shall be primed with a corrosion-resisting coating. Cabinet finish paint to be ANSI 161.
  10. Doors shall include plastic device holders for mounting up to six (6) operator devices. Factory mounted operator devices shall be factory wired.

11. The operating handle of the disconnect shall always remain connected to the breaker and shall not be mounted on the door. The position handle shall indicate ON, OFF or TRIPPED condition of the circuit breaker. The handle shall have provisions for padlocking in the Off position with at least three (3) padlocks. Interlock provisions shall prevent unauthorized opening or closing of the controller door with the disconnect handle in the ON position.
12. All logic control boards shall be interchangeable.
13. The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be listed by a nationally recognized testing agency such as UL, ETL.
14. The VFD's full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for sixty (60) seconds and 220% of rated current for up to one (1) second while starting.
15. Drive shall be capable of operating a motor up to 1,000 feet away without derating or field modification. Provide detuning output filters and shielded cabling as required.

C. Interface

1. Start, stop and speed control potentiometer terminations.
2. Linear independent timed acceleration and deceleration adjustable.
3. Non-isolated process signal follower for 0-10 VDC control of output frequency.
4. Variable torque performance from 2 to 60 hertz.
5. Frequency stability of 0.5% for twenty-four (24) hours with voltage regulation of +/-2% of maximum rated output voltage.
6. Individual door-mounted lights or LED's for indication of run, power on and interruption due to over-current, over-voltage, over-frequency, under-voltage, over-temperature and phase loss.
7. 115 volt AC isolated control power for operator devices.
8. Motor slip dependent speed regulation.
9. Logic power carryover during utility loss shall be sufficient to extend double the interval required for internal losses to decay the load inertia to zero.
10. Insensitive to input line rotation.
11. Fixed dwell time at start to increase motor starting torque.
12. Auto restart to automatically restart on phase loss, over-voltage and under-voltage trips only.
13. Local/Hand, Stop/Reset and Remote/Auto selector switches shall be provided to start and stop the drive and determine the speed reference.
14. Provide a 24 VDC, 40 mA max, output signal to indicate that the drive is in Remote/Auto mode.
15. Digital manual speed control. Potentiometers are not acceptable.
16. Lockable, alphanumeric backlit display keypad. VFD's up to 300 HP shall use the same control panel.
17. A quick setup menu with preset parameters shall be provided on the drive.
18. The drive shall be fitted with RS 485 serial communications port and be supplied with software to display all monitoring, fault, alarm and status signals. The software shall allow parameter changes to be made to the drive settings, as well as storage of each controller's operating and setup parameters.
  - a. The drive shall be fully able to communicate with PLC's, CDS's and DDC's. DDC's shall be able to monitor drive feedback signals which shall include, but shall not be limited to:
    - 1) Output Speed/Frequency
    - 2) Current (in amperes)
    - 3) Torque

- 4) Power
  - 5) Kilowatt-Hours
  - 6) Relay Outputs
  - 7) Diagnostic Faults
19. The RS 485 serial communications port and software shall allow parameter changes to be made to the drive settings, as well as storage of each controller's operating and setup parameters.
- a. Serial communications shall include, but shall not be limited to:
    - 1) Run-Stop Control
    - 2) Speed Set Adjustment
    - 3) Proportional-Integral Controller Adjustment
    - 4) Current Limit
    - 5) Acceleration/Deceleration Time Adjustment.
20. Setpoint control interface (Proportional-Integral-Derivative (PID) control) shall be standard in the unit.
21. Floating point control interface shall be provided to increase/decrease speed in response to switch closures.
22. An elapsed time meter with kWh meter shall be provided.
23. The following displays shall be accessible from the control panel in actual units.
- a. Reference Signal Percent
  - b. Output Frequency
  - c. Output Amps
  - d. Motor Horsepower
  - e. Motor Electrical Demand (kW)
  - f. Motor Electrical Energy Consumption (kW-hr)
  - g. Output Voltage
  - h. Drive Temperature (% until trip)
  - i. Motor speed expressed in engineering units per application (in percent speed, GPM, CFM).
24. Drive will sense the loss of lead and signal a no load/broken belt warning or fault.
25. The VFD shall store in memory the last three (3) minimum faults and record all operational data.
26. Minimum six (6) programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
27. Minimum six (6) programmable relay outputs shall be provided for remote indication of drive status.
28. Two (2) programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog referenc einputs accepted shall include 0-10 VDC, 0-20 mA and 4-20 mA.
29. Two (2) programmable analog outputs shall be provided for indication of drive status. These outputs shall be programmable for output speed, voltage, frequency, amps and input kW.
30. The VFD shall accept an external contract closure command. Through an integrally mounted Interface Terminal Block (ITB), to automatically disable the VFD and transfer the motor to full line signal. Automatic by pass shall be used to permit the facility fire alarm system to override the normal VFD operation and default to nominal motor speed.
- D. Protective characteristics
1. Input AC circuit breaker with an interlocked pad lockable handle mechanism.
  2. AC input line current limiting fuses for fault current protection of AC to DC



- converter section.
3. Electronic cover-current trip for instantaneous overload protection.
  4. AC input line under-voltage and phase loss protection.
  5. Over-frequency protection.
  6. Over-temperature protection.
  7. Surge protection form input line transients.
  8. Electrical isolation between the power and logic circuits, as well as between the 1150 volt AC control power and the static digital sequencing.
  9. Ability to withstand output terminal line-to-line short circuits without component failure.
  10.  $dV/dT$  and  $dI/dT$  protection for converter semi-conductors.
  11. Class 20 I<sup>2</sup>t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications.
  12. Protection against input transients, loss of AC line phase, short circuit, ground fault, over voltage, under voltage, drive over temperature and motor over temperature. The VFD shall display all faults in plain English. Codes are not acceptable.
  13. Protect VFD from sustained power or phase loss. The VFD shall incorporate a five (5) second control power loss ride through to eliminate nuisance tripping.
  14. The VFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.
  15. Drive shall have semi-conductor rated input fuses to protect power components.
  16. The drive shall be fitted with output line reactors to limit the rate of output voltage rise over time ( $dv/dT$ ), reduce motor operating temperature and RFI and EMI. To prevent breakdown of the motor winding insulation, the  $dV/dT$  must be below 1500 V/ $\mu$ sec per IEC recommendations. The supplier shall include with the quotation the  $dV/dT$  values of the drive.
  17. Drive shall be capable of starting into a rotating load operating forward or reverse up to full speed. VFD shall be capable of accelerating or decelerating to setpoint without safety tripping or component damage (flying start).
  18. VFD shall be rated for 100,000 amp interrupting capacity (AIC).
- E. Independent Adjustability
1. VFD shall have an adjustable carrier frequency of 1 to 12 kHz through 75 HP and 3 kHz (fixed) above 75 HP.
    - a. Minimum Speed: 4 to 60 hertz.
    - b. Maximum Speed: 40 to 90 hertz/
  2. Three (3) variable-torque V/Hz patterns shall be provided with the ability to select a constant torque start pattern for each of them.
    - a. Volts per hertz: Adjustable from 3.83 to 11.5 volts per hertz.
  3. Twenty (20) preset speeds shall be provided.
  4. Minimum two (2) acceleration and two (2) deceleration ramps shall be provided. The shape of these curves shall be adjustable.
    - a. Acceleration: .5 to 30 hertz per second with ranges of 2-120 seconds for 0-60 Hz.
    - b. Deceleration: .5 to 30 hertz per second with ranges of 2-120 seconds for 0-60 Hz.
    - c. The VFD shall also accept remote input acceleration and deceleration rams via direct digital programmable inputs.
  5. If VFD trips on one of the following conditions, the VFD shall be

programmable for automatic or manual reset and restart.

- a. Over voltage.
- b. Under voltage.
- c. Current limit.
- d. Inverter overload.
- e. Motor overload.
- f. Loss of input signal.

The number of restart attempts shall be selectable from 9 to 5 (minimum) and the time between attempts shall be adjustable for 0 to 120 seconds.

6. Four (4) current limit setting shall be provided.
7. Low frequency Boost: Up to 60 volts at 2 Hz.

F. Bypass

1. Provide a manual by pass consisting of a door interlocked main fused disconnect pad lockable in the off position, a built-in motor starter and a four position DRIVE/OFF/LINE/TEST switch controlling three contactors.
  - a. The DRIVE position shall allow the motor to be operated at an adjustable speed from the drive.
  - b. The OFF position shall allow the motor and drive to be disconnected.
  - c. The LINE position shall allow the motor to be operated at full speed from the AC power line. Power shall be disconnected from the drive, so that service can be performed.
  - d. The TEST position shall allow the motor to be operated at full speed from the AC line power. This shall allow the drive to be given an operational test while continuing to run the motor at full speed in bypass.
2. External normally closed dry contact shall be interlocked with eh drives safety trip circuitry to stop the motor whether the DRIVE or BYPASS mode in case of an external safety fault.

G. Required Options

1. Full time adjustable current limit shall sense an overload on the motor when current exceeds a preset limit. Output frequency, and therefore motor speed, shall be reduced. If current decreased with speed, the speed shall decrease until current drops below the limit. Once current is reduced to normal, the frequency shall return to the original setting.
2. AC output contactor.
3. Motor over current relay.
4. Isolated process signal follower for use with grounded input process signal.
5. Output load ammeter, voltmeter and speed indicating meters.
6. Door mounted NEMA 4 operator controls with heavy duty industrial rated devices.
7. Process control output signal of 0-10 VDC, proportional to controller frequency, including gains and bias adjustments.
8. Controller status relay with two (2) Form C relay pairs, rated 2 amps resistive at 115 volt AC for indication of "ON" condition.
9. Bypass contactor arrangement with overload relay complete with all control circuitry to disconnect the controller from the motor and reconnect the motor to line power, after a suitable time delay, when initiated manually.

H. Quality Assurance

1. To ensure quality and minimize infantile failures at the job site, the complete VFD shall be tested by the manufacturer. The VFD shall operate a dynamometer at full load and the load and speed shall be cycled during the test.
  2. All optional features shall be functionally tested at the factory for proper operation.
  3. Provide a written copy of the factory start-up results for inclusion in the close-out documentation.
- I. Compliance to IEEE-519
1. The variable (adjustable) frequency drive manufacturer shall provide calculations specific 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 to support the request for approval from the Engineer.
    - a. The calculations shall proceed from Owner-provided power quality and harmonics information for all retrofit, renovation and restoration projects.
  2. The VFD manufacturer shall conduct on-site harmonic measurements before and after start-up of the VFD's. Results of the measurements, showing the harmonic contribution of the VFD's, shall be provided to the Engineer as part of the Project Commissioning, prior to Final Acceptance by the Owner.
  3. If site measurements show that the IEEE-519 levels have been exceeded:
    - a. New Facilities:
      - 1) The VFD manufacturer shall provide proper filtering to attain the IEEE-519 levels, at no additional cost to the Owner.
    - b. Existing Facilities:
      - 1) Should the quality of the existing power be consistent with the Owner-provided information, the VFD manufacturer shall provide proper filtering to attain the IEEE-519 levels, at not additional cost to the Owner.
      - 2) Should the quality of the existing power be inconsistent with the Owner-provided information, the VFD manufacture shall provide recommendations concerning proper filtering to attain the IEEE-518 levels, for consideration by the Owner.
  4. Three phase alternating current input line reactors shall be provided as a minimum with all VFD's. The line reactors are to provide attenuation of the line side voltage transients, and shall prevent overload trips or other unnecessary VFD shutdowns, and provide a reduction in harmonic distortion.
  5. Inlet line reactors shall be:
    - a. 2-1/2% line impedance (minimum).
    - b. 150% continuous current rating for one (1) minute.
    - c. Saturation rating of not less than 2.5 times the continuous current rating.
    - d. UL listed.
- J. Approvable Manufacturers: The variable (adjustable) frequency AC drives shall be manufactured by Graham, Square D, Asea Brown Boveri, Cutler Hammer or Mitsubishi.

- K. The HVAC Subcontractor shall provide written confirmation of coordination of drives and motor starters of all equipment with the Electrical Subcontractor.

#### 2.29 VIBRATION ISOLATION AND SEISMIC RESTRAINTS

- A. Provide vibration isolation and seismic restraint systems as identified by the requirements of this section and the contract documents. Attention is directed to the structural, architectural, mechanical and electrical documents which identify HVAC equipment and systems requiring vibration isolation treatment and seismic restraint.
- B. The HVAC Subcontractor shall provide vibration isolation components as required such that all equipment shall operate without objectionable noise or vibration being transmitted to the structure.
- C. The HVAC Subcontractor shall provide seismic restraint of non-structural building components (HVAC). Restraint systems are intended to withstand the stipulated seismic accelerations applied through the component's center of gravity.
- D. The work in this section includes the following:
  - 1. Vibration isolation elements for equipment.
  - 2. Equipment isolation bases.
  - 3. Piping flexible connectors.
  - 4. Seismic restraints for isolated equipment.
  - 5. Seismic restraints for non-isolated equipment.
  - 6. Certification of seismic restraint designs and installation supervision.
  - 7. Conform to vibration isolation and seismic restraint types herein specified.
- E. Examine the contract documents for sizes, horsepowers, rotational speeds, equipment location, length of span between columns and beams and construction type to determine the isolator selection type and deflection required for each piece of mechanical equipment.
- F. Conform to the requirements of the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbooks, "HVAC Applications" 1995 Edition; Chapter 43 "Sound and Vibration Control", and Chapter 50 "Seismic Restraint Design".
- G. Isolators and restraints of the same type shall be the product of the same manufacturer. The manufacturer shall publish and maintain a full line of materials, engineering and application data and operating and maintenance instructions.
- H. Seismic Certification and Analysis:
  - 1. Seismic restraint calculations must be provided for all connections of equipment to the structure. All performance of products (such as strut, cable, anchors, clips, etc.) associated with restraints must be supported with manufacturer's data sheets or certified calculations.
  - 2. Seismic restraint calculations must indicate specific code paragraph references (see CODE AND STANDARDS REQUIREMENTS) for each acceleration criteria. Seismic calculations shall indicate the component values required to determine the force to be restrained ( $F_p = A_v C_c P a_c W_c$ ). Specifically,  $A_v$  value from Contour Map, USE GROUPS, SEISMIC

HAZARD EXPOSURE GROUP, SEISMIC PERFORMANCE CATEGORIES, MECHANICAL, ELECTRICAL COMPONENT AND SYSTEM SEISMIC COEFFICIENT ( $C_c$ ) Attachment Amplification Factor ( $a_c$ ) AND PERFORMANCE CRITERIA FACTOR (P) must be determined and the resultant values shall be clearly indicated in the certified calculations. Note: For roof mounted equipment both the seismic acceleration and wind load shall be calculated, the highest load shall be utilized for the design of the restraints and isolators.

3. Seismic restraint calculations must be provided for all connections of equipment to the structure. Performance of all products (such as strut, cable, anchors, clips, etc.) associated with restraints must be supported with manufacturer's data sheets or certified calculations.
  4. Seismic restraint calculations must be based on the acceleration criteria shown in TABLE A acting through the equipment's center of gravity.
  5. For roof mounted equipment both the seismic acceleration and wind loads (30 psf) shall be calculated, the highest load shall be utilized for the design of the restraints and isolators.
  6. Certification of calculations to support seismic restraint designs must be stamped by a professional engineer registered to practice in the Commonwealth of Massachusetts, with at least five years of seismic design experience.
  7. Analysis must indicate calculated dead loads, derived loads and materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or weld length.
  8. An in-force \$1,000,000.00 coverage limit Seismic Design Errors and Omissions insurance certificate must accompany submittals. Manufacturer's product liability insurance certificates are not an acceptable substitution.
- I. Manufacturer of vibration isolation and seismic control equipment shall assume the following responsibilities:
1. Determine vibration isolation and seismic restraint sizes and locations.
  2. Provide equipment vibration isolation and seismic restraints as specified. Furnish manufacturer's product data covering each isolator and restraint type for style, characteristics, and finish.
  3. Guarantee specified isolation system deflections.
  4. Provide installation instructions, drawings and field supervision to insure proper installation and performance of systems.
  5. Isolator quantities, dimensions, deflections, capacities and type shall remain the responsibility of the manufacturer and the Contractor.
- J. Provide project specific catalog cuts and/or data sheets on the vibration isolators and restraints proposed for inclusion on this project. Reference each and every "TYPE" and detail each compliance with this specification.
1. Provide an itemized list of all isolated and non-isolated equipment. Provide detailed schedules showing isolator and seismic restraints proposed for each piece of equipment, referencing material and seismic calculation drawing numbers.
  2. Show base construction for equipment; include dimensions, structural member sizes and support point locations.
  3. When walls and slabs are used as seismic restraint locations, details of acceptable methods for duct and pipe must be included.
  4. Indicate isolation devices selected with complete dimensional and deflection data before condition is accepted for installation.

5. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.
  6. Coordination or contract drawings shall be marked-up with the specific locations and types of restraints shown for all pipe and duct. Rod bracing at various installation angles and assigned load at each restraint location shall be clearly delineated. Any and all tributary loads shall be considered for proper restraint sizing.
  7. For ceiling suspended equipment provide minimum/maximum installation angle allowed for restraint system as well as braced and unbraced rod lengths at each allowable installation condition.
  8. Calculate thrust for fan heads, for axial and centrifugal fans, to determine whether thrust restraints are required.
- K. Housekeeping pad attachment shall be by the project Structural Engineer. Material and labor required for attachment and construction shall be by the Division 3 subcontractor.
1. Housekeeping pads shall be coordinated with the Seismic Restraint vendor and sized to provide a minimum edge distance of 10 bolt diameters of clearance all around the outermost anchor bolt to allow for the use of full anchor ratings.
- L. Supplementary support steel and connections shall be provided by the HVAC Subcontractor for all equipment, piping, ductwork, etc. including roof mounted equipment, as required or specified.
- M. The HVAC Contractor shall provide restraint attachment plates to the General Contractor, to be cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. by the Division 3 Subcontractor, in accordance with the requirements of the Seismic Restraint vendor.
- N. Definitions:
1. The term EQUIPMENT will be used throughout this specification and it includes ALL non-structural HVAC components within the facility and/or serving this facility, such as equipment located in out buildings or outside of the main structure on grade within five feet of the foundation all. Equipment buried underground is excluded. Entry of services through the foundation walls is included. Equipment requiring vibration isolation and seismic restraint includes, but is not limited to, the following:
    - a. Air cooled condensing units
    - b. Rooftop air handling units
    - c. Cabinet heaters
    - d. Ductwork
    - e. Fans (all types)
    - f. Motor control centers
    - g. Piping
    - h. Tanks (all types)
    - i. Unit heaters
    - j. Variable frequency drives
    - k. NOTE: HVAC equipment and systems not listed herein above are still included in this specification.
  2. Life Safety Systems defined:
    - a. All systems involved with fire protection such as fire dampers.
    - b. All systems involved with and/or connected to emergency power supply including smoke evacuation.

- c. All medical and life support systems.
  - d. Fresh air relief systems on emergency control sequences including air handlers, ductwork, dampers, etc.
  - 3. Positive attachments are those locations at which equipment, piping, ductwork, etc. are tied to the facility structural elements by incorporating:
    - a. Cast-in or wedge type expansion anchors, or
    - b. Double sided beam clamps, or
    - c. Welded or through bolted connections to the structure.
  - 4. Transverse bracing are those restraints applied to limit motion perpendicular or angular to the centerline of the pipe or duct.
  - 5. Longitudinal bracing are those restraints applied to limit motion along the centerline of the pipe or duct.
- O. Substitution of internally or externally isolated and restrained equipment in lieu of the isolation and restraints specified in this section is acceptable provided all conditions of this section are met. The equipment manufacturer shall provide a letter of guarantee from their Engineering Department stamped and certified per the section on Seismic Restraints and Analysis stating that the seismic restraints are in full compliance with these specifications. Letters from field offices or representatives are unacceptable.
- 1. All costs for converting to the specified vibration isolation and/or restraints shall be borne by the equipment manufacturer in the event of non-compliance with the preceding.
  - 2. In the event that the equipment is internally isolated and restrained, the entire unit assembly must be seismically attached to the structure. This attachment and certification thereof shall be by this section.

TABLE A

"G" FORCES FOR VARIOUS CONDITIONS  
(SEISMIC ZONE 2 -  $AV > 0.1 \leq 0.2$ )

PIPE AND DUCT	RIGIDLY MOUNTED EQUIPMENT	FLEXIBLY MOUNTED EQUIPMENT	ALL LIFE SAFETY
.25	.40	.40	.60

- P. All vibration isolation and seismic devices described in this section shall be the product of a single manufacturer. Mason Industries shall be considered the Base Manufacturer of these specifications for the purposes of establishing a standard of equality; products of other manufacturers are acceptable provided their systems strictly comply with intent, structural design, performance and deflections of the Base Manufacturer.
- Q. Seismic Restraint and Vibration Isolation Devices:
- 1. All isolation and seismic restraint devices shall be capable of accepting, without failure, the "G" forces as determined by the seismic certification and calculations as described in this section of the specifications.
  - 2. Corrosion protection for outdoor applications shall be as follows:
    - a. Springs cadmium plated, zinc electroplated or electrostatically deposited, baked enamel powder coated.
    - b. Hardware cadmium plated.
    - c. All other metal parts hot spray or hot dipped galvanized.

3. Seismic Restraint Types:
- a. All seismic restraint devices shall maintain the equipment in a captive position and shall not short circuit isolation devices during normal operating conditions.
  - b. All seismic restraint devices shall have provisions for bolting and/or welding to the structure.
  - c. Welding of springs to isolator housing, base plans, etc. is strictly prohibited.
  - d. TYPE I: Spring Isolator – Restrained
    - 1) Spring shall have a minimum outer diameter to overall height ratio of 0.8:1 at rated deflection.
    - 2) Reserve deflection (from published load ratings to solid height) of 50% of the rated deflection.
    - 3) Ductile top cut with adjusting bolt tapped for equipment attachment locking cap screw.
    - 4) Minimum 1/4" thick neoprene acoustical base pad or cup on underside, unless designated otherwise.
    - 5) Integral restraining bolts with elastomeric cushions preventing metal-to-metal contact.
    - 6) Internal spring adjusting nut or bolt with leveling capability.
    - 7) Built-in all-directional limit stops with minimum 1/4" clearance under normal operation.
    - 8) Mountings shall have Anchorage Preapproval "R" number from California OSHPD, certifying the horizontal and vertical seismic load ratings.
    - 9) Cast or aluminum housings, (except ductile iron) are not acceptable.
      - a) Mason Industries, Type SLR
  - e. Type II: Where required, each corner or side of equipment base shall incorporate a seismic restraint snubber having an all directional resilient pad limit stop. Restraints shall be fabricated of plate, structural members or square metal tubing. Angle bumpers are not acceptable.
    - 1) Mason Industries Type Z-1225/Z-1011
  - f. Type III: Restraints for suspended systems:
    - 1) Vibration isolated systems shall be braced with multiple 7 x 19 strand galvanized cable rope.
      - a) Mason Industries Type SCB
    - 2) Non-isolated systems shall be braced with structural steel strut type with approved fastening devices to equipment and structure.
      - a) Mason Industries Type SSB
    - 3) Steel angles (by HVAC Subcontractor) shall be provided to prevent rod bending of hung equipment where indicated by the Seismic Restraint vendor's submittals. Steel angles shall be attached to the rods with a minimum of three ductile iron clamps at each restraint location. Welding of support rods to angles is not acceptable. Rod clamp assemblies shall have Anchorage Preapproval "R" number from California OSHPD.
      - a) Mason Industries Model SRC
    - 4) Pipe clevis cross braces are required at all restraint locations. They shall be special purpose preformed



channels deep enough to be held in place by bolts passing over the clevis cross bolt. Clevis cross braces shall have Anchorage Preapproval "R" number from California OSHPD.

- a) Mason Industries Model CCB
  - g. Type IV: Double deflection neoprene isolator encased in ductile iron or steel casing.
    - 1) Mountings shall have Anchorage Preapproval "R" number from California OSHPD, certifying the horizontal and vertical seismic load ratings.
      - a) Mason Industries Type RC or BR
  - h. Type V: Rigid attachment to structure utilizing wedge type expansion anchors for bolting and steel plates, either cast-in or anchored with wedge type expansion bolts, for welding. Powder shots are not acceptable. Concrete anchor bolt spacing shall be in accordance with manufacturer's published standards.
4. Vibration Isolator Types:
- a. Type A: Spring Isolator – Free Standing
    - 1) Spring shall have a minimum outer diameter to overall height ratio of 0.8:1 at rated deflection.
    - 2) Reserve deflection (from published load ratings to solid height) of 50% of the rated deflection.
    - 3) Ductile top cut with adjusting bolt tapped for equipment attachment locking cap screw.
    - 4) Minimum 1/4" thick neoprene acoustical base pad or cup on underside, unless designated otherwise.
      - a) Mason Industries Type SLF
  - b. Type B: Spring Isolator – Restrained
    - 1) Spring shall have a minimum outer diameter to overall height ratio of 0.8:1 at rated deflection.
    - 2) Reserve deflection (from published load ratings to hold height) of 50% of the rated deflection.
    - 3) Ductile top cup with adjusting bolt tapped for equipment attachment locking cap screw.
    - 4) Minimum 1/4" thick neoprene acoustical base pad or cup on underside, unless designated otherwise.
    - 5) Integral restraining bolts with elastomeric cushions preventing metal-to-metal contact.
    - 6) Internal spring adjusting nut or bolt with leveling capability.
    - 7) Built-in all-directional limit stops with minimum 1/4" clearance under normal operation.
    - 8) Mountings shall have Anchorage Preapproval "R" number from California OSHPD, certifying the horizontal and vertical seismic load ratings.
      - a) Mason Industries Type SLR, SSLFH
  - c. Type C: Spring Hanger Isolator
    - 1) Spring shall have a minimum outer diameter to overall height ratio of 0.8:1 at rated deflection. Spring element shall have a steel upper spring retainer and a lower elastomer retainer cup with an integral bushing to insulate lower support rod from the hanger box.
    - 2) Reserve deflection (from published load ratings to solid height) of 50% of the rated deflection.

- 3) Steel hanger box shall be capable of 30 degree misalignment between the rod attachment to structure and the connection to the supported equipment. Hanger boxes shall withstand three times the rated load without failure.
  - a) Mason Industries Type 30
- d. Type D: Double deflection neoprene isolator encased in ductile iron or steel casing.
  - 1) Mountings shall have Anchorage Preapproval "R" number from California OSHPD, certifying the horizontal and vertical seismic load ratings.
    - a) Mason Industries Type RC or BR
- e. Type E: Elastomer Hanger Isolator
  - 1) Molded neoprene element with an integral bushing to insulate lower support rod from the hanger box.
  - 2) Steel hanger box shall withstand three times the rated load without failure.
    - a) Mason Industries Type HD
- f. Type F: Combination Spring/Elastomer Hanger Isolator
  - 1) Spring and neoprene elements in a steel hanger box with the features as described for Type C and E isolators.
    - a) Mason Industries Type 30N
- g. Type G: Pad type elastomer isolator
  - 1) Neoprene pad shall have 0.75" minimum thickness, deflection rating of 0.1 inch under rated load. Supports shall be connected in the center by a 1/8" tear strip to facilitate trimming to desired size in two inch increments.
  - 2) 1/16" galvanized steel plate between multiple pad layers.
  - 3) Load distribution plate where attachment to equipment bearing surface is less than 75% of the pad area.
  - 4) When bolting is required for seismic compliance, neoprene and duck washers and bushings shall be provided to prevent short circuiting of bolt.
    - a) Mason Industries Type Super Waffle (SW) pad
- h. Type H: Pad type elastomer isolator
  - 1) Laminated canvas duck and neoprene maximum loading 1000 psi, minimum 1/2" thick.
  - 2) Load distribution plate where attachment to equipment bearing surface is less than 75% of the pad area.
  - 3) When bolting is required for seismic compliance, neoprene and duck washers and bushings shall be provided to prevent short circuiting.
    - a) Mason Industries Type HL Pad
- i. Type I: Thrust Restraints
  - 1) A spring element same as Type A shall be combined with steel angles, backup plates, threaded rod, washers and nuts to produce a pair of devices capable of limiting thrust movement of air moving equipment to 1/4".
  - 2) Restraints shall be easily converted in the field from a compression type to tension type.
  - 3) Unit shall be factory pre-compressed.
    - a) Mason Industries Type WB
- j. Type J: Telescoping Riser Guide
  - 1) Telescoping arrangement of two sizes of steel tubing

- separated by a minimum 1/2" thickness of Type H pad.
- a) Mason Industries Type VSG
  - k. Type K: Resilient Pipe Anchors and Guides
    - 1) All directional acoustical pipe anchor, consisting of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" thickness of Type H pad.
    - 2) Vertical restraints shall be provided by a similar material arranged to prevent vertical travel in either direction.
    - 3) Allowable loads on neoprene pad shall not exceed 500 PSI and the design shall be balanced for equal resistance in any direction.
      - a) Mason Industries Type ADA
  - l. Type M: Flashable restrained isolator
    - 1) Shall have all features of Type B isolator.
    - 2) Shall have waterproof spring covers for adjustment or removal of springs.
    - 3) Unit shall have a structural top plate for welding or bolting of supplementary support steel.
    - 4) Isolator shall accept 2" roofing insulation and be flashed directly into the waterproofing membrane.
    - 5) To be complete with wood nailer and flashing.
      - a) Mason Industries Type RFS.
  - m. Type P: Elastomer Isolator
    - 1) Double deflection neoprene compression mountings shall have all metal surfaces neoprene coated.
    - 2) Non-skid top and bottom surfaces.
    - 3) Threaded bolting sleeves shall be embedded in the isolator.
    - 4) Drilled tie-down bolt holes shall be provided in the base plate.
      - a) Mason Industries Type ND
5. Equipment Bases:
- a. All curbs and roof rails are to be bolted or welded to the building steel or anchored to the concrete deck to attain specified acceleration criteria and shall also be capable of resisting a minimum psf wind loads (non-simultaneous).
  - b. Type B-1: Integral Structural Steel Base:
    - 1) Constructed of structural members as required to prevent base flexure at equipment startup and misalignment of driver and driven units. Perimeter members shall be a minimum of 1/10<sup>th</sup> the longest unsupported span.
    - 2) Centrifugal fan bases shall be complete with motor slide rails and drilled for driver and driven units.
    - 3) Height saving brackets shall be used to reduce operating height and maintain 1" operating clearance under base.
      - a) Mason Industries Type MSL, WFSL
  - c. Type B-2: Concrete Inertia Base
    - 1) Steel concrete forms for floating foundations. Bases for pumps shall be large enough to support elbows and/or suction diffusers. The base depth shall be a minimum of 1/12 the longest unsupported span, but not less than 6" or greater than 12".
    - 2) Forms shall include concrete reinforcement consisting of steel bars or angles welded in place on 8" centers both

- ways in a layer 1½” above the bottom.
- 3) Isolators may be set into pocket housings which are an integral part of the base construction or utilize height saving brackets set at the proper height to maintain 1” clearance below the base.
  - 4) Base shall be furnished with steel templates to hold anchor bolt sleeves and anchors while concrete is being poured.
    - a) Mason Industries Type KSL or BMK
- d. Type B-3: Spring Roof Curb
- 1) Spring isolation curbs that bear directly on the roof support structure and are flashed and waterproofed into the roof’s membrane waterproofing system. Equipment manufacturer’s or field fabricated curbs shall not be used.
  - 2) All spring locations shall have removable waterproof covers to allow for spring adjustment and/or removal. Disassembly of the weather and air seal to gain access to the isolators is not acceptable.
  - 3) Springs shall have all of the features of Type B.
  - 4) Curbs shall have continuous sheet metal sides and have provision for 2” insulation to be installed and furnished by the Roofing Contractor.
  - 5) Waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curb’s waterproofing membrane and joined at the corners by EPDM bellows.
  - 6) Wood nailer and flashing shall be provided.
  - 7) Shall have a California OSHPD Seismic Anchorage Preapproval “R” number.
  - 8) Shall include a means of incorporating a sound barrier package, supported from the top isolated rail consisting of two layers of waterproof gypsum board furnished and installed by the General Contractor.
  - 9) Contractor shall have the option of ordering the curb built to the roof pitch or field leveled in accordance with all seismic provisions of this section.
  - 10) Overhung condensing units (when applicable) shall be supported by Type B isolators and spanning (width) steel support angle. These isolators shall in turn be supported on a field built curb (by others).
    - a) Mason Industries Type RSC
- e. Type B-4: Flashable Roof Rail System – Isolated
- 1) Continuous structural support rails that combine equipment support and isolation mounting into one unitized assembly.
  - 2) Rails shall incorporate Type B springs which are adjustable, removable and interchangeable after equipment has been installed.
  - 3) The system shall maintain the same installed and operating height with or without the equipment load and shall be capable of being utilized as a blocking device.
  - 4) The entire assembly shall be an integral part of the roof’s membrane waterproofing.
  - 5) Unit to be supplied with continuous upper and lower

- galvanized flashing.
- a) Mason Industries Type RIR
- f. Type B-5: Not Used.
- g. Type B-6: Non-isolated roof curb
  - 1) Same as B-3 without spring isolation.
    - a) Mason Industries Type URC
- h. Type B-8: Non-isolated.
  - 1) Same as continuous support rails, Type B-4 without the spring isolation.
    - a) Mason Industries Type RUR
- i. Type B-9: Steel Rails
  - 1) Steel members of sufficient strength to prevent equipment flexure during operation.
  - 2) Height saving brackets as required to reduce operating height.
  - 3) Rails shall be cross braced at support and equipment attachment points when used in seismic zones.
    - a) Mason Industries Type R, ICS
- 6. Flexible Connectors:
  - a. All connectors shall be installed on the equipment side of shutoff valves; horizontal and parallel to equipment shafts whenever possible. Piping shall be supported and/or anchored to resist pipe movement beyond the allowable movement of the flexible connector.
  - b. Installations must include check valves and/or other design and installation precautions to reduce the threat to life safety when subjected to the specified seismic accelerations.
  - c. Type FC-1: Spherical Elastomer Connector
    - 1) Manufactured of peroxide cured EPDM in the covers, liners and polyester tire cord frictioning. Curing must take place in steel molds closed within heated hydraulic presses.
    - 2) Solid steel rings shall be used within the raised faced rubber flanged ends to prevent pullout. Flexible cable bead wire is not acceptable.
    - 3) Sizes 2" and larger shall have two spheres reinforced with a molded-in ductile iron external ring between spheres. Bolted-on strap type reinforcing are not acceptable. Flanges shall be split ductile iron with hooked or similar interlocks. Sizes 16" to 24" may be single sphere.
    - 4) Threaded one piece bolted flange assemblies with female threaded ends for sizes 3/4" to 1 1/2".
    - 5) Rated at 250 psi up to 170° F. with a uniform drop in allowable pressure to 170 psi at 250° F. for sizes through 14". 16" through 24" single sphere minimum ratings are 180 psi at 170° F and 130 psi at 250°F.
    - 6) Factory tested at 150% of rated pressure for 12 minutes before shipment. Safety factor to burst and flange pullout shall be a minimum of 3:1.
    - 7) Concentric reducing expansion joints with equal ratings and features may be substituted.
    - 8) Connectors shall be installed in piping gaps equal to the length of the connector under pressure.
    - 9) Control rods are required in unanchored installations

- where the installation exceeds the pressure requirement without control rods.
- a) Control rods shall have 1/2" thick neoprene washer bushings large enough in diameter to take the thrust at 1,000 psi maximum on the washer area.
- 10) Connectors bolted to Victaulic type coupling or gate, butterfly or check valves to have a minimum 5/8" flange spacer (by others) installed between the connector and the coupling flange. Connectors must mate to a flat faced flange in all instances.
- a) Mason Industries SAFEFLEX Type SFU, SFEJ, SFDEJ or SFDCR
- d. Type FC-2: Flexible Stainless Steel Hose
- 1) Stainless steel hose and braid rated with 3:1 safety factor.
  - 2) 2" diameter and smaller with male nipples, 2½" and larger with fixed flat faced steel flanges.
  - 3) Lengths shall be: 9" for 2½" through 4"; 11" for 5" and 6"; 12" for 8"; 13" for 10"; 14" for 12" through 16".
  - a) Mason Industries Type BSS
- e. Type FC-3: Upbraided Exhaust Hose
- 1) Low pressure stainless steel annularly corrugated with one floating and one fixed flanged end.
  - 2) Maximum temperature of 1500 degrees F.
  - a) Mason Industries Type SSE
- f. Type FC-4: Flexible Bronze Braided Hose
- 1) Metal hose and braid rated with a minimum 3:1 safety factor. (Minimum 150 PSI)
  - 2) Copper tube ends.
  - a) Mason Industries Type BBF

## 2.30 AUTOMATIC TEMPERATURE CONTROLS

### A. General

1. Furnish and install, as hereinafter specified, a native BACnet, Direct Digital Control (DDC), automatic temperature control system as manufactured by Johnson Controls Metasys or approved equal.
2. The DDC Contractor shall be fully licensed at the time of bid to do business in the job site area. The DDC Contractor must have a wholly owned factory branch office with a technical staff, complete spare parts inventory, and test and diagnostic equipment to keep systems in operation 24 hours per day, seven days per week. He shall have emergency service available in the local area for temperature control systems for which he is currently performing on-call emergency service 24 hours per day, seven days per week. Wholesale, distributor, or representative type ATC Contractors are unacceptable. This requirement will be strictly enforced

### B. Scope of Work

1. The ATC contractor shall furnish and install all equipment, accessories, and wiring required for a complete and functioning web-based building management system.
2. The control system shall consist of, but not limited to all temperature controls as specified herein including all CPU's, DDCP's, CRT's, printers, sensors, software, thermostats, valves, actuators, dampers, damper

- operators, relays, control panels, and other accessory equipment and appurtenances, including electrical wiring, to fulfill the intent of the specifications and provide for a complete and operable system.
3. Provide actuators for equipment such as dampers, inlet guide vanes, etc., where such actuators are not provided by the equipment manufacturers. Refer to floor plans for location and numbers of required actuators. Actuators shall be Belimo, or equal. Coordinate requirements with the HVAC subcontractor.
  4. All materials and equipment used shall be standard components, regularly manufactured for this type of work and shall not be custom designed especially for this project. All components shall have been thoroughly tested and proven in actual use.
  6. The ATC contractor shall review and study all HVAC drawings and the entire specification to familiarize themselves with the equipment and systems operation and to verify the quantities and types of dampers, operators, alarms, bells, etc., he has to provide. Numerous references to the ATC contractor are made throughout this specification identifying work to be performed under the HVAC section in addition to work specifically indicated under this paragraph. It will be assumed that, if no specific inquiries are made during the bidding period, the HVAC/ATC subcontractors have reviewed all requirements and interfaces between equipment and controls, to result in a complete, integrated and fully operational HVAC system.
  7. The Automatic Temperature Control Contractor shall provide one (1) copy of ADS server software to be installed on customer provided server, located in Technology Office.
  8. The automatic temperature control contractor shall furnish and install power meters. Meters shall be networked into the building management system and shall provide point mapping of all available data to the new workstations. Meters shall be manufactured by Veris Model H8206. Exact location and installation of meters shall be coordinated with electrical subcontractor.
- C. Work by Others
1. Automatic temperature control valves, duct humidifiers and separable wells for immersion elements furnished by the control manufacturer shall be installed by the HVAC contractor under the ATC contractor's supervision.
  2. Automatic dampers that are specified to be furnished by the ATC contractor shall be installed by the HVAC subcontractor, under the ATC contractor's supervision.
  3. Concrete foundations shall be provided by the general contractor. The HVAC Contractor shall furnish dimensional drawings to the general contractor.
  4. All finished painting required for the temperature control piping and equipment, shall be by the general contractor.
  5. All cutting and patching necessary for the installation of the temperature control system, shall be by the HVAC contractor.
  6. Installation of duct smoke detectors shall be by the HVAC subcontractor, under the ATC contractor's supervision.
- D. Submittals and Shop Drawings
1. Submit shop drawings and obtain written review comments before ordering or installing any equipment or material.

2. Submit shop drawings of all equipment. Shop drawings shall consist of but not limited to manufacturer's scaled drawings, valves and damper schedules, cuts and catalogs, including descriptive literature which shall indicate the construction, material, physical dimensions and complete operating data. All ATC shop drawings shall also contain a written description of the Sequence of Operations, enumerating and describing the function of each component.
  3. Submit the following for approval:
    - a. Control drawings with detailed wiring diagrams, including bills of materials and written sequences of operation, for each system type.
    - b. Valve and damper schedules showing sizes, configurations, capacities, pressure drops and locations of equipment. Include type and quantities of actuators.
    - c. Data sheets for control system components.
    - d. Complete software information including names of software packages provided, control sequences performed, complete information on user programmability (commands, language details, programming sequences, etc.), and detailed printouts of the actual software within each DDCP including user definable comment statements inserted throughout the program to guide a novice operator through the various sequences of the actual program.
    - e. Calculations for valve coefficients (CVs).
    - f. Operators user's manuals.
      - g. Complete point-to-point check-out procedures to ensure that all physical points are consistently tested and verified for this project.
- E. Equipment Operation Instruction and Maintenance Manuals
1. On completion and acceptance of the work, furnish for approval three copies of written instructions on the proper operation and maintenance of all equipment and apparatus furnished under this section.
  2. Each manual shall be provided with an index sheet listing the contents in alphabetical order and shall contain but not limited to the following material:
    - a. Updated copies of all submittal data and shop drawings as specified previously.
    - b. Manufacturer's instructions regarding the installation, maintenance and calibration of each component used in the ATC system installed by the ATC contractor.
    - c. Copies of all warranties and guarantees issued by each equipment manufacturer.
    - d. "As-built" interconnecting wiring diagrams and wire lists of the field installed system with complete, properly identified numbering of each system component and device.
    - e. A set of "User's Manual" detailing the operation of the Building Management and Control System (BMCS). The manual shall describe the hardware operation as well as provide instructions in computer access and programming. This manual shall be submitted under separate cover. The User Manual shall be written for an inexperienced user. It shall describe in layman's language, the functions and procedures of "using" the system.



F. Acceptance Testing

1. At substantial completion of the work, the ATC contractor shall prepare a punch list of all items remaining to be completed or corrected. The failure to include any items on such list does not alter the responsibility of the ATC contractor to complete all work in accordance with the contract documents. This list shall be delivered to the engineer prior to the ATC contractor's request for formal acceptance testing.
2. Additionally, the ATC contractor shall provide an equipment list and point list to the engineer prior to formal acceptance testing. Each material item and point must be initialed by the installing DDC technician that the item has been physically inspected for proper installation, functionality, and database entry.

The verification form shall be similar to the following:

<u>DDC Floor</u>	<u>Point Cabinet #</u>	<u>Point Name</u>	<u>Point Type</u>	<u>Point Address</u>	<u>Sensor On/Off</u>	<u>Oper. Reading</u>	<u>Test Initials</u>	<u>Test Time Date</u>
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3. The engineer will prepare a list of items to be corrected or completed that shall include the punch list items identified by the ATC contractor, and any additional items found to be incomplete or incorrect. All items on both lists shall be completed or corrected before acceptance testing may proceed. The ATC contractor shall notify the engineer when he is ready to proceed with the acceptance test that system is complete and operates as required by the contract documents.
4. Acceptance Test Procedure:
  - a. The ATC contractor shall demonstrate in the presence of the Engineer that all functions of the ATC and BMCS systems are operating as specified in the contract documents, including any required change orders. The final checkout will include, but not be limited to, the following items:
    - 1) Verification of the location, calibration and proper wiring/connection of all BMCS input and output devices.
    - 2) 1 BMCS software and output functions shall be tested individually.
    - 3) The proper operation and calibration of all ATC devices and actuators shall be verified individually.
    - 4) When system performance is deemed satisfactory by the Architect, system parts shall be accepted for beneficial use. Warranty shall begin. All minor deficiencies found will be noted in writing by the Engineer. All deficiencies so noted shall be corrected by the ATC contractor before the final acceptance will be issued.
    - 5) The ATC contractor shall allow sufficient time to complete the acceptance test procedure.
  - b. Acceptance testing shall be coordinated with the Commissioning Agent. Refer to specification section 019100 for additional requirements.

G. Training/Owner's Instruction

1. The ATC contractor shall provide three copies of an operator's user's manual describing all operating and routine maintenance service procedures to be used with the system as specified previously. The ATC contractor shall instruct the Owner's designated representatives in these

procedures during the start-up and test period. The duration of the instruction period shall be no less than 40 hours and shall take place at the site. The training sessions shall be delineated such that at least 16 hours of training occur after the completion of system testing and balancing and commissioning. This training shall include instruction in the use and operation of the point editor function and graphics.

2. Training sessions shall be coordinated with the Commissioning Agent. Refer to specification section 019100 for additional requirements.

H. Warranty

1. The ATC contractor shall guarantee the control system free from defects in material and workmanship and guarantee performance of the systems as required by the contract documents for one year of normal use and service beginning on the date the Owner has accepted the system.
2. The ATC contractor shall through the warrantee period, schedule visits to the site in order to provide two seasonal system review sessions with the building operators. The intent is for system review to take place at the time of seasonal system changeover. The contractor shall establish diagnostic trend logs on the OWS for the purposes of evaluating all major systems in the building, and a sample of terminal systems. Following any calibrations and adjustments the logs shall be submitted to the Architect for review.

I. Products

1. The Building Management and Control System (BMCS) shall consist of Network Level 1 controllers and Level 2 DDC controllers to monitor and control equipment per the control sequences. Level 1 controllers shall provide overall system coordination, accept control programs, perform automated DDC and energy management functions, control peripheral devices and perform all necessary mathematical functions. The controller shall be a microcomputer of modular design. The word size shall be 16 bits or larger, with a memory cycle time of less than 1 microsecond. Level 1 controllers will share information with and from the entire network of Level 1 and Level 2 controllers for full global control. Level 1 controllers shall permit multiuser operation from workstations and laptop computers connected either locally or over the Level 1 network. Level 2 controllers, also referred to as local control units shall provide intelligent, stand alone control of HVAC, lighting equipment, and access control. Each unit shall have its own internal RAM memory and will continue to operate all local control functions in the event of a failure to any Level 1 controller. In addition, it shall be able to share information with and from the entire network for full global control.

J. Communications Processing

1. The BMCS shall operate as a true token-pass peer-to-peer communication network. Resident processors in each Multi-purpose controllers shall provide for full exchange of system data between other Multi-purpose controllers on the high performance peer to peer communications network. Systems that limit data exchange to a defined number of system points are not acceptable.
2. Systems that operate via polled response or other types of protocols that rely on a central processor or similar device to manage interpanel communications may be considered only if a similar device is provided as a stand-by. Upon a failure or malfunction of the primary device, the stand-by shall automatically, without any operator intervention, assume all

- BMCS network management activities.
3. The failure of any Multi-purpose controller on the network shall not affect the operation of other Multi-purpose controllers. A panel failure shall be annunciated at the specified graphical workstation, alarm printers, or operator terminals.
- K. Color Graphic Workstation (located in Custodians Office).
1. The operator workstation will be furnished by the automatic temperature control contractor. The workstation shall consist of the latest generation of PC and shall operate at speed commensurate with the requirements of the ATC graphics and trending requirements. The ATC contractor shall furnish the PC with a dedicated UPS.
  2. Network Connection: Graphical workstations shall allow for access to the BMCS network through a pull-down menu approach using only a mouse or similar point device. The keyboard shall be required only when entering text or for programming functions.
    - a. The workstation shall be used as an interface to the BMCS network and shall not be required to process any control or energy management algorithms nor manage any BMCS network communications.
  3. Graphical Software
    - a. Software Description - workstation functions will include monitoring and programming of Level 1 and Level 2 controllers. Monitoring consists of alarming, reporting, graphic displays, long term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments. The workstation software must be able to communicate to all Level 1 and Level 2 controllers, and where necessary integrate information that is common to one or more controllers. It shall be possible to program off-line from any Level 1 or Level 2 controller.

The software will be oriented towards operators and programmers. In the operator's mode, all information will be available in graphic or text displays. Graphic displays will feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location of information throughout the DDC system.

All operator functions shall be selectable through a mouse. A "windows" environment shall be used to allow multiple functions to be displayed on the screen simultaneously.
    - b. Operating System - The software will utilize the IBM's OS/2 Warp multi-user, multi-tasking operating system or equivalent. Provide Microsoft's OS/2 Lan Manager software for operation of the file server.
    - c. Network Communications - The network consists of a high speed LAN comprised of Level 1 controllers, workstations and a file server. The file server acts as the central database for the workstations, so that all additions or changes made by one operator are immediately available to other operators on the network.
    - d. System Database - The workstation database shall consist of all points and programs in each of the controllers that have

been assigned to the network. In addition, the database will contain all workstation files including graphic slides, alarm reports, text reports, historical data logs, schedules, and polling records. The software shall conform to the following:

- 1) Utilize Microsoft's SQL database server.
  - 2) Whenever a new controller is added to the system, the software will automatically update that controller with its assigned points and programs. The system will also be able to verify that the point database in each controller is identical to the one at the workstation. If any discrepancy is found, it will automatically modify its database or notify an operator of the error.
  - 3) The database shall also contain host level points consisting of variables which can be used for host level reports and alarming. These variables can be setpoints or the result of any boolean algebra expression.
  - 4) Object Tree - It shall possible for an operator view the entire database through a graphical object tree display. This tree will present all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure.
- e. System Configuration - Configuration of the database shall be through application modules, each having a unique "icon" for easy visual identification. Each module will provide a windowed menu in which to enter the required data base information. System configuration shall have the following features:
- 1) Each site, whether local or remote, shall have a separate record for storing pertinent communication parameters.
  - 2) Controllers will be associated with a specific site file. The controller record will also contain the controller passwords and communication logon and logoff text strings as required.
  - 3) Point records will include as a minimum a 32 character point description, engineering units, logging parameters, point status, and point value.
  - 4) All database records will be available to the user at all times, regardless of the current tasks being performed by the workstation.
- f. Color Graphic Displays - The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse. Requirements of the color graphic subsystem include:
- 1) SVGA, bit-mapped displays. The user shall have the ability to import CAD-generated picture files in the OS/2 Metafile format as background displays. Updates to imported CAD drawings will not affect workstation added animation.
  - 2) A library of built in stencils, symbols and display

- shapes common to the HVAC industry.
- 3) An online graphics drawing editor that provides for all standard geometric shapes, multiple line thicknesses, shading, up to 16 colors, cutting and pasting of objects, inclusion of text, and zooming.
  - 4) Built-in control panel objects such as buttons, knobs, gauges, line graphs, etc. to enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels.
  - 5) Status changes or alarm conditions can be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.
  - 6) Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression. Operators will be able to move from one graphic to another by selecting an object with a mouse, no menus will be required.
  - 7) The graphic system shall allow for one touch modification of any analog or digital point in the database regardless of its location in the network.
- g. Automatic Monitoring - The software shall allow for the collection of data and reports from any Level 1 or Level 2 controller through either a hardwire or modem communication link. The time schedules and content of the polling shall be user configurable and include any subset of the controller's data base including application programs.
- h. Alarm Management - The software shall be capable of both accepting alarms directly from Level 1 controllers, or generating alarms based on polling of data in controllers and comparing to limits or conditional equations configured in the host software. Any alarm (regardless of its origination) will be integrated into the overall alarm management system and will appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, reports, or initiating communication to another controller or remote computing device. Alarm management features shall include:
- 1) A minimum of 255 alarm levels. Each alarm level will establish a unique set of parameters for controlling alarm display, acknowledgment, keyboard annunciation, alarm printout and record keeping.
  - 2) When an alarm occurs the Alarm counter will be incremented by one.
  - 3) Printout of the alarm or alarm report to an alarm printer or report printer.
  - 4) Print the alarm acknowledgment or Return to Normal message.
  - 5) Sound an audible beep on alarm initiation or acknowledgment.
  - 6) It shall be possible to direct alarm displays to all or any of 16 groups of workstations on the network. Each configured path can be assigned on a unique basis to

- individual alarm levels.
- i. Report Generation - The software will contain a built-in report generator, featuring word processing tools for the creation of custom building reports.
    - 1) Reports can be of any length and contain any points with the database of Level 1 and Level 2 controllers.
    - 2) The report generator will have access to the user programming language in order to perform mathematical calculations inside the body of the report, control the display output of the report, or prompt the user for additional information needed by the report.
    - 3) It shall be possible to run other executable programs whenever a report is initiated.
    - 4) Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.
  - j. Scheduling - It shall be possible to configure and download from the workstation schedules for any of the controllers on the network.
    - 1) Time of day schedules shall be in a calendar style configured for either monthly or weekly operation. Scheduling shall be programmable up to one year in advance.
    - 2) Each schedule will appear on the screen as a monthly calendar correctly showing the day, weekday, month and year. It shall be possible to scroll from one month to the next and view or alter any of the schedule times.
    - 3) Schedules will be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation will be automatically updated to the corresponding schedule in the controller.
    - 4) It shall be possible to configure multiple Holiday schedules in a yearly format. Holiday schedules will override the standard operating schedule for those days that have been defined as holidays. Holidays shall be differentiated on the calendar through color coding of the date. Any changes to a holiday schedule will be automatically updated to the standard schedule to which it has been superimposed.
    - 5) There shall also be a provision for Special Day schedules. Special Day schedules will override both the standard schedule and its associated Holiday schedule. Special Days will be differentiated on the calendar through color coding of the date. Any changes to a Special Day schedule will be automatically updated to the standard schedule to which it has been superimposed.
    - 6) The use of Holiday or Special Day schedules is strictly optional. Standard schedules do not require either of these two types of schedules.
    - 7) The Scheduling application shall include built-in editing tools to permit users to copy and paste portions of schedules to different days, weeks or months. Users can select from a particular day, a range of days, or a

- nonconsecutive group of days over which to edit a schedule.
- k. Programmer's Environment - the programmer's environment will include access to a superset of the same programming language supported in the Level 1 controllers. Here the programmer will be able to configure application software off-line (if desired) for custom program development, write global control programs, system reports, wide area networking data collection routines, and custom alarm management software.
  - l. Security
    - 1) The software shall employ a two tiered password system. The first tier shall consist of the user's name. The second tier shall be a unique password consisting of up to 8 alphanumeric characters.
    - 2) Each password shall have a unique access level. At least 8 levels will be defined as follows:
      - ◇ No Access - View only graphics as presented in the log-in program.
      - ◇ View Only - View all applications, but perform no database modifications.
      - ◇ Acknowledge Alarms - View Only privileges plus the ability to acknowledge alarms.
      - ◇ Change Values - View and Control point information, Acknowledge Alarms and modify Time Schedules.
      - ◇ Enable / Disable - Change Value level plus allow the enabling or disabling of points and alarms.
      - ◇ Configure - Minimal program level functions including creating and editing any object.
      - ◇ Program - All privileges except password and create users
      - ◇ Administrative - All privileges.
  - m. Saving/Reloading Programs
    - 1) The workstation software shall have an application to save and restore field controller memory dumps. The site and device record files shall serve as a menu tree to coordinate save/reload records. Each record shall have a minimum 12 character record name and a 32-character description.
    - 2) The Save/Reload application shall have the capability to set the system clock in a Level 1 controller.
    - 3) Default values store in the workstation database shall be sent to the controller during a reload operation either automatically or at the user's option.
    - 4) If during a poll of a controller, the workstation determines that the controller program has been lost, it shall be possible for the workstation to automatically reload the program without operator involvement.
      - a) The software shall provide, as a minimum, the following functionality:
        - Graphical viewing and control of environment
        - Scheduling and override of building operations
        - Collection and analysis of historical data
        - Definition and construction of dynamic color

- graphics
- Editing, programming, storage and downloading of controller database.
- b) The graphical interface shall allow for all system operations and applications to be quickly and easily selected using the mouse in conjunction with groups of drop-down menus, lists, graphics and icons. Provide functionality such that all operations can also be performed using the keyboard as a backup interface device. Provide additional capability that allows at least ten (10) special function keys to perform often-used operations.
- c) Software shall provide for a windowed approach which supports concurrent viewing and commanding of system operations. The software shall provide a multi-tasking environment that allows the user to run several applications simultaneously. The mouse shall be used to quickly select and switch between multiple applications. This shall be accomplished through the use of Microsoft Windows or similar industry standard software that supports concurrent viewing and controlling of systems operations. The software shall be capable of simultaneously displaying and performing a minimum of two of the functions listed below in any workstation:
- (1) Dynamic color graphics and graphic control
  - (2) Alarm reporting and acknowledging
  - (3) Time-of-day scheduling
  - (4) Trend data definition and presentation
  - (5) Graphic definition
  - (6) Graphic construction
- d) Graphic displays shall be high-resolution, multi-colored presentations of actual building data and parameters. Graphic displays may be quickly and easily viewed via any or all of the following methods as a minimum:
- Graphic links
  - Drop down menus
  - Special functions keys for points in alarm
- (1) Graphic links shall be standard symbols which can be located on graphic displays as desired by the user. These links shall allow the user to view any graphic display, either in a hierarchical fashion or as otherwise defined. The quantity of possible links shall be limited only by the space available on each display.
- (2) Drop-down menus may be used to view graphic displays by selecting from customized lists which include all



- graphics available for viewing. Provide the capability to quickly scroll through all lists.
- e) Special function keys shall be used to quickly view graphic alarm displays and user-defined default graphics, such as campus or building site plans. From the alarm display, the user may quickly view the graphic on which the associated point in alarm resides.
  - f) Provide static and dynamic graphic display capabilities. Static displays such as site plans, building layouts, floor plans and schematics shall provide the user with maps to allow for quick and easy access to any building information. Dynamic graphic displays may represent any real-time system information. Any system point or group of points may reside on a dynamic display. Dynamic displays such as schematics of any mechanical system or piece of equipment shall allow the user to monitor and control actual building operating parameters. Point values such as temperature, humidity and flow, and point status such as on/off, normal and alarm shall automatically and continually update to indicate current operating conditions. As a minimum, symbols, text and colors shall be dynamic in nature.
  - g) Provide functionality to allow for any analog point value to be displayed as an individual dynamic display window for use as a convenient control and diagnostic tool. The display window shall include the following information as a minimum:
    - Point name
    - Point description
    - Setpoint
    - Current value
    - Range of values
    - High and low limit setpoints
    - (1) All values shall be displayed in both text and symbolic form, such as an analog bar, gauge or other standard measurement device. Setpoint values shall be changed by simply moving a pointer to the desired setting on the measurement device. After user verification of the correct setting the system shall control at the new setpoint. Provide the capability to superimpose these displays on their associated schematic graphics or on separate displays in user-defined groups.
  - h) Provide the capability to control any point from a dynamic graphic display. Relevant point information windows may be accessed by

pointing to a symbol or text. Setpoints may be changed by simply entering the new value. Status may be changed by selecting from predefined lists. The display shall ask the user to verify the change before allowing the system to respond.

- i) Provide alarm annunciation capabilities, such that alarm status shall be displayed automatically on the screen regardless of system operation or application modes. The quantity of current alarms shall be displayed via a flashing icon or similar symbol. In addition, provide an audible signal to indicate the occurrence of new alarms. An alarm window may be displayed to view the alarms. From the alarm window the user shall be able to view the graphic and display a customized message of at least 250 characters associated with the point in alarm. When the graphic is displayed, the symbol of the point in alarm shall be flashing and shall have changed color. The user shall also be able to acknowledge, respond to and clear selected alarm conditions as desired.
- j) Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Provide the following spreadsheet graphic types as a minimum:
  - Weekly schedules
  - Zone schedules
  - Monthly calendars
  - (1) Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Each schedule shall include columns for each day of the week as well as holiday and special day columns for alternate scheduling on -user-defined days. Equipment scheduling shall be accomplished by simply inserting occupancy and vacancy times into appropriate information blocks on the graphic. In addition, temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.
  - (2) Zone schedules shall be provided for each building zone as previously described. Each schedule shall include all commandable points residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for

- sequential starting and control of equipment within the zone. Scheduling and re-scheduling of points may be accomplished easily via the zone schedule graphic.
- (3) Monthly calendars for a 24-month period shall be provided which allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.
- k) 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 (physical or calculated) may be trended automatically at predetermined time-based intervals or changes of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. Any point, regardless of physical location in the network, shall be collected and stored in each DDC controller's point group. Each DDC controller panel shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 70,000 samples.
    - (1) Trend data report graphics shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or pre-defined groups of at least six points. Provide additional functionality to allow any trended data to be transferred easily to an off-the-shelf spreadsheet package such as Lotus 1-2-3 or Microsoft Excel. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.
    - (2) A collection schedule function shall be provided to automatically collect trend data. A menu shall prompt for days of the week and time of day for collection of selected points. Provide a minimum of 12 user-selected time schedules per day.
  - l) Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both static and real-time dynamic point data. Up to four points may be viewed simultaneously on a

single graph, with color selection and line type for each point being user-definable. Displays shall include an "X" axis indicating elapsed time and a "Y" axis indicating a range scale in engineering units for each point. The "Y" axis may be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the "Y" axis. All "Y" axis data shall be color-coded to match the line color for the corresponding point.

- (1) Static graphics shall represent actual point data that has been trended and stored on disk. Exact point value may be viewed on a data window by pointing or scrolling to the place of interest along the graph. Provide capability to print any graph on the system printer for use as a building management and diagnostics tool.
  - (2) Dynamic graphs shall represent real-time point data. Any point or group of points may be graphed, regardless of whether they have been predefined for trending. The graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the PC disk for future recall and analysis. As with static graphs, exact point values may be viewed and the graphs may be printed.
- m) A full screen, forms based point editor and programming function shall allow for point additions, deletions, changes, program modification and creation and point and program storage. This program shall be similar to a word-processing format such that full documentation of program changes may be available. This program shall provide the user with the capability to insert full English narratives to describe the control program. Search, insert, find, cut and paste functions shall allow for quick program modifications.
- n) Provide a general purpose graphics package such as PC Paint Plus "In-a-Vision" which shall allow the user to quickly and easily define or construct color graphic displays. In addition, provide a library of standard HVAC equipment and symbols such as Rooftop air handling units and standard electrical symbols that shall aid the user in definition of standard or custom graphics. Additional libraries of standard symbols may be easily added to the

package or the user can define or construct symbols as desired for additional customization. Graphic displays may be defined or created to represent any building parameter, mechanical system or group of system points as described to facilitate building operation and analysis.

- (1) Provide the user with the capability to easily define all system operating parameters.
  - (2) Libraries of standard application modules such as temperature, humidity and static pressure control may be used as “building blocks” in defining or creating new control sequences.
  - (3) The user shall have the capability to easily create and archive new modules and control sequences as desired via a word processing type format.
  - (4) Provide a library of standard forms to facilitate definition of point characteristics. Forms shall be self-prompting and incorporate a fill-in-the-blank approach for definition of all parameters.
  - (5) The system shall immediately detect an improper entry and automatically display an error message explaining the nature of the mistake.
- o) Provide the capability to backup and store all system databases on the PC hard disk. In addition, all database changes may be performed while the PC is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate multi-purpose control units. Similarly, changes made at the multi-purpose control units shall be automatically uploaded to the PC, ensuring system continuity. The user shall also have the option to selectively download changes as desired.
- (1) The workstation shall provide for automatic upload and download of program changes. Any program change made at the workstation shall be downloaded to the respective multi-purpose control unit. Any program change made at the multi-purpose control unit shall be uploaded to the workstation disk.
  - (2) Should a multi-purpose control unit lose its RAM database, the workstation shall automatically download that control unit’s program from the hard disk.
  - (3) An auto-boot function shall allow an unattended workstation to automatically

- re-start from a power failure.
- p) Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed.
  - q) Multiple user security levels shall be provided to allow for various degrees of system access and control. Provide a minimum of four levels of access, with each increasing level allowing control of additional system operations and applications. A minimum of twelve unique passwords, including user initials, shall be provided. The system shall automatically generate a report of log-on/log-off time and system activity for each user. Provide automatic log-off capability to prevent unauthorized system use. Automatic log-off time shall be user-definable in one-minute increments and may be disabled if desired.
  - r) The workstation shall be provided with a key element display that **records** log-ons, log-offs, TOD overrides, alarms and alarm acknowledgments. Provide a 500 element circular buffer for recording purposes. Key element reports may be filtered by operator name and may be run for a user defined time interval.
- n. All points mapped to the workstation shall be available in both text and graphic format. All operator functions available on the text side of the workstation must also be available on the graphics side.
- L. Multi-Purpose Controllers
- 1. Provide multi-purpose DDC controllers as required. Each multi-purpose controller shall be a microprocessor-based direct digital control unit and shall be capable of operating as a standalone controller on a high performance peer to peer network. Provide each multi-purpose controller with sufficient memory to operate in a truly independent manner; that is, each controller shall support its own inputs and outputs, operating system, database and programs necessary to perform control sequences and energy management routines. Additionally, each multi-purpose controller shall have sufficient memory to support the application specific controllers and LAN control panels connected to it over the local area networks.
  - 2. Each multi-purpose controller shall be capable of full operation either as a completely independent unit or as a part of the building-wide control system. All units shall contain the necessary equipment for direct interface to the sensors and actuators connected to it.
  - 3. Control strategies shall be owner definable at each multi-purpose controller, and for all control units in the system from any one operator terminal. Each control unit shall provide the ability to support its own operator terminal if so desired.
  - 4. Each multi-purpose controller shall include its own microcomputer direct digital controller, power supply, input/output modules, and battery. The battery shall be self-charging and be capable of supporting all memory within the control unit if the commercial power to the unit is interrupted or lost for a minimum of 100 hours. Upon a power failure at the remote unit,

operator intervention shall not be required to maintain the database.

M. Networking Communications

1. General - the network architecture shall consist of two levels. The top level shall be a high speed Ethernet LAN designed to support network controllers, central plant controllers, work stations and a file server. The second level shall be a RS485 Token passing bus to support a family of dedicated local controllers for control of HVAC equipment, lighting, and access control. The second level bus shall communicate bidirectionally with the high speed LAN through Level 1 controllers for transmission of global data.
2. High Speed LAN - this Ethernet local area network shall operate at a minimum speed of 10 Mb/sec utilizing a TCP/IP communications architecture. The high speed LAN will provide transfer of point data, alarms and file activity among Level 1 controllers, work stations and the file server. The high speed LAN shall support a minimum of 50 nodes consisting of Level 1 controllers or workstations.  
Any data from a Level 2 controller can also be transmitted onto this bus through a Level 1 controller. The high speed LAN shall support multi-user communications and multi-session activity. That is, all global data sharing shall occur simultaneously with the transmission of alarm data or user activity.
3. Field Bus - the level 2 bus, or field bus, supports local control units of modular size for operation of the building's HVAC, lighting and access control systems. This RS485 bus shall operate at a minimum speed of 19200 baud, with a minimum length of 4000 feet or 32 nodes before requiring a network repeater. A minimum of 127 Level 2 controllers shall be configureable on the field bus. Manufacturers with baud rates of less than 19200 shall be limited to 64 Level 2 controllers to insure adequate global data and alarm response times.  
The field bus shall permit peer to peer communications among all Level 2 controllers and allow simultaneous communications with laptop computers that are connected to a Level 2 controller. Failure of the Level 1 controller will not impair the operation of its associated field bus.
4. Network Transparency - all points contained on Level 1 and Level 2 controllers shall be considered global points. Any program in any controller on the network shall be able to reference any point in any controller regardless of its location on the network.
5. Workstation Communications - workstations shall be connected directly to the high speed LAN. Workstations shall be able to communicate to any Level 1 controller, Level 2 controller, to additional workstations or the file server. Work stations shall also be able to communicate via modems to remote controllers via a RS232 connection. Telephone communications shall operate simultaneously with communication to any controllers connected on the high speed LAN.
6. Laptop Communications - the laptop computer shall communicate with either Level 1 or Level 2 controllers. Through the laptop, operators shall be able to view points and change parameters on any Level 1 or Level 2 controller on the network.
7. Dial-up Communications - it shall be possible to access the network remotely through a standard dial-up modem. This modem shall permit direct access to the high speed LAN via a Level 1 controller. It shall be possible to configure multiple modems in Level 1 controllers to enable

multi-user communications when more than 1 telephone line is available.

N. DDC Controllers:

1. A Level 1 controller has its own on-board CPU, clock/calendar, EPROM, RAM, ROM, communication port(s), and network connections to the high speed LAN and the field bus. The Level 1 controller may either have on-board or remote mounted I/O. Level 1 controllers are capable of complete standalone operation. Level 1 controllers are available with an optional user display.  
The firmware shall consist of the operating system, communication software, programming language, and resident control application software. The firmware may optionally contain user interface software to support dumb terminal operation. Where this is not provided the Level 1 controller must be optionally programmable from the laptop computer.  
The custom application software shall reside in battery backed RAM or EPROM. RAM will also be used for storing trend data and clock/calendar information.  
Level 1 controllers shall provide communication to both the high speed LAN and the field bus. In addition, a minimum of 1 RS232 or RS485 port shall be provided for connection to a workstation or laptop computer. When the port is RS232, it shall optionally support communication to a modem or printer. Where multiple RS232 ports are available, multi-user communications shall be supported.
2. Analog Inputs - the Analog Input (AI) function shall monitor each analog input, perform A/D conversion, and hold the digital value in a buffer for interrogation. The A/D conversion shall have a minimum resolution 12 bits. Input ranges shall be within the range of 0-10 VDC or 4 - 20 mA.
3. Digital Inputs - the Digital Input (DI) function shall accept dry contact closures and voltage level transitions. A voltage level below 1 volt shall be read as ON (closed), a voltage level above 3 volts shall be read as OFF (open).
4. Pulse Accumulator Inputs - the pulse accumulator input function shall have the same characteristics as the DI, except that, in addition a buffer shall be included to totalize pulses between interrogations. Each input shall accept pulses at a minimum of 2 per second.
5. Temperature Inputs - temperature inputs originating from a thermistor, shall be monitored and buffered as an AI, and provide automatic conversion to degrees F or C without any additional signal conditioning.
6. Input Wiring - all inputs shall be two wire devices and shall not require shielded wire for accurate operation.
7. Outputs - output types shall include digital, universal and tri-state. Outputs shall be available with built-in hand-off-auto switches for local overrides.
8. Digital Output - the Digital Output (DO) function shall provide contact closure for momentary (Pulse Width Modulation) and maintained operation of field devices. Output pulse width shall be selectable between 0.1 and 3200 seconds with a minimum resolution of 0.1 seconds. Isolation and protection against voltage surges up to 180 VAC peak shall be provided. Contact rating shall be a minimum of 1 amps at 24 VAC. Each digital output shall be equipped with an optional ON/OFF/AUTO switch to manually obtain either output state. Manual overrides shall be reported to the controller at each update. An LED shall be provided to indicate the state of each digital output.
9. Universal Output - a Universal Output shall provide 0-20VDC, 0-20 mA control signal (with a maximum resolution of .1 volt and .1 mA), and



- standard Form C relay operation (1 amps, 24 VAC). It shall be possible to select the mode of output operation for each output by simply wiring to the appropriate terminations on the controller. No circuit boards or output cards shall have to be exchanged to select the desired output mode.
10. A three-position manual override switch shall allow selection of the ON, OFF, or AUTO output state. In addition each UO shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3 position manual override switch is placed in the ON position.
  11. The Form C output mode shall be capable of standard digital output operation including pulse width modulation.
  12. All current outputs shall be fuse protected to 120VAC.
  13. Tri-State Outputs - tri-state outputs shall consist of two 24VAC relays for control of bi-directional motors and actuators. Each tri-state output is capable of PWM (pulse width modulation) to a resolution of .1 second.
- O. DDC Controller Resident Software Features
1. General:
    - a. All necessary software to form a complete operating system as described in this specification shall be provided.
    - b. The software programs specified in this Section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher level computer for execution.
  2. Control Software Description:
    - a. Software Description - The application software shall be configured for each Level 1 controller either locally through a laptop computer or through a workstation. Level 1 controllers shall contain PROM as the resident operating system. Application software will be RAM resident. Application software will only be limited by the amount of RAM memory. There will be no restrictions placed on the type of application programs in the system.

Each Level 1 controller shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function by Level 1 controllers shall not be interrupted due to normal user communications including; interrogation, program entry, printout of the program for storage, etc.
    - b. Real-Time Operating System - Provide a real time operating system in PROM memory requiring no operator interaction to initiate and commence operations. The program shall include:
      - 1) Operation and management of all devices.
      - 2) Error detection and recovery from arithmetic and logical faults
      - 3) Editing software to allow the user to develop or alter application programs.
      - 4) System self-testing
      - 5) Multi-user.
      - 6) Multi-tasking.
    - c. Editor - When programming a controller through either a dumb terminal or laptop computer, editing and word processing features

will include as a minimum:

- 1) Cut, copy, paste, and undo.
- 2) Search and replace.
- 3) Comments.
- 4) Scrolling.
- 5) Character, line, and page cursor control.

When programming in terminal mode, the system will allow full screen, character editing for correction or modification of any portion of a program. Syntax errors will be highlighted, and programmers must make corrections prior to the program being compiled. When programming Level 2 controllers, the programming environment will be identical to Level 1 programming with automatic uploading and downloading of the compiled code to the controller.

- d. Point Identification - Users must be able to assign unique identifiers for each connected point. Identifiers must have at least twelve alpha/numeric characters. All references to these points in programs, reports, and command messages shall be by these identifiers.

Each point name can have up to a 40 character description, and optionally engineering units (up to 8 characters).

- e. User Programming Language - The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be English language and programmable by the user.

The language shall be structured to allow for the easy configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, passwords, and histories.

The language shall allow the creation of timers anywhere in the logic of a program. Each timer shall increment in seconds and increment to a maximum of 365 days.

The language shall be self-documenting. Users shall be able to place comments anywhere in the body of a program. Program listings shall be configurable by the user in logical groupings.

- f. Application Software - The system shall contain include ROM based, built-in software modules for the creation of standard application programs. Modules will include as a minimum:

- 1) PID Algorithm
- 2) Self-tuning PID
- 3) Calendar Functions (Seconds, minutes, hour, day of week, day of month, day of year, month and year)
- 4) Curve fit
- 5) Optimum Start

- g. Mathematical Functions - Each controller shall be capable of performing basic mathematical functions (+,-,X,/), squares, square roots, exponential, logarithms, boolean logic statements, or combinations of both.

The controllers shall be capable of performing complex logical statements including operators such as >,<=, and,or,exclusive or, etc. These must be able to be used in the same equations with the mathematical operators and nested up to five parenthesis

deep.

- h. Passwords - Level 1 controllers will have up to 8 levels of passwords. The highest level will allow access to all functions within the system. The remaining 4 levels will be definable by the user to include any subset of system commands.
- i. History Logging - Each controller shall be capable of logging any system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system variables (inputs, outputs, math calculations, flags, etc.) can be logged in history. A maximum of 32767 values can be store in each log. Each log can will record either the instantaneous, average, minimum or maximum value of the point. Logs can be automatic or manual. If shall be possible to find the average of a log, the standard deviation, the sum, minimum or maximum. It shall also be possible to reference any value within a log for use in a control program.
- j. Reporting - The system shall be able to create user definable reports containing any combination of text and system variables. Report templates will be created by users in a word processing environment. Reports can be displayed based on any logical condition or through a user command.  
Numerical displays shall be up to 10 digits in length, with up to 4 digits to the right of the decimal point. The format of each numerical display shall be user definable.
- k. Alarming - For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan and can result in the display of one or more alarm messages or reports. Messages and reports can be sent to the optional display panel, a local terminal, to the Host Computer, via modem to a remote computing device.
- l. Debugging Tools - The language shall have built in program debugging tools for program simulation and error detection.  
When a control program is placed in a debug mode, a continuous record shall be kept of the last 128 steps before discarding the oldest data. Up to 4 control programs can be placed in a debug mode concurrently.
- m. Overriding Programs - It shall be possible to disable any point in the system and modify it to a user definable value. Any points that have been disabled will be kept in a log and viewable by an operator at any time.

Q. Dampers

- 1. All automatic dampers shall be furnished by this Contractor. Automatic control dampers shall be Ruskin CD60 or approved equal. All dampers for modulating control shall be of the proportioning type with adjacent louvers rotating in opposite directions. Damper frames shall be constructed of 16 gauge galvanized sheet metal. Bearings shall be nylon with oil impregnated sintered iron bushings. All linkages shall be fastened to blades within the damper. Provide double linkages on damper panels over 42" wide.
- 2. Replaceable rubber seals shall be provided with the dampers. Seals shall be installed along the top, bottom and sides of the frames and along each blade. Seals shall provide a tight closing, low leakage damper. Leakage and floor characteristics charters shall be submitted to the architect prior

- to approval of dampers.
3. Electronic Actuator
    - a. Actuators for damper control shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of a “V” bolt design with associated “V” shaped toothed cradle attaching to the shaft for maximum strength eliminating slippages. Spring return actuators shall have a “V” clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or set screw type fasteners are not acceptable.
    - b. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
    - c. For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.
    - d. All spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
    - e. Actuators shall be Belimo, or equal.
  4. All of the automatic dampers shall be furnished by the Temperature Control Contractor and installed by the Sheetmetal Subcontractor.
  5. Combination smoke/fire control dampers amperage draw of motor shall be provided by temperature control contractor. Dampers shall meet UL555S leakage class 2 standards and shall be equipped with wall sleeves and factory mounted electric actuators. Dampers shall be Ruskin S050 or approved equal.
- R. Electronic Sensors
1. All mixed air and coil discharge sensors shall utilize industry standard thermistor with averaging elements. Sensing elements shall be a minimum of 25 ft. and temperature sensed shall be averaged over the entire length of the element.
  2. Space type sensors shall have an accuracy of +/- .5 degrees over sensed temperature range (20/120F).
  3. Well type sensors used for liquid immersion shall have stainless steel removable wells. Sensing element shall have an accuracy of +/- .5 degrees over amperage draw of motor the range (70/220F or 20/120F) of the sensor. Each sensor shall have a suitable electrical box to enclose all wiring connections.
  4. Temperature control wells shall be installed by mechanical contractor under supervision of temperature control contractor.
- S. Smoke Detectors
1. The Electrical Contractor shall furnish smoke detectors to be installed in ductwork by the Sheetmetal Subcontractor. The Electrical Contractor shall wire from the detectors to the associated HVAC unit control circuit for shutdown of fans. The Electrical Contractor shall wire the normally closed contacts in series to the fan starter holding coil. All wiring to smoke detectors shall be by the Electrical Contractor.
  2. All units shall utilize smoke detectors, as specified.

- T. Current Sensors
1. Current sensors shall be analog type, sensitivity dated for the application with a 4-20 ma or 0-10 Vdc output. Span and sensitivity shall be adjustable. Sensors shall be used for all fans and pumps.
- U. Air Static Pressure Transmitter
1. Transmitter shall have range of 0-1" or 0.5" w.g. and send a 4-20 milliamp output signal. Zero set range and span set range +/- 5% of full range output. A combined static error (non-linearity, non-repeatability, and hysteresis) +/- .5% of full range output. Transmitter ranges shall be selected by ATC contractor as appropriate for intended use.
- V. Water Differential Pressure Transmitter
1. Low differential pressure transducer for wet-wet application. 4-20 milliamp output signal. Setra C230 or equal.
- W. Building Management and Control System Wiring
1. All input and output control wiring to the control units shall be #18 twisted and shielded cable. All shield to be grounded at the control panel, shields at the sensors or transducers to be folded back and taped.
  2. Communication trunk wiring shall be #18 twisted and shielded cable. Trunk isolator/extenders shall be installed on either end of trunk.
  3. All cable splices shall have joints soldered and taped including the shield. No mechanical connections will be acceptable.
  4. No digital input or output points shall be more than 250 feet from its respective panel.
  5. All wiring within the panels must be made with connectors of appropriate size and design for the terminals being applied.
  6. All connections within the panels must be made with connectors of appropriate size and design for the terminals being applied.
  7. All cables must be labeled and identified on corresponding termination drawings. A copy of the termination drawing will be adequately protected and left in its respective panel.
- X. Control Wiring
1. Electrical work will be in accordance with NFPA 70, ANSI C2 and Division 16 of these specifications. Electrical wiring, terminal blocks and other high voltage contacts will be fully enclosed and marked to prevent accidental injury.
  2. All wiring associated with the installation will be the responsibility of the Contractor. The term "wiring" is construed to include furnishing of wire, conduit, miscellaneous material and labor as required to install a total working system.
  3. It is the responsibility of the Electrical Contractor to provide adequate connections and extensions from 120 volt power sources to the various items of equipment requiring power under this contract. Branch circuits serving equipment under this contract will be separate and used only for such equipment. All branch circuit conductors 120 volts or greater will be at least 14 gauge copper, type THW, 600 volt insulation, installed in minimum 3/4 inch conduit (EMT).
  4. Transient Protection - All electronic equipment including processors, relays, monitoring devices, temperature sensors and other non-computerized solid state equipment will be adequately protected against

power line transients or RFI interference. Equipment that fails to operate properly due to transient or other electrical interference, in the opinion of the Engineer, will be required to be retrofitted with the appropriate protection device(s).

- Y. Points List: (the following points list is the minimum required points that will be available to all user interface devices)
1. Solar Array
    - a. Status
    - b. Production
  2. Demand Response
    - a. Unit enable/disable.
    - b. Status.
  3. Rooftop Energy Recovery Units (ERU):
    - a. Unit enable/disable.
    - b. Supply fan status.
    - c. Return fan status.
    - d. Discharge air temp. setpoint (winter)
    - e. Discharge air temp. setpoint (summer)
    - f. Discharge static pressure.
    - g. Discharge air humidity.
    - h. Return air temp.
    - i. Return air humidity.
    - j. Recirculation air damper command.
    - k. Filter status.
    - l. Occupied setpoint.
    - m. Unoccupied setpoint.
    - n. Freezestat.
    - o. Return air CO2 monitoring (where applicable).
    - p. DX command/position.
    - r. Outside air entering temperature. (DB/WB)
    - s. Supply air temp. leaving enthalpy wheel. (DB/WB)
    - u. Supply air temp. leaving heat pipe. (DB/WB)
    - v. Exhaust air temp. leaving heat pipe. (DB/WB)
    - w. Exhaust air temp. leaving enthalpy wheel. (DB/WB)
  4. Kitchen Make-up Air Units (Interlocked with ERV)
    - a. Kitchen hood exhaust fan interlock.
    - b. Return air and outside air damper position command.
  5. Exhaust Fans:
    - a. Exhaust fan enable/disable.
    - b. Exhaust fan status.
  6. Unit heaters/Cabinet unit heaters:
    - a. Room temperature.
    - b. Room setpoint.
  7. Global Points:
    - a. Outdoor air temp. (DB/WB)
    - b. Outdoor air humidity. (Rh)
  8. Variable air volume terminal boxes:
    - a. Room temp.
    - b. Room setpoint
    - c. CFM
    - d. Minimum CFM setpoints (cooling, heating, standby, unoccupied).
    - e. Maximum CFM setpoints (cooling, heating, standby, unoccupied).

- f. Discharge air temp.
- g. Room occupancy sensor.
- h. Room CO<sub>2</sub> sensor.
- 9. VRF system
  - a. Room temp.
  - b. Room setpoint
  - c. Room occupancy sensor.
  - d. Room CO<sub>2</sub> sensor.
  - e.
- 10. Hot Water Heater
  - a. Setpoint temperature.
  - b. Pump status.
  - c. Operational status (on/off)

### PART 3 EXECUTION

#### 3.1 MATERIALS AND WORKMANSHIP

- A. All materials installed in this work shall be new, unless noted for re-use, without damaged functional or aesthetic components. All equipment finished shall be touched up with matching finishes where slight scratches occur. Equipment or material subject to severe deterioration shall be completely refinished or replaced as directed by the Architect.
- B. All labor utilized in the installation of work shall be experienced in the respective trade required. The installation of exposed finished materials shall be neatly done flush, straight and/or plumb, without distortion, meeting the building finished surfaces.
- C. All HVAC materials and equipment shall conform to the Standards listed within this Section of the Specifications and wherever such standards have been established, items shall bear its respective label.
- D. Where labor to be furnished must meet specific Code requirements, only individuals certified to do such shall be used.
- E. All equipment shall be installed in accordance with the manufacturer's instructions and recommendations with adequate clearance for access for maintenance.

#### 3.2 COORDINATION

- A. This Contractor shall give full cooperation to other trades and to the General Contractor and shall furnish any information necessary to permit the work of all trades to be installed satisfactorily and with least possible interference or delay. If this Contractor installs his work before coordinating with other trades, he shall make the necessary changes in his work to correct the condition, without extra charge. In areas, if due to construction conditions, more than one trade is required to use common openings in beams, conduits, etc., this Contractor must plan and locate the positions of the items of piping, ducts, conduits, etc., which are under the scope of his Contract with that of items under the scope of other Contractors, in order that all items are properly located and may be accommodated within the space available. Location and positioning shall be done prior to installation and to the satisfaction of the Architect and/or Engineer.

- B. This Contractor shall obtain detailed printed information from the manufacturer of equipment which he is to provide for the proper methods of installation. He shall also obtain all information from the General Contractor and other Contractors which may be necessary to facilitate his work and the completion of the whole project. All equipment shall be installed in strict accordance with manufacturer's recommendations.
- C. The work to be accomplished under this Section includes work within existing areas adjacent to the site of new construction. Continuity of services within existing areas shall be maintained. Any interruption of services necessary to accomplish the work shall be made only with the consent of the General Contractor and at such time(s) as the Owner designates.
- D. This Contractor shall not unnecessarily disturb or interfere with the Owner's use of the facilities associated with or adjacent to this Contract. When interference is necessary, permission shall be obtained from the General Contractor before any operation or service line is disturbed or disconnected.
- E. This Contractor shall include under coordination work the installation of all systems in conformance with governing codes. This Contractor is advised that no piping, ducts or equipment foreign to the electrical equipment shall be permitted to be installed in, enter or pass through such spaces or rooms provided for switchboards and panelboards in accordance with Article 384 of the National Electrical Code.
- F. Diffusers, grilles and registers located in the ceiling shall be located as shown on the Architectural Reflected Ceiling Plan and coordinated with ceiling grid, lights, speakers, etc. Items shown on the HVAC Drawings, but not located on the Reflected Ceiling Plan shall be coordinated to be located as indicated on the HVAC Drawings.

### 3.3 COORDINATION DRAWINGS

- A. Coordination Drawings shall be initiated under this Section of the Specifications. It is this Contractor's responsibility for preparation of project Coordination Drawings showing the installation of all equipment, piping, ducts and accessories to be provided under this Section of the Specifications. These Drawings shall be prepared at not less than 3/8 inch = 1'0" scale and shall show building room layouts, structural elements, ceiling grid, diffusers, registers, grilles, ductwork and lighting layouts out of function. A reproducible copy of each Drawing prepared shall then be submitted to each Contractor working under the Plumbing, Fire Protection and Electrical Sections of this Specification, who shall be responsible to coordinate their equipment and systems and shall show these on the Drawings submitted. After each Trade Contractor has fulfilled their obligations, they shall return the Drawings to the HVAC Contractor. After each Drawing has been coordinated between trades, each trade shall sign each Drawing indicating acceptance of the installation condition. This Contractor shall then print the coordination original, and these prints shall be submitted, through the General Contractor to the Architect, for review and comment, similar to Shop Drawings. Comments made on these Drawings shall result in a correction and resubmittal of the Drawings. A master small scale Drawing of the entire building shall be initially prepared showing all areas involved and the Drawing numbers covering each area.



### 3.4 PROTECTION AND CLEAN UP

- A. This Contractor shall be responsible for maintenance and protection of all materials and equipment furnished by him during the construction period from loss, damage or deterioration until final acceptance by the Owner. All materials and equipment on the job site shall be stored and protected from the weather. All piping and equipment openings shall be temporarily closed during construction to prevent obstruction and damage.
- B. All equipment with damaged finished surfaces shall be cleaned and repainted with the same paints as were factory applied.
- C. Clean-Up: Keep the job site free from the accumulation of waste materials and rubbish daily. At completion of the work, remove all rubbish, construction equipment and surplus materials from the site and leave the premises in a clean condition

### 3.5 OPERATING AND MAINTENANCE MANUALS

- A. This Contractor shall provide four (4) complete sets of operating and maintenance manuals to the Owner prior to the operating instruction period. Maintenance manuals shall be submitted for approval. The receipt of approved maintenance manuals by the Owner shall be a prerequisite to system acceptance. Each manual shall include the following:
  - 1. A complete set of Shop Drawings arranged in accordance with their appearance in the Specifications. Drawings shall be folded and included in envelopes and bound into the manual.
  - 2. A complete set of operational and servicing instructions for each piece of equipment, bound into the manual adjacent to the corresponding Shop Drawing.
  - 3. A complete listing of all equipment suppliers, together with local agent's names, addresses and telephone numbers.
  - 4. A complete set of valve listings.
  - 5. Copies of all service contracts provided for the guarantee period.
  - 6. Copies of all equipment and system warranties.

### 3.6 OPERATING INSTRUCTIONS

- A. This Contractor shall provide competent representatives of his firm and also qualified representatives for his major equipment to instruct Owner-designated personnel on the start-up, operation, shut-down and servicing of all equipment and systems furnished and installed under this Section. No less than ten (10) days notice shall be given to the Owner for the beginning of the instruction period to permit scheduling of Owner personnel. The instruction period shall be a prerequisite to system acceptance. This contractor shall coordinate this requirement with the Commissioning Agent. Refer to specification section 019100 for additional requirements.
- B. Training of the Tenant's and Building Owner's operation and maintenance personnel is required in cooperation with the Tenant's and Building Owner's representatives. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation and troubleshooting of the installed systems. The instruction shall be

scheduled in coordination with the Tenant's and Building Owner's Representatives after submission and approval of formal training plans. Refer to Commissioning Specifications, Section 019100 for contractor training requirements.

- C. At the conclusion of the operating instructions, this Contractor shall have the Owner's personnel sign-off stating they have received the required instruction. Separate statements shall be required for each piece of equipment and system. These statements shall include date, names of Owner's representative, name of instructor, and brief description of equipment or system.

### 3.7 SYSTEM START-UP AND OPERATION

- A This Contractor shall provide all labor and materials and services necessary for the initial start-up and operation of all systems and equipment furnished and installed under this Section of the Specifications.
- B This Contractor shall provide the services of qualified factory representatives for all major equipment pre-start set-up, start-up and initial operation. Such periods shall be sufficient to insure proper operation of systems and equipment.
- C This Contractor shall check all equipment during the initial start-up to insure correct rotation, proper lubrication, adequate fluid flows, non-overloading electrical characteristics, proper alignment and minimal vibration. Systems shall be checked for air flows throughout without blockages. Rooftop air handling units shall be checked for proper damper connections and positions aligned and adjusted belt drives, proper lubrication, temporary air filters installed, non-excessive electrical characteristics and minimal vibration. Miscellaneous equipment shall be started and operated as described above, as applicable. This Contractor shall prepare and submit monthly start-up and status reports for all equipment and systems as indicated on the schedules. Initial form of this report shall be submitted for review with the initial submittals. Upon closing in of the structure or upon first equipment start-up, the report filing shall be started. One copy of this report shall be submitted to the Testing and Balancing Contractor for his record purposes. Submittal of these reports is a prerequisite for processing and evaluating requisitions.
  - 1. Contractors' tests shall be scheduled and documented in accordance with the commissioning requirements. Refer to Commissioning Specifications, Section 019100 for additional requirements.
  - 2. System verification testing is part of the commissioning process. Verification testing shall be performed by the contractor and witnessed and documented by the Commissioning Agent. Refer to Commissioning Specification Section 019100 for system verification tests and commissioning requirements.
- D During operation of systems, qualified licensed personnel shall be provided and designated for maintenance of the equipment and systems in good running order. Items such as strainer cleanout, bearing lubrication, packing replacement and other consumables shall be provided without cost to the Owner. Failure of equipment during this period due to lack of proper supervision is the responsibility of this Contractor, and continued failures shall be grounds for the Owner to provide such services with back-charges to this Contractor.
- E Prior to building flush out, all filters installed within all air handling equipment shall be replaced with filters having minimum rating of MERV 10 unless such equipment was specified with filters having a higher rating. Air handling equipment shall

include but not be limited to air handling units, rooftop units, energy recovery units, make-up air units, fancoil units and classroom unit ventilators. Upon completion of building flush out, all filters installed within all air handling equipment shall be replaced with filters having minimum rating of MERV 10 unless such equipment was specified with filters having a higher rating.

- F. Coordinate all start-up, operation, and testing activities with the Project Manager, General Contractor and the Commissioning Agent per specification section 019110.

### 3.8 SYSTEMS IDENTIFICATION

#### A. General:

1. All equipment, ductwork and piping furnished under this Section shall be marked for ease of identification in accordance with ANSI A13.1-1981 Standard or as indicated below by this Contractor.
2. Marking shall be done using painted stenciling applied to clean, smooth surfaces.
3. Lettering type and size shall be in accordance with paragraph 3.4 and Table 3 of ANSI Standard, with sharply contrasted background for ease of identification. Duct labeling shall not be less than 3 inches in height. Colors shall be in accordance with paragraph 3.2 and Table 2 of the ANSI Standard.

#### B. Equipment:

1. Equipment markings shall be prominently painted on each normally visible side of equipment. Equipment intended for installation in finished areas shall have markings located behind normally used access panels mounted so as to be readily found.
2. Equipment identification designations shall be taken from equipment schedules as indicated on the Drawings.
3. All rooftop air handling units, energy recovery units and make-up air units shall be numbered on at least two (2) sides in 4" to 6" letters of contrasting color. Number shall be associated with the street or occupancy address preceding the HVAC unit number (example, 23-1, 23-2, etc.). LED or keyed remote test switch shall be labeled with device number information corresponding to rooftop designation. Where rooftop units with duct smoke detectors are above a suspended ceiling, the tile grid shall be marked with a red dot if an LED is not present.

#### C. Piping:

1. Piping marking, except as noted below, shall be prominently painted on all piping concealed and exposed to view, at entries to shafts and at all valving. Marking spacing shall be every 20 feet and at all changes in direction.
2. Piping markings shall indicate direction of flow with piping designation taken from piping legend indicated on Drawings.
3. In lieu of painting pipe marking for outside diameters of no less than 3/4 inches but less than 6 inches labeling shall be on semi-rigid plastic which shall be wrapped entirely around the item being identified and attached to itself to form a non-removable band.
4. In lieu of painting pipe marking for outside diameters of 6 inches or greater, springs or metal bands secured to the corners at each end of the semi-rigid plastic marker so as to hold each end of the marker firmly against the

- pipe may be utilized.
5. In lieu of painting, for outside diameters less than 3/4 inches, labeling of 1/2 inch high lettering on 1-1/2 inch minimum diameter tags shall be attached so as direction of flow arrows will indicate proper flow direction when tag is being read.
- D. Ductwork:
1. Ductwork marking shall be prominently painted on all ductwork concealed and exposed to view. Marking spacing shall be every 20 feet at all dampers and at all changes in direction.
  2. Ductwork marking shall indicate direction of air flow with ductwork designation to consist of the equipment designation to which it is connected and indicate either high or low velocity system.
  3. Access doors at service openings for fire dampers, smoke dampers and smoke detectors shall be identified with letters no less than 1/2 inch in height to indicate the location of the fire protection device(s) within.
- E. Valve Tags:
1. Valve tags shall be 1-1/2 inch diameter brass with 1/4 inch high lettering for service designation over 1/2 inch high valve number designation and shall be provided for all valving.
  2. Two (2) sets of valve lists shall be prepared showing tag numbers, valve locations and valve service. Valve tag numbers shall be marked on Record Drawings. One valve list shall be prepared based on sequenced room numbers of valve locations; one valve list shall be prepared based on valve numbers. One set of lists shall be framed under glass and duplicate list laminated between plastic sheets.
  3. One (1) additional copy shall be framed under glass and mounted on the wall in location as designated by the Architect.

### 3.9 SHEET METAL WORK REQUIREMENTS

- A. Furnish and install all sheet metal work as herein specified for all air handling systems shown on drawings and/or described in the specifications.
- B. All sheet metal work shall be done in a neat and workmanlike manner with ductwork following building lines and in straight lines with smooth transitions and offsets as required to suit actual installation. Sheet metal work which does not conform to drawings and/or specifications or is poorly done shall be repaired and/or replaced as described by the Architect.
- C. Reference shall be made to the paragraph covering Coordination Drawings for the responsibility in the preparation of same.
- D. Sheet Metal Contractor shall include in his work furnishing and installing volume dampers in accordance with SMACNA requirements; additional dampers as required in the duct system for the purpose of balancing by the Balancing Contractor, as well as dampers shown on the drawings.
- E. Sheet Metal Contractor include in his work furnishing and installing automatic control, fire, smoke and combination fire/smoke dampers.
- F. Air handling systems shall conform to the following:
  1. All sheet metal work required for ductwork casing and plenums of all low

- pressure air handling systems shall be galvanized steel and shall conform to requirements of sheet metal work. Exceptions to this requirement shall be as specifically listed below or as indicated on the drawings.
2. All sheet metal work required for ductwork, casings and plenums of air handling system with scheduled total static pressure equal to or greater than 3 inches shall conform to the requirements for the static pressure scheduled. This construction shall apply from the outside air and return air dampers at the unit inlet and extend to the system terminal boxes.
  3. Sheet metal supply and return ductwork for the surgery areas from the terminal boxes to the supply diffuser (including plenum) and from the exhaust registers for 10 feet shall be aluminum.
  4. Sheet metal exhaust ductwork for lab exhaust and all other fumehoods shall be 316 stainless steel. All joints and seams shall be welded to provide a continuous seal.
- G. All casings and plenums shall be provided with 54 inch high, 20 inch wide access doors, except where larger door is required for equipment replacement, or when casing or plenum will not accommodate this size door. When alternate door of larger size is required, it shall be sized to meet requirements of equipment being served. For doors smaller than 54" x 20" the largest following door size which can be accommodated shall be provided: 48" x 20"; 36" x 18"; 24" x 18"; 18" x 18"; 18" x 12"; or 12" x 22". In all cases the bottom of the door opening shall be a minimum of 6 inches above the plenum's bottom.
- H. Two-piece streamliner shall be furnished and installed at no additional cost to the Owner around each conduit, beam or other obstruction passing through ductwork. Obstructions in ductwork shall be allowed only when offsets around ducts are not possible and shall be indicated on Coordination Drawing.
- I. Sealants: All seams in sheet metal work shall be permanently sealed airtight by the use of appropriate mastic compounds. Joints between dissimilar materials shall be provided with lead gaskets. Louver plenums shall be provided with lead gaskets. Louver plenums shall have all bottom seams and side seams up to distance of 12 inches sealed using solder.
- J. Duct Liners: Where ducts indicated on drawings or specified are to be lined, such lining shall conform to the requirements specified under Acoustic Liner indicated in Paragraph "Sheet Metal Work". Duct sizes indicated on the drawings are nominal internal dimensions and therefore shall be increased accordingly to accommodate duct lining.
- K. The Sheet Metal Contractor shall install all duct mounted smoke detectors, heat detectors and other devices furnished by the Electrical Contractor for mounting in the ductwork or air handling equipment.
- L. Fire dampers shall be installed in accordance with the manufacturer's installation instructions. Fire dampers shall be capable of maintaining the integrity of the required fire-resistance rating and shall be accessible. Where ductwork is rearranged to facilitate coordination or installation, the fire dampers shall be provided at locations where air distribution systems penetrate assemblies required to have a fire-resistance rating.
1. Exception when approved by the Architect and Engineer are as follows:
  2. When proper fire tests have shown that fire dampers are not necessary to maintain the integrity of the fire-resistance rated assembly.

3. Sub-ducts extending 22 inches vertically upward may be used in lieu of fire dampers for exhaust ducts penetrating a fire-resistance rated shaft wall.
  4. Penetrations of tenant separation and corridor walls in buildings equipped throughout with an approved automatic fire suppression system.
  5. When the ducts are constructed of steel and are part of an engineered smoke removal system.
  6. Penetrations of corridor walls when the ducts are constructed of steel and do not have openings which communicate the corridor with adjacent spaces or rooms.
  7. Penetrations of a roof assembly when ducts are open to the atmosphere.
  8. Hazardous exhaust systems as defined in the Mechanical Code.
- M. All prefabricated duct sections shall be cleaned prior to storage on the site and be provided with protective covering on all openings to maintain the interior of the ductwork clean and free of dust and other materials prior to installation. Field assembled duct sections shall be cleaned during assembly and similarly protected until installation.
- N. Blank off all portions of louvered openings not required for ventilation systems.
- O. Access doors shall be provided adjacent to each fire damper, smoke damper, combination fire/smoke damper, and smoke detector. The access opening shall be large enough to permit inspection, maintenance and resetting of the device. Where the size of the duct permits, the minimum size door should be 18 inches x 16 inches.
- P. Testing for ductwork shall be performed for all duct systems specified to be constructed to a static pressure class of 4" w.g. or greater and to all stainless steel exhaust systems serving laboratory hoods or other systems designed to convey hazardous fumes or materials. The leakage class shall be in accordance with Table 4-1 of SMACNA HVAC Air Duct Leakage Test Manual, First Edition 1985.
- Q. The Sheet Metal Contractor shall install automatic control dampers furnished by the Automatic Temperature Control System manufacturer and shall include all safing and/or duct transitions as required to complete damper installation.

### 3.10 PIPING SYSTEM INSTALLATION

- A. Installation of Pipe, Fittings and Valves:
1. Furnish and install piping approximately as indicated; straight, plumb and as direct as possible; form right angles on parallel lines with building walls.
  2. Keep pipes close to walls, partitions and ceilings; offset only where necessary to follow walls, as indicated.
  3. Locate groups of pipes parallel to each other; space them at distances to permit applying full insulation and to permit access for servicing valves.
  4. Piping shall be accurately cut to measurements established in the field and worked into place without springing or forcing. All piping shall be assembled using standard manufacturer's screwed or welded fittings. Where standard fittings are not available for branch connections, use "Threadolets" or "Weldolets" as appropriate to suit pipe sizes, neatly cut and welded into the line.
  5. Grooved joints shall be installed in accordance with the manufacturer's latest published instructions. The gasket style and elastomeric material

(grade) shall be verified as suitable for the intended service. Gaskets shall be molded and produced by the grooved coupling manufacturer. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove. Grooved coupling manufacturer's factory trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools, application of groove, and installation of grooved piping products. Factory trained representative shall periodically visit the jobsite to ensure best practices in grooved product installation are being followed. Contractor shall remove and replace any improperly installed products.

6. All piping shall be reamed to be free of burrs.
  7. Keep pipe free from scale and dirt; protect open pipe ends whenever work is suspended during construction to prevent foreign bodies entering and lodging there. Use temporary plug or other approved material for protection.
  8. Use all long radius ells on welded piping.
  9. Provide bypass line with globe valve with isolation valves to provide bypass around all control valves which serve air handler coils and other central system equipment. Bypass valves are not required for terminal units, radiation, fancoils, cabinet heaters, unit heaters and similar equipment served from a central system. Bypass valve size shall be a minimum of one-half the supply line size.
  10. Prior to installation of any piping, submit shop drawings indicating location of all pipes larger than 2 inches in diameter. Piping may be shown on Coordination Drawings in lieu of shop drawings.
  11. Provide cap and chain for 3/4 inch hose connection for all drain valves.
- B. DX Systems:
1. Charging of refrigerant piping shall be done subsequent to pressure testing.
  2. Evacuate system to 2.5 mm of mercury and hold vacuum for eight (8) hours and then break vacuum with dry nitrogen. Re-evacuate piping to 2.5 mm and break vacuum with refrigerant charge.
  3. Pipe sizing, where indicated on drawings, are the sizes estimated for specific manufacturer's equipment and anticipated piping installation.
    - a. The Contractor shall provide piping sized for actual piping installation requirements for the field installation conditions in accordance with the system equipment manufacturer's recommendations.
  4. All refrigerant systems which require field piping shall include a filter-dryer, moisture indicator, liquid line sightglass, refrigerant charging connections and solenoid valves. Devices not furnished with the refrigeration equipment shall be provided by this Contractor.
- D. Installation of Unions:
1. Provide unions, screwed or flanged, in the following locations:
    - a. In long runs of piping to permit convenient disassembly for alterations or repairs. Provide unions in all trench piping located every 20 feet and at all connections in branch and mains leaving the trench.
    - b. In bypass around equipment.
    - c. In connections to traps, tanks, pumps, and other equipment.
- E. Installation of Valves:

1. Provide shut-off valves where indicated and in the following locations:
    - a. Risers and main branches at points of take-off from their supply or return mains. Valves shall be arranged so that piping mains for the building and for each floor can remain in service while branch line piping is out of service. Balancing valves suitable for shut-off service shall be used in returned piping.
    - b. Individual equipment, control valves, strainers, traps and other piping systems devices at inlet and outlet to permit unit removal for repairs without interfering with remainder of system.
  2. Locate valves for easy access and operation.
  3. Do not locate valves with stems below horizontal.
  4. Provide balancing valve at outlet of each equipment connection.
- F. Pipe Welding: Welding backing rings shall be used at each pipe weld. All pipe welders shall be tested and qualified under the National Certified Pipe Welders Bureau. Welders for high pressure steam shall be certified for ASME Code welding.
- G. Expansion:
1. Provide for taking up expansion in guides and anchors, where indicated and/or required.
  2. Use swing or swivel joints for connections from mains to risers and from risers to radiators, unit heaters and other heating units; use at least five (5) fittings from main to riser, including tee in main; use at least four (4) fittings from riser to radiator or unit heater, including tee in riser.
  3. When installing expansion loops, they may be cold sprung. Cold springing shall compensate for approximately half of the total expansion.
- H. Drains: All coiling coils shall have drip pans, trapped and condensation discharge piped to nearest suitable receptor except as noted otherwise. All traps shall be located inside to prevent freezing. Trap seals shall be appropriate for respective units scheduled pressure differential plus 50 percent on coils downstream of fans, and a minimum 3 inches for coils upstream of fans.
- I. Gas Piping: This Contractor shall provide for piping all vent lines to outdoors as required for the specific type of pressure reducing valves or other gas train devices requiring venting to outdoors under the Gas Codes.
- J. Intake and exhaust plenums not detailed to have through-louver drainage shall have a 1 inch drain connection with a serviceable 3 inch deep trap provided within a heated space to prevent freezing and piped to the nearest floor drain or janitor sink. Bottom of plenum shall pitch toward drainage opening. Drain lines indicated on the drawings to terminate through the wall to outdoors shall not be required to include a trap.

### 3.11 PIPING SYSTEM FLUSHING AND CLEANING

- A. This Contractor shall make temporary connections and required adjustments to the piping system for the purpose of cleaning and flushing.
- B. Steam and return piping shall be blown out by operating steam with all returns run to waste until the system is thoroughly cleaned out. During the above period, all strainer and thermostatic trap interiors shall be removed and strainers and traps cleaned, together with dirt pockets. The system shall be left free from oil, scale



and dirt. The strainer and trap interiors shall be replaced after the system has been cleaned.

- C. Compressed air lines shall be blown out using compressed air. All filters and instruments shall be removed from system during this flushing and then replaced.
- D. Chemical treatment required for cleaning shall be provided as specified under "Chemical Treatment".

3.12 PIPING SYSTEM PRESSURE TESTS

- A. All piping systems furnished and installed under this section shall be pressure and/or vacuum tested prior to being buried, concealed, and/or insulated. This Contractor shall make all necessary temporary connections and gauges required and shall isolate all equipment which may be damaged by testing procedures. This Contractor shall notify Architect in writing of his testing schedule to permit observation of procedures. Tests shall be initiated only after testing medium has reached ambient temperatures. Systems which fail testing shall be repaired in a manner approved by the Architect and testing repeated. Testing of sections of extensive systems are permitted. Written summary of all testing shall be submitted upon completion of testing indicating system, date of test, testing medium, initial and final pressures and temperatures, repair procedures and supervisor's name.
- B. The following systems shall be tested as indicated:

<u>SYSTEM</u>	<u>TEST MEDIUM</u>	<u>TEST PRESSURE PSIG</u>	<u>TIME PERIOD HOURS</u>	<u>ALLOWED DEVIATION PERCENT</u>	<u>NOTES</u>
Refrigerant	Nitrogen	250	4	-5	1
Refrigerant	Vacuum	29.5" Hg	4	-5	1

Note 1: Dry nitrogen shall be used for pressure test followed by vacuum test. Introduce refrigerant into piping to break vacuum.

- C. For testing of piping systems exposed to low ambient conditions, this Contractor shall assume responsibility of taking suitable precautions to prevent freezing within piping systems.
- D. Fuel oil systems shall be tested in accordance with requirements of applicable requirements of NFPA 30 and NFPA 31 and in accordance with all governing code requirements

3.13 INSULATION APPLICATION REQUIREMENTS

- A. Insulation materials shall be installed in accordance with the applicable insulation classes for piping, ductwork and equipment.
- B. Insulation shall be applied in a workmanlike manner so as to provide a neat and smooth surface, suitable for painting. Work and/or material that is poorly done or done in a manner not conforming to the specifications and/or drawings shall be repaired or replaced as directed by the Architect.
- C. Insulation shall not be applied to piping and related equipment until the completion

- of pressure testing. Insulation shall not be applied to ductwork and related equipment until air systems have been sealed and/or pressure tested.
- D. Sections of piping and equipment may be covered as the work progresses, provided the above requirements have been met for pressure testing and tightness.
  - E. All piping and equipment to be covered shall be clean and dry prior to the application of insulation.
  - F. Insulation shall not be applied when ambient temperatures within the space are below 40 degrees F.
  - G. Piping and duct insulation shall be carried full thickness through all floor and wall openings, except when installed through sleeves through fire-rated construction, insulation shall be discontinued at the penetration and replaced with caulking material specified for sleeves.
  - H. All insulation shall be applied with edges tightly butted.
  - I. All voids and/or seams in insulation shall be filled with insulating cement plaster or insulating cement.
  - J. All insulation ends shall be finished to a 45 degree level with insulation cement troweled to a neat and smooth finish.
  - K. Equipment nameplates, pressure vessel code labels and equipment access doors shall be left exposed with insulation edges finished as described in Paragraph J. above.
  - L. Piping installed outdoors with the exception of underground conduit shall be furnished with layers of insulation of equal thicknesses with the total thickness twice that specified in insulation thickness schedule. The double layer insulation shall be installed so that all seams are staggered. Apply 45 pound roofing felt with 2 inch overlap at joints. All joints to be sealed with asphalt. Wire jacket in place with 16 gauge copper annealed wire on 9 inch centers.
  - M. Under no circumstances shall pneumatic control tubing be covered with insulation.
  - N. When installation thickness specified exceeds that provided as manufacturer's standard, then multiple layered material shall be used to achieve specified thickness.
  - O. Any piping, ductwork or equipment which may convey a fluid gas or air below 75 degrees F. at any time in its normal operation shall be provided with insulation with an external vapor barrier except where explicitly indicated otherwise.
  - P. Where specified under Pipe Hangers, Supports and Hangers, insulated refrigerant suction lines shall have calcium silicate used at all points of support. Calcium silicate sections shall be of the same thickness as the adjacent insulation with vapor barriers continued unbroken through the support section. Support sections shall be three times the pipe diameter in length or not less than 12 inches nor more than 24 inches. 14 gauge galvanized sheet metal saddles the same length and diameter as the calcium silicate section and covering not less than 120 degrees of

arc shall be provided at support points.

- Q. Insulation for piping and equipment shall be provided with wire or band supports to prevent sagging and cracking of finished surface or vapor barrier. Supports shall be applied in accordance with insulation manufacturer's recommendations. Supports shall generally be located beneath finish jacketing.
- R. Valves which are specified to be insulated shall be covered to top of bonnets.
- S. Insulation for piping systems shall be provided up to coil connections and the exterior casing, including tube returns or manifolds external to casing shall also be insulated except where noted otherwise.
- T. Engine exhaust pipes, fittings, and silencers shall be covered with 4 inch calcium silicate insulation. Insulation shall be applied in two (2) layers with staggered joints. Secure insulation in place with heavy gauge stainless steel bands. Seal all seams and joints in each layer with high temperature cement. Cover insulation with reinforced glass fiber cloth.
- W. All unlined supply and return ductwork located outdoors shall have a minimum thickness of 2 inches of rigid board insulation and an aluminum weatherproof cover applied over the vapor barrier.

#### 3.14 SYSTEM BALANCING

- A. This Contractor, as part of his contract, shall obtain the services of a testing and balancing agency that specializes in this type of work, to perform the work required under this section. The testing and balancing agency selected shall not have installed, fabricated or engineered any part of the system that the testing and balancing work shall be performed on, so as to prevent any conflict of interest. In addition, the selected company shall not be a subsidiary of or be associated with persons having financial interests in the accessories, ductwork, controls, etc., undergoing these tests so that the Owner will receive a completely unbiased test and balance report upon completion of the work.
- B. The selected testing and balancing agency shall be a certified member of the AABC or the NEBB. Minimum criteria for this project shall be the General Membership Standards of the Associated Air Balance Council, as published nationally in AABC NSFMI Volume One, #81266 or as otherwise noted herein.
- C. All work performed by the approved agency shall be done in full accordance with minimum standards as set forth in AABC National Standards, Fourth Edition (1982) and ASHRAE Systems Manual (1984). In addition, vibration readings shall be taken on all rotating equipment in this section and recorded in mills of deflection.
- D. Submittals:
  - 1. The TAB Agency shall submit a company resume listing personnel and project experience in air and hydronic system balancing and a copy of the agency's Test and Balance Engineer (TBE) certificate.
  - 2. The TAB agency shall submit the TAB procedures and agenda proposed to be used.
  - 3. The TAB agency shall submit sample forms, which shall include the minimum data required by the AABC National Standards.

- E. This Contractor shall cooperate with the test and balance agency in the following manner:
1. Provide sufficient time before final acceptance data so that tests and balancing can be accomplished and reviewed.
  2. Provide immediate labor and tools to make corrections when required without undue delay. Install balancing dampers as required by test and balance agency.
  3. Put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of same during each working day of testing and balancing.
  4. The testing and balancing agency shall be kept informed of any major changes made to the system during construction, and shall be provided with four (4) complete sets of Construction and Coordination drawings, one (1) set of which shall be turned over to the Owner with ductwork systems differentiated by coloring each system's ductwork in a distinguishing color and diffusers, registers and grilles identified with a number corresponding with the respective item on the balancing report.
  5. Include the costs of test openings, dampers, pulley and belt changes in his contract.
- F. The items requiring testing, adjusting and balancing include the following:
1. Air Systems:
    - a. Supply Fan AHU's
    - b. Return Fans
    - c. Exhaust Fans
    - d. Zone Branch and Main Ducts
    - e. VAV Systems
    - f. Diffusers, Registers and Grilles
    - g. Coils (Air Temperature)
    - h. Induction Units
- G. TAB Preparation and Coordination:
1. Shop drawings, submittal data, up-to-date revisions, change orders, and other data required for planning, preparation, and execution of the TAB work shall be provided to the TAB agency no later than 30 days prior to start of TAB work.
  2. System installation and equipment start-up shall be complete prior to the TAB agency's being notified to begin.
  3. The building control system shall be complete and operational. The Building Control System Contractor shall install all necessary computers and computer programs, and make these operational. Assistance shall be provided as required for reprogramming, coordination, and problem resolution.
  4. All test points, balancing devices, identification tags, etc., shall be accessible and clear of insulation and other obstructions that would impede TAB procedures.
  5. Qualified installation or start-up personnel shall be readily available for the operation and adjustment of the systems. Assistance shall be provided as required for coordination and problem resolution.
- H. Reports:
1. The TAB agency shall submit the final TAB report for review by the Engineer. All outlets, devices, HVAC equipment, etc., shall be identified, along with a numbering system corresponding to report unit identification.

The TAB agency shall submit an AABC “National Project Performance Guaranty” assuring that the project systems were tested, adjusted and balanced in accordance with the project specifications and AABC National Standards.

2. Submit four (4) copies of the final TAB Report.
- I. Deficiencies:
    1. Any deficiencies in the installation or performance of a system or component observed by the TAB agency shall be brought to the attention of the appropriate responsible person.
    2. The work necessary to correct items on the deficiency listing shall be performed and verified by the affected contractor before the TAB agency returns to retest. Unresolved deficiencies shall be noted in the final report.
    3. System balance reports which, upon field inspection of the systems, are found to be erroneous, shall have the questioned systems corrected by the test and balance agency until a proper balance is achieved. Such correction work shall be done at no cost to the Owner. Balancing Contractor shall field verify balancing settings and measurements as randomly selected by the Architect.
  - J. All instruments used for measurements shall be accurate and calibrated. Calibration and maintenance of all instruments shall be in accordance with the requirements of AABC National Standards.
  - K. The specified systems shall be reviewed and inspected for conformance to design documents. Testing, adjusting and balancing on each identified system shall be performed. The accuracy of measurements shall be in accordance with AABC National Standards. Adjustment tolerances shall be + or – 10% unless otherwise stated.
    1. Equipment settings, including manual damper quadrant positions, manual valve indicators, fan speed control levers, and similar controls and devices shall be marked to show final settings.
    2. All information necessary to complete a proper TAB project and report shall be per AABC Standards unless otherwise noted. The descriptions for work required, as listed in this section, are a guide to the minimum information needed.
  - L. Air Systems:
    1. The TAB agency shall verify that all ductwork, dampers, grilles, registers and diffusers have been installed per design and set in the full open position. The TAB agency shall perform the following TAB procedures in accordance with the AABC National Standards.
    2. For Supply Fans:
      - a. Test and adjust fan RPM to achieve maximum or design CFM.
      - b. Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure fan motor is not in or above the service factor.
      - c. Perform a Pitot-tube traverse of main supply and return ducts, as applicable to obtain total CFM.
      - d. Test and adjust the outside air on applicable equipment using a pitot-tube traverse. If a traverse is not practical use the mixed air temperature method if the inside and outside temperature difference is at least 20 degrees F. or use the difference between pitot-tube traverses of the supply and return air ducts.

- e. Test and record system static profile of each supply fan.
  - 3. For Return Fans:
    - a. Test and adjust fan RPM to achieve maximum or design CFM.
    - b. Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure fan motor is not in or above the service factor.
    - c. Perform a pitot-tube traverse of the main return ducts to obtain total CFM.
    - d. Test and record system static profile of each return fan.
  - 4. For Exhaust Fans:
    - a. Test and adjust fan RPM to achieve maximum or design CFM.
    - b. Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure motor is not in or above the service factor.
    - c. Perform a pitot-tube traverse of main exhaust ducts to obtain total CFM.
    - d. Test and record system static profile of each exhaust fan.
  - 5. The Balancing Contractor shall make all necessary tests and measurements and provide information as required to provide for replacement of adjustable sheaves utilized for initial balancing with optimum sized fixed sheave and select optimum replacement sheave sizes for existing equipment fan drives for systems indicated to be modified. All adjustable sheaves replaced shall be tagged to indicate which unit it was on and turned over to the Owner.
  - 6. For Zone, Branch and Main Ducts:
    - a. Adjust ducts to within design CFM requirements. As applicable, at least one zone balancing damper shall be completely open. Multi-diffuser branch ducts shall have at least one outlet or inlet volume damper completely open.
  - 7. For VAV Systems:
    - a. Set volume regulators on all terminal boxes to meet design maximum and minimum CFM requirements.
    - b. Identify the type, location, and size of each terminal box. This information shall be recorded on terminal box data sheets.
  - 8. For Diffusers, Registers and Grilles:
    - a. Test, adjust and balance each diffuser, grille and register to within 10% of design requirements. Minimize drafts.
    - b. Identify the type, location, and size of each grille, diffuser and register. This information shall be recorded on air outlet data sheets.
  - 9. For Coils:
    - a. Once air flows are set to acceptable limits, take wet bulb and dry bulb air temperatures on the entering and leaving side of each cooling coil. Dry bulb temperature shall be taken on the entering and leaving side of each coil.
  - 10. Where air balancing can not be completed due to lack of air flow and the reason for the lack of air flow can not be identified, a static profile shall be performed as required to identify the reason for loss of adequate air flow.
- M. The TAB agency shall conduct sound testing in the following areas per AABC National Standards and to the criteria listed, using sound meter with octave band analyzer:
- | 1. | Test Area      | Number of Locations | NC Level Acceptable |
|----|----------------|---------------------|---------------------|
|    | General Office | 16                  | 30-35               |

Computer/Equipment Rooms	4	40-45
Schools/Classrooms	16	25-30

- N. The TAB agency shall conduct vibration testing on the following equipment per AABC National Standards. Test deflection in mils and velocity in inches per second shall be measured and the results compared to requirements in equipment specification sections.
- EQUIPMENT  
Fans over 3.0 Horsepower  
Pumps over 3.0 Horsepower
- O. Indoor Air Quality Verification:
- The TAB agency shall take measurements at design outside air. It shall measure temperature and humidity uniformity throughout the space, check filter installation for proper fit, seal, and operation and verify condensate drain operation. The TAB agency shall note any water damage or obvious contamination sources from inside or outside.
  - The TAB agency shall conduct the following air sampling tests for every 2,500 square feet of space:
    - Carbon Dioxide
    - Carbon Monoxide
    - Ozone
    - Nitrogen Oxides
    - Formaldehyde
  - The TAB agency shall prepare a report showing the results, location, time and date of each test. A summary of the HVAC operating conditions, and a listing of any discrepancies shall be provided.
  - All IAQ readings are applicable only to the date and time noted in 3.06C.
- P. The TAB agency shall review the project documents and Contractor submittals for their effect on the TAB process and overall performance of the HVAC system. It shall submit recommendations for enhancements or changes to the system within 30 days of document review.
- Q. During construction, the TAB agency shall inspect the installation of pipe systems, sheet metal work, temperature controls, and other component parts of the HVAC systems. Inspections shall be conducted a minimum of two times. (Typically, these are performed when 60% of the total system is installed and again when 90% of the total system is installed, prior to insulation of the duct and piping.) The TAB agency shall submit a written report of each inspection.
- R. The Installing Contractor shall isolate and seal sections of ductwork for testing. The test pressures required and the amount of duct to be tested shall be described by the Engineer in the appropriate duct classification section. All testing shall be based on one test per section only unless otherwise noted.
- S. The TAB agency shall be assisted by the Building Control Systems Contractor in verifying the operation and calibration of all HVAC and temperature control systems.
- Automatic Temperature Control Contractor shall have all automatic valves adjusted and calibrated prior to balancing.
  - The Balancing Contractor shall make all necessary tests and measurements and provide information as required by the Automatic Temperature Control Contractor to select the optimum range of sensing

- and control devices.
3. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water resets, fire and freezestats, and other safety devices.
  4. Verify that all controlling instruments are calibrated and set for design operating conditions.
- T. To verify system control and operation, a series of three temperature tests shall be taken at approximately two hour intervals in each separately controlled zone. The resulting temperatures shall not vary more than two degrees F. from the thermostat or control setpoint during the tests. Outside temperature and humidity shall also be recorded during the testing periods.
- U. At the time of final inspection, the TAB agency may be required to recheck, in the presence of the Owner's representative, specific or random selections of data recorded in the certified report. Points and areas for recheck shall be selected by the Owner's representative. Measurements and test procedures shall be the same as approved for the initial work for the certified report. Selections for recheck, specific plus random, will not exceed 10% of the total number tabulated in the report.
- V. The TAB agency shall test and adjust fume hood total air flow by duct pitot-tube traverse. If a pitot-tube traverse is not practical, an explanation of why a traverse was not made must appear on the appropriate data sheet. Test and record face velocities under design operating conditions using a maximum of a one square foot grid pattern across the entire open face. The TAB agency shall set sash height on hoods to obtain face velocities within 20% of 100 feet per minute unless specified otherwise. It shall test and adjust VAV controllers to obtain design exhaust air flows and make-up air flows to maintain design hood pressures and face velocities, and design room pressurization. The TAB agency shall test for turbulence and proper air flow patterns at the face and inside the hoods using a hand-held smoke puffer or other approved smoke-emitting device.
- W. The TAB agency shall test and adjust building/zone pressurization by setting the design flows to meet the required flow direction and pressure differential. For positive pressure areas, it shall set the supply air to design flow, and gradually reduce the exhaust air rate to obtain the required flow or pressure difference. For negative pressure areas, it shall set the supply air to design flow, and gradually increase the exhaust air rate to obtain the required flow or pressure difference.
- X. The TAB agency shall test and record life safety control operation on the HVAC equipment. It shall verify the installation of required smoke detectors in air handling equipment (AHE), and shall verify operation of the smoke detector by activating the smoke detector and observing air handler shut-down. With the controls and alarm contractors, the TAB agency shall verify the operation of interconnected systems such as the AHE smoke detector's activation of the fire alarm system and the alarm system's activation of the life safety control sequences.

END OF SECTION



TISBURY SCHOOL  
VINEYARD HAVEN, MA

TAPPÉ ARCHITECTS, INC.  
BID SET – JUNE 6, 2022

SECTION 26 00 00

ELECTRICAL

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SECTION 26 00 00

ELECTRICAL

(Filed Sub-Bid Required as Part of Section 26 00 00)

PART 1 – GENERAL

1.1 GENERAL PROVISIONS

A. Filed Sub-Bid Requirements: As provided under Section 26 00 00 – ELECTRICAL FILED SUB-BID REQUIREMENTS and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 – GENERAL REQUIREMENTS.

1. Work of this Filed Sub-Bid includes all individual Specification Sections listed in Section 26 00 00

B. Time, Manner and Requirements for Submitting Sub-Bids:

1. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the Awarding Authority at a time and place as stipulated in the "Instructions to Bidders".

The following should appear on the upper left hand corner of the envelope:

NAME OF SUB-BIDDER: (Insert name of sub-bidder)

SUB-BID FOR SECTION: 26 00 00– ELECTRICAL

2. Each sub-bid submitted for work under this Section shall be on forms furnished by the Awarding Authority as required by Section 44F of Chapter 149 of the General Laws, as amended.

3. Sub-bids filed with the Awarding Authority shall be accompanied by BID BOND or CASH or CERTIFIED CHECK or TREASURER'S CHECK or CASHIER'S CHECK issued by a responsible bank or trust company payable to the Town of Tisbury in the amount of five percent of the sub-bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

C. Sub Sub-Bid Requirements:

27 01 00 Structured Cabling System  
27 41 16 Audio-Video Communications System  
27 50 00 Distributed Communications System  
28 00 00 Integrated Security System  
Lightning Protection

D. Reference Drawings: The Work of this Filed Sub-Bid is shown on the Contract Drawings indicated in the Drawing Matrix in Document 00 01 15 List of Drawings which is hereby made a part of this Section of the Specifications.

1.2 SCOPE OF WORK

A. The scope of work consists of the installation of all materials to be furnished under this

Section, and without limiting the generality thereof, consists of furnishing all labor, materials, equipment, plant, transportation, rigging, staging, scaffolding, appurtenances, programming, software, vendor inspections, component energization, startup testing, training, scheduling, documentation, and services necessary and/or incidental to properly complete all electrical work as shown on the Drawings, as described in the Specifications, or as reasonably inferred from either, in the opinion of the Architect as being required.

B. The work of this Section includes:

1. Access Panels.
2. Building Preparation for Communications Systems.
3. Building Preparation for Electronic Safety and Security Systems.
4. Building Preparation for Theatre and Stage Equipment.
5. Cable Tray.
6. Conduit.
7. Cord Reels.
8. Disconnect Switches.
9. Distributed Digital Lighting Control System.
10. Dry-type K-Rated Transformers.
11. Dry-type Transformers.
12. Electrical Supporting Devices.
13. Electrical Switchboard.
14. Electric Service.
15. Emergency Standby System.
16. External Telephone Service.
17. External Cable TV Service.
18. Fans (Destratification).
19. Fire Alarm System and Mass Notification System.
20. Fire Stopping.
21. Floor Boxes.
22. Fuses.
23. Grounding.
24. Lighting Fixtures.
25. Lightning Protection.
26. Mineral Insulated Metal Sheathed Cable (MI Cable).
27. Nameplates.
28. Outlet Boxes and Accessories.
29. Panelboards.
30. Poke-Thrus.
31. Public Safety Booster System.
32. Pull Boxes, Junction Boxes and Wireways.
33. Short Circuit Coordination Selective Coordination Study.
34. Sleeves, Inserts and Supports.
35. Starters.
36. Surge Protection Devices (SPD's).
37. Telephone, Data, Video Outlet and Conduit System.
38. Thermal Switches.
39. Wire and Cable.
40. Wiring Device Plates.
41. Wiring Devices.
42. Zero Sequence Harmonic Filters.
43. Alternates.
44. Furnish, erect and maintain staging and scaffolding, including electrical hoisting and rigging equipment required for the performance of the electrical work.

- C. The Electrical Subcontractor shall be responsible for all cutting related to the work of this Section except in finished surfaces. Patching is the responsibility of the trade effected.
  - 1. For coordination of cutting and patching refer to Section 01 31 00, Project Management and Coordination.
  - 2. For cutting and patching Specifications, refer to Section 01 73 29, Execution.

### 1.3 CODES, REGULATIONS AND PERMITS

- A. All work done under this Section shall conform to the Codes and regulations governing such work as follows:
  - 1. ANSI American National Standards Institution
  - 2. ASTM American Society for Testing Materials
  - 3. CS Commercial Standards
  - 4. FS Federal Specifications
  - 5. IEEE Institute of Electrical and Electronic Engineers
  - 6. IES Illuminating Engineering Society
  - 7. NEC National Electrical Code
  - 8. Massachusetts Electrical Code
  - 9. NECA National Electrical Contractors Association
  - 10. NEMA National Electrical Manufacturer's Association
  - 11. NFPA National Fire Protection Association
  - 12. UL Underwriters Laboratory
  - 13. NESC National Electrical Safety Code
  - 14. IPCEA Insulated Power Cable Engineers Association
  - 15. EEI Edison Electrical Institute
  - 16. EIA Electronic Industry Association
  - 17. All Local Governing Codes.
  - 18. NETA, National Electrical Testing Association.
- B. Give notices, file plans, obtain and pay for permits and licenses and obtain necessary approvals from authorities having jurisdiction. Permits shall be secured through the City. Deliver certificates of inspection to Architect. No work shall be covered before examination and approval by Architect, inspectors and authorities having jurisdiction. Imperfect or condemned work shall be replaced with work conforming to requirements, without extra cost to Owner, subject to the approval of the Architect. If work is covered before due inspection and approval, the Electrical Subcontractor shall pay costs of uncovering the installed work, whether it meets contract requirements or not. Refer to Section 00 21 13 Instruction to Bidders and General Conditions Contract for Construction Services for payment of fees.

### 1.4 DEBRIS REMOVAL AND CLEAN-UP

- A. The Electrical Subcontractor shall, at the end of each day's work, remove waste materials and debris resulting from the installation of the electrical system. The Electrical Subcontractor shall deposit such waste and debris in a dumpster on site. Dumpster shall be provided by the General Contractor. The General Contractor shall be responsible for the emptying of dumpster when required.
- B. The Electrical Subcontractor shall, at the completion of his work, remove from the property all tools, equipment and surplus materials resulting from the installation of the electrical system.

## 1.5 DEFINITIONS

- A. "E.C." or "Contractor" as used herein after in this Section shall mean the "Electrical Subcontractor," i.e., the filed bid Subcontractor under this Section 26 00 00.
- B. "Concealed" shall be defined as areas where conduit and wiring is located in chases, walls, partitions, shafts, and above finished ceilings.
- C. "Underground" shall mean conduit and wiring exterior to or within the Building that is buried. All other conduit and wiring shall be considered "exposed."
- D. "Exposed" shall mean conduit and wiring run on the surface of the Building construction.
- E. "Conduit" shall mean in addition to conduit, all fittings, hangers and other accessories relating to such conduit systems.
- F. "Provide" shall mean "provided complete in place," that is, "furnished and installed."

## 1.6 DRAWINGS AND SPECIFICATIONS

- A. The Drawings and Specifications are complementary each to the other, and any labor or material called for by either, whether or not by both, or necessary for the successful operation of any components shall be furnished and installed.
- B. Before installing any work, verify that it does not interfere with the clearances required for other work. Installed work which interferes with existing necessary services shall be modified as directed by the Architect, at no additional cost to the Owner.
- C. Be familiar with the Drawings and Specifications of all other trades to prevent interferences and assure complete coordination.

## 1.7 ELECTRICAL CHARACTERISTICS

- A. In general, and unless specifically indicated otherwise in the Specifications or noted on the Drawings, all new Building service, heating, ventilating, air conditioning and plumbing equipment shall be of the following characteristics:
  - 1. Motors up to and including 1/3 HP shall be suitable for 120 volt, single phase operation.
  - 2. Motors larger than 1/3 HP shall be suitable for 208 volt, three phase operation.

## 1.8 EXAMINATION OF SITE AND CONTRACT DOCUMENTS

- A. Bidders are advised to visit the site and inform themselves as to conditions under which this work will be performed. Failure to do so will, in no way, relieve the successful bidder from the responsibility of furnishing any materials or performing any work in accordance with the true intent and meaning of the Drawings and Specifications.
- B. No claim for extra compensation will be recognized if difficulties are encountered which an examination of the site conditions and contract documents prior to executing the contract would have revealed.
- C. The Electrical Subcontractor shall be responsible for ordering and furnishing the correct quantity of material required. Routing and equipment arrangements shown on the Drawings are approximate only and are not warranted to be accurate.

- D. Arrangements shall be made with the Owner prior to the visit for inspection of the existing Buildings.
- E. The Electrical Subcontractor and the General Contractor shall be responsible to coordinate with the work of other trades and vendors. The Electrical requirements involved with HVAC, Plumbing, and Fire Suppression, shall be considered part of the Electrical Subcontractors scope of work.

1.9 GIVING INFORMATION

- A. Keep fully informed as to the shape, size and position of all openings and foundations required for all apparatus furnished under this Section and give full information to the General Contractor sufficiently in advance of the work, so that all such openings and foundations may be built in advance. Furnish all sleeves and supports herein specified, so the General Contractor may install same in place.
- B. In the case of failure to give proper information as noted above, assume the cost of having necessary changes to the work made by the General Contractor.

1.10 GUARANTEE AND SERVICE

- A. The Electrical Subcontractor shall guarantee the performance of the installation and all equipment included in this Section in writing for one year from the date of final acceptance of same. Should any defects in materials or workmanship appear during this period, they shall be corrected or replaced by the Electrical Subcontractor to the satisfaction of the Architect, and at no additional expense to the Owner.

1.11 INTENT

- A. It is not intended that the Drawings show every conduit, fitting and appurtenance. All such parts necessary for the complete execution of the work, in accordance with the best practices of the trade and to the satisfaction of the Architect shall be provided whether these parts may have been specifically mentioned or not, or indicated on the Drawings.
- B. Electrical Subcontractor is responsible to provide equipment, components, and systems that are complete and fully working, with all necessary tests and documents.

1.12 MATERIALS AND EQUIPMENT

- A. All materials and equipment furnished under this Section shall be new and of the best grade for the service intended. The manufacturers mentioned in the Specifications are intended to indicate the quality desired. Any substitutions shall be approved by the Architect as herein provided by the "or equal" clause, in addition to meeting the limitations of space and capacity shown or specified. Re-built materials and equipment will not be accepted.

1.13 OBTAINING INFORMATION

- A. Obtain detailed information from the manufacturers of apparatus which is to be provided, for the proper methods of installation. Obtain all information from the General Contractor and other Subcontractors which may be necessary to facilitate the work and the completion of the whole project.
- B. Electrical Subcontractor shall inspect the site associated with this project prior to submitting



his bid and shall investigate all conditions under which this work will be performed. This shall include determination of exact locations of items indicated as existing on the Drawings. Such existing locations are diagrammatic and shall not be construed as exact enough to use for equipment and labor estimating purposes. Failure to inspect existing conditions or to fully understand the work which is required shall not excuse the Electrical Subcontractor from his obligation to supply and install work in accordance with the Specifications and Drawings and under all existing site conditions. It shall be the responsibility of the Electrical Subcontractor to investigate and locate all existing underground utilities which may conflict with the installation of this electrical work. Coordinate elevations of conduits required to be installed under this Contract to avoid interference with any existing underground utilities.

#### 1.14 OPERATIONS AND MAINTENANCE MANUALS

- A. At least two (2) months prior to the time of turning over this contract to the Owner for use and occupancy or substantial completion, secure and deliver to the Architect three (3) complete indexed files containing approved operating and maintenance manuals, Shop Drawings and other data as follows:
  - 1. Operation description of all systems.
  - 2. Complete Shop Drawings of all equipment.
  - 3. Preventive maintenance instructions for all systems.
  - 4. Spare parts lists of all system components.
  - 5. Names, addresses and telephone numbers of all suppliers of the systems.
- B. Non-availability of operating and maintenance manuals or inaccuracies therein may be grounds for cancellation and postponement of any scheduled final inspection by the Owner until such time as the discrepancy has been corrected and/or retainage of sufficient monies to prepare same.
- C. Provide qualified trained personnel to insure proper operation of the systems and to train the Owner's operating and maintenance personnel in the proper operation and maintenance of the systems. Instruction period shall be five (5) eight-hour days.
  - 1. Training of the Tenant's and Building Owner's operation and maintenance personnel is required in cooperation with the Tenant's and Building Owner's Representatives. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Tenant's and Building Owner's Representative after submission and approval of formal training plans.

#### 1.15 RECORD DRAWINGS

- A. General: Refer to Division 1, General Requirements, Section 01 77 00, Closeout Submittals for Requirements.
- B. The Record Drawings required to be furnished under this Section are of the "E" and "T" Series Drawings.

#### 1.16 RELATED WORK SPECIFIED ELSEWHERE

- A. The following related work or material shall be provided under the designated Divisions:
  - 1. Excavation, backfill, pumping, and shoring: Division 31, "Earthwork."
  - 2. Concrete work: Division 03, "Concrete."
  - 3. Flashing and counterflashing for all roof openings: Division 07, "Thermal and Moisture Protection."

4. Field Painting: Division 09, "Finishes."
5. Specialty Equipment: Division 11, "Equipment."
6. Elevator: Division 14, "Conveying Systems."
7. Sprinkler System: Section 21 00 00, "Fire Suppression."
8. Plumbing Equipment: Section 22 00 00, "Plumbing."
9. HVAC Equipment: Section 23 00 00, "HVAC."
10. Door Hardware: Section 08 71 10.
11. For restrictions concerning the hanging of materials, piping, mounts, brackets, hangers, hooks and other items from metal decking. Steel Decking, Section 05 31 00.

#### 1.17 SHOP DRAWINGS

- A. General: Refer to Division 1, General Requirements, Section 01 33 00, Submittal Procedures, for submittal provisions and procedures.
- B. In accordance with Division 1, General Requirements, submit to the Architect for approval complete sets of detailed information consisting of manufacturer's bulletins, capacities, Shop Drawings, and parts lists of all material to be provided for this project.
- C. Any 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 unless otherwise noted and it should be noted that or approved 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 approved equal. It is the intent of this Specification to encourage open and competitive involvement from multiple manufacturers' that are able to supply similar products.

#### 1.18 TEMPORARY LIGHT AND POWER

- A. Provide capacity from the local utility company power lines, make arrangements with the local utility company for temporary service and pay all expenses related thereto.
- B. Refer to Division 1, Section 01 50 00 for requirements.

### PART 2 - PRODUCTS

#### 2.1 ACCESS PANELS

- A. 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.
- B. Access panels shall be located in a workmanlike manner in closets, storage rooms, and/or other non-public areas, positioned so that junction can be easily reached and size shall be sufficient for purpose (minimum size 12" x 16"). When access panels are required in corridors, lobbies, or other habitable areas, they shall be located as directed by the Architect.
- C. Access panels shall be as specified under Section 08 31 00, Access Panels and Doors.

#### 2.2 BUILDING PREPARATION FOR COMMUNICATIONS SYSTEMS

- A. The Electrical Subcontractor shall be responsible for properly preparing the project for

installation by the Communications Integrator, Section 27 01 00, 27 41 16, 27 50 00, and as specified.

- B. Responsibilities of the Electrical Subcontractor shall include: The Electrical Subcontractor shall be responsible for providing and installing all related Building preparation including, but not limited to: outlet boxes with plaster rings, floor boxes, poke through devices, pathways, power, cableways, J hooks, cable tray including cable tray over each rack and cabinet to facilitate a neat and orderly installation of cables, cable protection, wiremold, surface raceways, cable supports, conduits with bushings, conduit stubs with bushings. Sleeves with bushings (all conduits, stubs, and sleeves, shall be brought to an accessible hallway ceiling or accessible area below floor), backboxes, plaster rings, pull strings, bonding, grounding, core drilling, cutting, patching, fireproofing of penetrations and openings, environmental seals, smoke and fire stopping seals including all conduits, raceways, sleeves, and slots, where cables pass from one location to another, removal and re-installation of ceiling tiles to install concealed cabling, seismic supports, supplementary steel and channels, for a completely operational system as specified. The Electrical Subcontractor shall also accept delivery and properly store and secure all equipment and materials required by the systems integrator. The Electrical Subcontractor shall install all specialized backboxes (clock, speaker, and amplifier) and any exterior antennas provided by the Systems Integrator.
1. The Electrical Subcontractor shall be responsible for providing and installing: conduits from each IDF location back to the MDF location to comply with Code for applicable sound, voice, data and video cabling: conduits from the Point of Demarcation to the MDF location to comply with Code for applicable sound, voice, data and video cabling: conduits from the Video Headend location back to the MDF location to comply with Code for applicable video cabling.
- C. Responsibilities of the Communications Integrator for this Section: The Communications Integrator 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 Communications Integrator shall furnish all specialized backboxes (clock, speaker, and amplifier) and all exterior antennas to the Electrical Subcontractor for their installation.

### 2.3 BUILDING PREPARATION FOR ELECTRONIC SAFETY AND SECURITY SYSTEMS

- A. The Electrical Subcontractor shall be responsible for properly preparing the project for installation by the Electronic Safety and Security Integrator, Section 28 00 00 as specified.
- B. Responsibilities of the Electrical Subcontractor shall include: The Electrical Subcontractor shall be responsible for providing and installing all related Building preparation including, but not limited to: outlet boxes, pathways, power, cableways and J hooks to facilitate a neat and orderly installation of cables, cable protection, surface raceways, cable supports, conduits with bushings, conduit stubs with bushings. Sleeves with bushings (all conduits, stubs, and sleeves shall be brought to an accessible hallway ceiling or accessible area below floor), backboxes, pull strings, bonding, grounding, core drilling, cutting, patching, fireproofing of penetrations and openings, environmental seals, smoke and fire stopping seals including all conduits, raceways, sleeves, and slots where cables pass from one location to another, removal and re-installation of ceiling tiles to install concealed cabling, seismic supports, supplementary steel and channels, for a completely operational system as specified. The Electrical Subcontractor shall also accept delivery and properly store and secure all equipment and materials required by the Systems Integrator. The Electrical Subcontractor shall install all specialized backboxes.

- C. Responsibilities of the Electronic Safety and Security Integrator for this Section: The Electronic Safety and Security Integrator shall be responsible for providing, installing, programming, troubleshooting, training and warranty service of all cabling and equipment specified in this Section for a completely operational system. The Electronic Safety and Security Integrator shall furnish all specialized backboxes to the Electrical Subcontractor for their installation.

#### 2.4 BUILDING PREPARATION FOR THEATRE AND STAGE EQUIPMENT

- A. The Electrical Subcontractor shall be responsible for the following:
  - 1. Install theatrical lighting equipment as furnished by Section 11 61 00.
  - 2. Provide all wiring and conduit to connect all theatrical lighting equipment as furnished by Section 11 61 00.
- B. The Electrical Subcontractor shall be responsible for properly preparing the project for installation by the Theatre and Stage Equipment Integrator, Section 11 61 00 as specified.
  - 1. Responsibilities of the Electrical Subcontractor shall include: The Electrical Subcontractor shall be responsible for providing and installing all related Building preparation including, but not limited to: outlet boxes, pathways, power, cableways and J hooks to facilitate a neat and orderly installation of cables, cable protection, surface raceways, cable supports, conduits with bushings, conduit stubs with bushings. Sleeves with bushings (all conduits, stubs, and sleeves, shall be brought to an accessible hallway ceiling or accessible area below floor), back boxes, pull strings, bonding, grounding, core drilling, cutting, patching, fireproofing of penetrations and openings, environmental seals, smoke and fire stopping seals including all conduits, raceways, sleeves, and slots, where cables pass from one location to another, removal and re-installation of ceiling tiles to install concealed cabling, seismic supports, supplementary steel and channels, for a completely operational system as specified. The Electrical Subcontractor shall also accept delivery and properly store and secure all equipment and materials required by the Theatre and Stage Equipment Integrator. The Electrical Subcontractor shall install all specialized back boxes.

#### 2.5 CABLE TRAY

- A. Conform to NEMA VE1.
- B. Ladder Type Cable Trays:
  - 1. Material: Aluminum 6036-T6 alloy.
  - 2. Width: 20 inches overall.
  - 3. Inside depth: 6 inches.
  - 4. Cross rung spacing: 9 inches.
  - 5. Minimum fitting radius: 24 inches.
  - 6. Design Load: Provide tray capable of supporting 50 pounds per linear foot, when supported on 12 foot centers.
  - 7. Hangers: 1/2 inch diameter threaded steel rods; furnish with pair of 1/2 inch nut and washers for each rod. Rods shall be supported from the structural floor above, independent of furred or suspended ceilings, unless otherwise noted.
- C. Cable Tray Accessories
  - 1. Fittings: Furnish tees, crosses, risers, elbows, and other fittings as indicated, manufactured with the same materials and finishes as the cable trays.
  - 2. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

## 2.6 CONDUIT

- A. Electric metallic tubing shall be electrogalvanized or sherardized steel and the rigid steel conduit shall be hot-dipped galvanized or sherardized, inside and outside, manufactured by one of the following: Pittsburgh Standard, Republic Steel Corp., Allied Tube and Conduit Corp. or equal.
- B. Flexible metal conduit shall be galvanized steel and shall contain a separate copper grounding conductor. Liquid-tight flexible metal conduit shall be similar, but shall also have an extruded moisture and oil proof outer jacket of polyvinyl chloride plastic.
- C. Non-Metallic Conduit (NMC): Rigid polyvinyl chloride (PVC) shall be Schedule 40, rated for use with 90 degree conductors, UL rated or approved equal, conforming to industry standards and NEMA TC-2, NEMA TC-3, Fed. Spec. W-C-1094, and UL 651.
- D. Rigid steel conduit fittings, couplings and connectors shall be threaded and shall be galvanized or cadmium plated. Conduit fittings and outlet boxes shall be held in place by fittings of a type approved by the Architect. Steel supports or racks shall be galvanized steel channel and fittings, Unistrut, Kindorf or Husky Products Company, or equal.
- E. Couplings and connectors for electric metallic tubing shall be galvanized steel of the compression type other than the identer type and with insulated throat or set-screw type.
- F. Steel support rods or support bolts for conduits shall be 1/8" diameter for each inch or fraction thereof of diameter of conduit size, but no rod or bolt shall be less than 1/4" in diameter.
- G. Conduit shall be supported from the Building structure, and shall be independent of ducts, pipes, ceilings and their supporting members.

## 2.7 CORD REELS

- A. References:
  - 1. American National Standards Institute (ANSI)/ Underwriters Laboratories Inc. (UL), ANSI/UL 355-2016.
  - 2. CSA Group (CSA), CSA C22.2 No 21-2018 – Cord Sets and Power Supply Cords.
- B. Basis of design for the Cord Reels is based on products manufactured by Hubbell Wiring Device Kellems, or equal.
- C. Cord Reels shall be listed and labeled by a qualified agency and marked for intended location and application.
- D. Industrial Cord Reels:
  - 1. Industrial Cord Reels shall be provided with minimum 45 foot cable rated for 20 amperes 600V with required phase conductors, neutral, and equipment grounding conductor. Reels shall be constructed of powder coated cast aluminum.
  - 2. Cord Reels shall have a movable guide arm that can be mounted in two positions, positive latch mechanism automatically maintains desired cord lengths, ratchet lock that can be disengaged in field for constant tension applications.
  - 3. Cord Reels conductor size shall be 12 AWG, unless otherwise indicated.
  - 4. Cord Reels shall be Hubbell HBLI45123R220M1, or equal.

- E. Accessories:
  - 1. Manufacturer shall provide a full line of accessories to include and not be limited to cord sets, receptacles, and housings. Provide double duplex receptacles on ends of cord reels.
  - 2. Manufacturer shall provide cable strain relief connectors that accommodate the cable range for the Cord Reels.
  - 3. Mounting brackets shall be available that will attach to the structural supports and allow quick and easy installation. The support shall be equal to Hubbell wiring device inREACH mounting bracket.
- F. Examine conditions in which the Cord Reels are to be installed. Notify the respected managing construction parties in writing of any conditions that will be detrimental in the proper installation of the Cord Reels.
- G. Color of Cord Reels shall be white, unless otherwise indicated.

## 2.8 DISCONNECT SWITCHES

- A. The Electrical Subcontractor shall furnish and install disconnecting means to comply with the National Electrical Code for all motors. Disconnect switches shall be fused or unfused as shown on the Drawings, NEMA Type HD safety switches for heavy duty, with interlocking cover, side operated with provisions for padlocking the switch handle in the off position.
- B. All motor isolating switches indicated on the Drawings shall be rated in horsepower, and shall be rated for the voltage of the motor and shall be furnished and installed at the motor location whether or not the motor is within sight of the motor feeder disconnecting means.
- C. Disconnect switch enclosures shall be of the proper NEMA type for the intended location as defined by NEMA and shall be phosphate coated or equivalent code gauge galvanized sheet steel with USAFI No. 24 dark gray baked enamel finish.
- D. Disconnect switches shall bear the Underwriters' Laboratories label and be manufactured by Square D Company, Eaton/Cutler-Hammer, Siemens, or equal.

## 2.9 DISTRIBUTED DIGITAL LIGHTING CONTROL SYSTEM

- A. Part 1 – General
  - 1. Summary
    - a. Section Includes:
      - 1) Digital Lighting and Plug Load Controls
      - 2) Relay Panels
      - 3) Emergency Lighting Control
    - b. Related Sections:
      - 1) Wiring Devices
      - 2) Lighting Fixtures
      - 3) Building integrator shall provide integration of the lighting control system with Building Automation Systems.
      - 4) Drawings and general provision of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections apply to this Section
      - 5) Electrical Sections, including wiring devices, apply to the work of this Section.
    - c. Control Intent – Control Intent includes, but is not limited to:

- 1) Defaults and initial calibration settings for such items as time delay, sensitivity, and fade rates.
  - 2) Initial sensor and switching zones
  - 3) Initial time switch settings
  - 4) Emergency Lighting Control
2. References
- a. American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE)
  - b. International Electrotechnical Commission (IEC)
  - c. International Organization for Standardization (ISO)
  - d. National Electrical Manufacturers Association (NEMA)
  - e. WD1 (R2005) - General Color Requirements for Wiring Devices.
  - f. Underwriters Laboratories, Inc. (UL)
    - 1) 20 – Plug Load Controls
    - 2) 508– Industrial Controls
    - 3) 916 – Energy Management Equipment.
    - 4) 924 – Emergency Lighting
3. System Description and Operation
- a. The Lighting Control and Automation system as defined under this section covers the following equipment:
    - 1) Digital Occupancy Sensors – Self-configuring, digitally addressable and calibrated occupancy sensors with LCD display and two-way active infrared (IR) communications.
    - 2) Digital Switches – Self-configuring, digitally addressable pushbutton on/off, dimming, and scene switches with two-way active infrared (IR) communications.
    - 3) Handheld remotes for personal control – One-button dimming, two-button on/off, or five-button scene remotes provide control using infrared communications. Remote may be configured in the field to control selected loads or scenes without special tools.
    - 4) Digital Daylighting Sensors – Single-zone closed loop, multi-zone open loop and single-zone dual-loop daylighting sensors with two-way active infrared (IR) communications can provide switching, bi-level, tri-level or dimming control for daylight harvesting.
    - 5) Digital Room Controllers – Self-configuring, digitally addressable one, two or three relay plenum-rated controllers for on/off control. Selected models include 0-10 volt or line voltage forward phase control dimming outputs and integral current monitoring capabilities.
    - 6) Digital Plug-Load Controllers – Self-configuring, digitally addressable, single relay, plenum-rated application-specific controllers. Selected models include integral current monitoring capabilities.
    - 7) Configuration Tools – Handheld remote for room configuration and relay panel programming provides two way infrared (IR) communications to digital devices and allows complete configuration and reconfiguration of the device / room from up to 30 feet away. Unit to have Organic LED display, simple pushbutton interface, and allow bi-directional communication of room variables and occupancy sensor settings. Computer software also customizes room settings.
    - 8) Digital Lighting Management (DLM) local network – Free topology, plug-in wiring system (Cat 5e) for power and data to room devices.
    - 9) Digital Lighting Management (DLM) segment network – Linear

- topology, BACnet MS/TP network (1.5 twisted pair, shielded,) to connect multiple DLM local networks for centralized control
- 10) Network Bridge – Provides BACnet MS/TP-compliant digital networked communication between rooms, panels and the Segment Manager or building automation system (BAS) and automatically creates BACnet objects representative of connected devices.
  - 11) Segment Manager – Provides web browser-based user interface for system control, scheduling, power monitoring, room device parameter administration and reporting.
  - 12) Programming and Configuration Software – Optional PC-native application capable of accessing DLM control parameters within a room, for the local network, via a USB adapter, or globally, for many segment networks simultaneously, via BACnet/IP communication.
  - 13) LMCP Digital Lighting Management Relay Panel – Provides up to 8, 24, or 48 mechanically latching relays. Relays include a manual override and a single push-on connector for easy installation or removal from the panel. Panel accepts program changes from handheld configuration tool for date and time, location, holidays, event scheduling, button binding and group programming. Provides BACnet MS/TP-compliant digital networked communication between other lighting controls and/or building automation system (BAS).
  - 14) Emergency Lighting Control Unit (ELCU) – Allows a standard lighting control device to control emergency lighting in conjunction with normal lighting in any area within a building.
4. Lighting Control Applications
- a. Unless relevant provisions of the applicable local Energy Codes are more stringent, provide a minimum application of lighting controls as follows:
    - 1) Space Control Requirements – Provide occupancy/vacancy sensors with Manual-ON functionality in all spaces except where indicated.
    - 2) Bi-Level Lighting – Provide multi-level controls where indicated.
    - 3) Task Lighting / Plug Loads – Provide automatic shut off of non essential plug loads and task lighting where indicated. Provide Automatic-ON of plug loads whenever spaces are occupied. For spaces with multiple occupants a single shut off consistent with the overhead lighting may be used for the area.
    - 4) Daylit Areas – Provide daylight-responsive automatic control where indicated.
      - a) All luminaires within code-defined daylight zones shall be controlled separately from luminaires outside of daylight zones.
      - b) Daytime setpoints for total ambient illumination (combined daylight and electric light) levels that initiate dimming shall be programmed in compliance with relevant local building energy codes.
      - c) Multiple-leveled switched daylight harvesting controls may be utilized for areas marked on drawings.
      - d) Provide smooth and continuous daylight dimming for areas marked on drawings. Daylighting control system may be designed to turn off electric lighting when daylight



- is at or above required lighting levels, only if system functions to turn lamps back on at dimmed level, rather than turning full-on prior to dimming.
- 5) Where indicated controls that allow for independent control of each local control zone shall be provided. Rooms larger than 300 square feet shall instead have at least four (4) pre-set lighting scenes unless otherwise specified. Occupancy / vacancy sensors shall be provided to extinguish all lighting in the space. Spaces with up to four moveable walls shall include controls that can be reconfigured when the room is partitioned.
5. Submittals
- a. Submittals Package: Submit the shop drawings, and the product data specified below at the same time as a package.
- b. Shop Drawings:
- 1) Composite wiring and/or schematic diagram of each control circuit as proposed to be installed.
  - 2) Show exact location of all digital devices, including at minimum sensors, room controllers, and switches for each area on reflected ceiling plans. (Provide AutoCAD format reflected ceiling plans.)
  - 3) Provide room/area details including products and sequence of operation for each room or area. Illustrate typical acceptable room/area connection topologies.
  - 4) Network riser diagram including floor and building level details. Include network cable specification and end-of-line termination details, if required. Illustrate points of connection to integrated systems. Coordinate integration with mechanical and/or other trades.
- c. Product Data: Catalog sheets, specifications and installation instructions.
- d. Include data for each device which:
- 1) Indicates where sensor is proposed to be installed.
  - 2) Prove that the sensor is suitable for the proposed application.
6. Quality Assurance
- a. Manufacturer: Minimum [10] years experience in manufacture of lighting controls.
7. Project Conditions
- a. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
- 1) Ambient temperature: 0° to 40° C (32° to 104° F).
  - 2) Relative humidity: Maximum 90 percent, non-condensing.
8. Warranty
- a. Provide a five year limited manufacturer's warranty on all room control devices and panels.
- B. Part 2 – Products
1. Manufacturer
- a. Acceptable Manufacturer:
- 1) WattStopper
    - a) System: Digital Lighting Management (DLM)
  - 2) Basis of design product: WattStopper Digital Lighting Management (DLM) or subject to compliance and prior approval with specified requirements of this section, one of the following:
    - a) Lutron, Crestron, or Equal.
  - 3) Substitutions:

- a) Proposed substitutes must be accompanied by a review of the specification noting compliance on a line-by-line basis.
  - b) By using substitutions, the Electrical Subcontractor accepts responsibility and associated costs for all required modifications to circuitry, devices, and wiring. The Electrical Subcontractor shall provide complete engineered shop drawings (including power and control wiring) with deviations from the original design highlighted for review and approval prior to rough-in.
2. Digital Lighting Controls
- a. Furnish the Company's system which accommodates the square-footage coverage requirements for each area controlled, utilizing room controllers, digital occupancy sensors, switches, daylighting sensors and accessories which suit the lighting and electrical system parameters.
3. Digital Wall Switch Occupancy Sensors
- a. Wallbox mounted passive infrared PIR or dual technology (passive infrared and ultrasonic) digital occupancy sensor with 1 or 2 switch buttons.
  - b. Digital Occupancy Sensors shall provide scrolling LCD display for digital calibration and electronic documentation. Features include the following:
    - 1) Digital calibration and pushbutton configuration for the following variables:
      - a) Sensitivity – 0-100% in 10% increments
      - b) Time delay – 1-30 minutes in 1 minute increments
      - c) Test mode – Five second time delay
      - d) Detection technology – PIR, Dual Technology activation and/or re-activation.
      - e) Walk-through mode
      - f) Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the DLM local network.
    - 2) Programmable control functionality including:
      - a) Each sensor may be programmed to control specific loads within a local network.
      - b) Sensor shall be capable of activating one of 16 user-definable lighting scenes.
      - c) Adjustable retrigger time period for manual-on loads. Load will retrigger (turn on) automatically during the configurable period of time (default 10 seconds) after turning off.
      - d) On dual technology sensors, independently configurable trigger modes are available for both Normal (NH) and After Hours (AH) time periods. The retrigger mode can be programmed to use the following technologies:
        - i. Ultrasonic and Passive Infrared
        - ii. Ultrasonic or Passive Infrared
        - iii. Ultrasonic only
        - iv. Passive Infrared only
    - 3) Independently configurable sensitivity settings for passive infrared and ultrasonic technologies (on dual technology sensors) for both Normal (NH) and After Hour (AH) time periods.
    - 4) Two RJ-45 ports for connection to DLM local network.
    - 5) Two-way infrared (IR) transceiver to allow remote programming

- through handheld configuration tool and control by remote personal controls.
- 6) Device Status LEDs including:
    - a) PIR detection
    - b) Ultrasonic detection
    - c) Configuration mode
    - d) Load binding
  - 7) Assignment of occupancy sensor to a specific load within the room without wiring or special tools.
  - 8) Assignment of local buttons to specific loads within the room without wiring or special tools.
  - 9) Manual override of controlled loads.
  - 10) All digital parameter data programmed into an individual wall switch sensor shall be retained in non-volatile FLASH memory within the wall switch sensor itself. Memory shall have an expected life of no less than 10 years.
- c. BACnet object information shall be available for the following objects:
- 1) Detection state
  - 2) Occupancy sensor time delay
  - 3) Occupancy sensor sensitivity, PIR and Ultrasonic
  - 4) Button state
  - 5) Switch lock control
  - 6) Switch lock status
- d. Units shall not have any dip switches or potentiometers for field settings.
- e. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required.
- f. Two-button wall switch occupancy sensors, when connected to a single relay dimming room controller, shall operate in the following sequence as a factory default:
- 1) Left button
    - a) Press and release - Turn load on
    - b) Press and hold - Raise dimming load
  - 2) Right button
    - a) Press and release - Turn load off
    - b) Press and hold - Lower dimming load
- g. Low voltage momentary pushbuttons shall include the following features:
- 1) Load/Scene Status LED on each switch button with the following characteristics:
    - a) Bi-level LED
    - b) Dim locator level indicates power to switch
    - c) Bright status level indicates that load or scene is active
- h. The following button attributes may be changed or selected using a wireless configuration tool:
- 1) Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
  - 2) Individual button function may be configured to Toggle, On only or Off only.
  - 3) Individual scenes may be locked to prevent unauthorized change.
  - 4) Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.
  - 5) Ramp rate may be adjusted for each dimmer switch.
  - 6) Switch buttons may be bound to any load on a room controller

- and are not load type dependent; each button may be bound to multiple loads.
- i. WattStopper part numbers: LMPW, LMDW. Available in white, light almond, ivory, grey, red and black; compatible with wall plates with decorator opening.
4. Digital Wall or Ceiling Mounted Occupancy Sensor
- a. Wall or ceiling mounted (to suit installation) passive infrared (PIR), ultrasonic or dual technology digital (passive infrared and ultrasonic) occupancy sensor.
  - b. Digital Occupancy Sensors shall provide graphic LCD display for digital calibration and electronic documentation. Features include the following:
    - 1) Digital calibration and pushbutton configuration for the following variables:
      - a) Sensitivity – 0-100% in 10% increments
      - b) Time delay – 1-30 minutes in 1 minute increments
      - c) Test mode – Five second time delay
      - d) Detection technology – PIR, Ultrasonic or Dual Technology activation and/or re-activation.
      - e) Walk-through mode
    - 2) Load parameters including Auto/Manual-ON, blink warning, and daylight enable/disable when photosensors are included in the DLM local network.
    - 3) Programmable control functionality including:
      - a) Each sensor may be programmed to control specific loads within a local network.
      - b) Sensor shall be capable of activating one of 16 user-definable lighting scenes.
      - c) Adjustable retrigger time period for manual-on loads. Load will retrigger (turn on) automatically within a configurable period of time (default 10 seconds) after turning off.
      - d) On dual technology sensors, independently configurable trigger modes are available for both Normal (NH) and After Hours (AH) time periods. The retrigger mode can be programmed to use the following technologies:
        - i. Ultrasonic and Passive Infrared
        - ii. Ultrasonic or Passive Infrared
        - iii. Ultrasonic only
        - iv. Passive Infrared only
        - v. Independently configurable sensitivity settings for passive infrared and ultrasonic technologies (on dual technology sensors) for both Normal (NH) and After Hour (AH) time periods.
    - 4) One or two RJ-45 port(s) for connection to DLM local network.
    - 5) Two-way infrared (IR) transceiver to allow remote programming through handheld commissioning tool and control by remote personal controls.
    - 6) Device Status LEDs, which may be disabled for selected applications, including:
      - a) PIR detection
      - b) Ultrasonic detection
      - c) Configuration mode

- d) Load binding
  - 7) Assignment of occupancy sensor to a specific load within the room without wiring or special tools.
  - 8) Manual override of controlled loads.
  - 9) All digital parameter data programmed into an individual occupancy sensor shall be retained in non-volatile FLASH memory within the sensor itself. Memory shall have an expected life of no less than 10 years.
  - c. BACnet object information shall be available for the following objects:
    - 1) Detection state
    - 2) Occupancy sensor time delay
    - 3) Occupancy sensor sensitivity, PIR and Ultrasonic
  - d. Units shall not have any dip switches or potentiometers for field settings.
  - e. Multiple occupancy sensors may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration will be required.
  - f. WattStopper product numbers: LMPX, LMDX, LMPC, LMUC, LMDC
5. Digital Wall Switches
- a. Low voltage momentary pushbutton switches in 1, 2, 3, 4, 5 and 8 button configuration. Wall switches shall include the following features:
    - 1) Two-way infrared (IR) transceiver for use with personal and configuration remote controls.
    - 2) Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
    - 3) Configuration LED on each switch that blinks to indicate data transmission.
    - 4) Load/Scene Status LED on each switch button with the following characteristics:
      - a) Bi-level LED
      - b) Dim locator level indicates power to switch
      - c) Bright status level indicates that load or scene is active
      - d) Dimming switches shall include seven bi-level LEDs to indicate load levels using 14 steps.
    - 5) Programmable control functionality including:
      - a) Button priority may be configured to any BACnet priority level, from 1-16, corresponding to networked operation allowing local actions to utilize life safety priority
      - b) Scene patterns may be saved to any button other than dimming rockers. Once set, buttons may be digitally locked to prevent overwriting of the preset levels.
    - 6) All digital parameter data programmed into an individual wall switch shall be retained in non-volatile FLASH memory within the wall switch itself. Memory shall have an expected life of no less than 10 years.
  - b. BACnet object information shall be available for the following objects:
    - 1) Button state
    - 2) Switch lock control
    - 3) Switch lock status
  - c. Two RJ-45 ports for connection to DLM local network.
  - d. Multiple digital wall switches may be installed in a room by simply connecting them to the free topology DLM local network. No additional configuration shall be required to achieve multi-way switching.
  - e. The following switch attributes may be changed or selected using a

- wireless configuration tool:
- 1) Load and Scene button function may be reconfigured for individual buttons (from Load to Scene, and vice versa).
  - 2) Individual button function may be configured to Toggle, On only or Off only.
  - 3) Individual scenes may be locked to prevent unauthorized change.
  - 4) Fade Up and Fade Down times for individual scenes may be adjusted from 0 seconds to 18 hours.
  - 5) Ramp rate may be adjusted for each dimmer switch.
  - 6) Switch buttons may be bound to any load on a room controller and are not load type dependent; each button may be bound to multiple loads.
  - 7) WattStopper product numbers: LMSW-101, LMSW-102, LMSW-103, LMSW-104, LMSW-105, LMSW-108, LMDM-101. Available in white, light almond, ivory, grey, red and black; compatible with wall plates with decorator opening.
6. DLM Handheld User Interface Remotes
- a. Battery-operated handheld devices in 1, 2 and 5 button configurations for remote switching or dimming control. Remote controls shall include the following features:
    - 1) Two-way infrared (IR) transceiver for line of sight communication with DLM local network within up to 30 feet.
    - 2) LED on each button confirms button press.
    - 3) Load buttons may be bound to any load on a room controller and are not load type dependent; each button may be bound to multiple loads.
    - 4) Inactivity timeout to save battery life.
  - b. A wall mount holster and mounting hardware shall be included with each remote control
  - c. WattStopper part numbers: LMRH-101, LMRH-102, LMRH-105.
7. Digital Partition Controls
- a. Partition controls shall enable manual or automatic coordination of lighting controls in flexible spaces with up to four moveable walls by reconfiguring the connected digital switches and occupancy sensors.
  - b. Four-button low voltage pushbutton switch for manual control.
    - 1) Two-way infrared (IR) transceiver for use with configuration remote control.
    - 2) Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
    - 3) Configuration LED on each switch that blinks to indicate data transmission.
    - 4) Each button represents one wall; Green button LED indicates status.
    - 5) Two RJ-45 ports for connection to DLM local network.
    - 6) WattStopper part number: LMPS-104. Available in white, light almond, ivory, grey and black; compatible with wall plates with decorator opening.
  - c. Contact closure interface for automatic control via input from limit switches on movable walls (by others).
    - 1) Operates on Class 2 power supplied by DLM local network.
    - 2) Includes 24VDC output and four input terminals for maintained third party contact closure inputs.
    - 3) Input max. sink/source current: 1-5mA

- a) Logic input signal voltage High: >18VDC
  - b) Logic input signal voltage Low: <2VDC
  - 4) Four status LEDs under hinged cover indicate if walls are open or closed; supports LMPS-104 as remote status indicator.
  - 5) Two RJ-45 ports for connection to DLM local network.
  - 6) WattStopper part number: LMIO-102
8. Digital Daylighting Sensors
- a. Digital daylighting sensors shall work with room controllers to provide automatic switching, bi-level, or tri-level or dimming daylight harvesting capabilities for any load type connected to a room controller. Daylighting sensors shall be interchangeable without the need for rewiring.
    - 1) Closed loop sensors measure the ambient light in the space and control a single lighting zone.
    - 2) Open loop sensors measure incoming daylight in the space, and are capable of controlling up to three lighting zones.
    - 3) Dual loop sensors measure both ambient and incoming daylight in the space to insure that proper light levels are maintained as changes to reflective materials are made in a single zone.
  - b. Digital daylighting sensors shall include the following features:
    - 1) The sensor's internal photodiode shall only measure lightwaves within the visible spectrum. The photodiode's spectral response curve shall closely match the entire photopic curve. The photodiode shall not measure energy in either the ultraviolet or infrared spectrums. The photocell shall have a sensitivity of less than 5% for any wavelengths less than 400 nanometers or greater than 700 nanometers.
    - 2) Sensor light level range shall be from 1-6,553 footcandles (fc).
    - 3) The capability of ON/OFF, bi-level or tri-level switching, or dimming, for each controlled zone, depending on the selection of room controller(s) and load binding to room controller(s).
    - 4) For switching daylight harvesting, the photosensor shall provide a field-selectable deadband, or a separation, between the "ON Setpoint" and the "OFF Setpoint" that will prevent the lights from cycling excessively after they turn off.
    - 5) For dimming daylight harvesting, the photosensor shall provide the option, when the daylight contribution is sufficient, of turning lights off or dimming lights to a field-selectable minimum level.
    - 6) Photosensors shall have a digital, independently configurable fade rate for both increasing and decreasing light level in units of percent per second.
    - 7) Photosensors shall provide adjustable cut-off time. Cut-off time is defined by the number of selected minutes the load is at the minimum output before the load turns off. Selectable range between 0-240 minutes including option to never cut-off.
    - 8) Optional wall switch override shall allow occupants to reduce lighting level to increase energy savings or, if permitted by system administrator, raise lighting levels for a selectable period of time or cycle of occupancy.
    - 9) Integral infrared (IR) transceiver for configuration and/or commissioning with a handheld configuration tool, to transmit detected light level to wireless configuration tool, and for communication with personal remote controls.
    - 10) Configuration LED status light on device that blinks to indicate data transmission.

- 11) Status LED indicates test mode, override mode and load binding.
  - 12) Recessed switch on device to turn controlled load(s) ON and OFF.
  - 13) BACnet object information shall be available for the following daylighting sensor objects, based on the specific photocell's settings:
    - a) Light level
    - b) Day and night setpoints
    - c) Off time delay
    - d) On and off setpoints
    - e) Up to three zone setpoints
    - f) Operating mode – on/off, bi-level, tri-level or dimming
  - 14) One RJ-45 port for connection to DLM local network.
  - 15) A choice of accessories to accommodate multiple mounting methods and building materials. The photosensors may be mounted on a ceiling tile, skylight light well, suspended lighting fixture or backbox. Standard tube photosensors accommodate mounting materials from 0-0.62" thickness (LMLS-400, LMLS-500). Extended tube photosensors accommodate mounting materials from 0.62"-1.25" thickness (LMLS-400-L, LMLS-500-L). Mounting brackets are compatible with J boxes (LMLS-MB1) and wall mounting (LMLS-MB2). LMLS-600 photosensor to be mounted on included bracket below skylight well.
  - 16) Any load or group of loads in the room can be assigned to a daylighting zone
  - 17) Each load within a daylighting zone can be individually enabled or disabled for discrete control (load independence).
  - 18) All digital parameter data programmed into a photosensor shall be retained in non-volatile FLASH memory within the photosensor itself. Memory shall have an expected life of no less than 10 years.
- c. Closed loop digital photosensors shall include the following additional features:
- 1) An internal photodiode that measures light in a 100-degree angle, cutting off the unwanted light from bright sources outside of this cone.
  - 2) Automatic self-calibration, initiated from the photosensor, a wireless configuration tool or a PC with appropriate software.
  - 3) Automatically establishes application-specific setpoints following self-calibration. For switching operation, an adequate deadband between the ON and OFF setpoints shall prevent the lights from cycling; for dimming operation a sliding setpoint control algorithm with separate Day and Night setpoints shall prevent abrupt ramping of loads.
  - 4) WattStopper Product Number: LMLS-400, LMLS-400-L.
- d. Open loop digital photosensors shall include the following additional features:
- 1) An internal photodiode that measures light in a 60-degree angle cutting off the unwanted light from the interior of the room.
  - 2) Automatically establishes application-specific setpoints following manual calibration using a wireless configuration tool or a PC with appropriate software. For switching operation, an adequate deadband between the ON and OFF setpoints for each zone shall prevent the lights from cycling; for dimming operation, a proportional control algorithm shall maintain the design lighting level in each zone.



- 3) Each of the three discrete daylight zones can include any non overlapping group of loads in the room.
- 4) WattStopper Product Number: LMLS-500, LMLS-500-L.
- e. Dual loop digital photosensors shall include the following additional features:
  - 1) Close loop portion of dual loop device must have an internal photodiode that measures light in a 100 degree angle, cutting off the unwanted light from sources outside of this con
  - 2) Open loop portion of dual loop device must have an internal photodiode that can measure light in a 60 degree angle, cutting off the unwanted light from the interior of the room.
  - 3) Automatically establishes application-specific set-points following self-calibration. For switching operation, an adequate deadband between the ON and OFF setpoints shall prevent the lights from cycling; for dimming operation a sliding setpoint control algorithm with separate Day and Night setpoints shall prevent abrupt ramping of load.
  - 4) Device must reference closed loop photosensor information as a base line reference. The device must be able to analyze the open loop photosensor information to determine if an adjustment in light levels is required.
  - 5) Device must be able to automatically commission setpoints each night to provide adjustments to electrical lighting based on changes in overall lighting in the space due to changes in reflectance within the space or changes to daylight contribution based on seasonal changes.
  - 6) Device must include extendable mounting arm to properly position sensor within a skylight well.
  - 7) WattStopper product number LMLS-600
9. Digital Load Controllers (Room, Plug Load and Fixture Controllers)
  - a. Digital controllers for lighting and plug loads automatically bind the room loads to the connected devices in the space without commissioning or the use of any tools. Room and plug load controllers shall be provided to match the room lighting and plug load control requirements. The controllers will be simple to install, and will not have dip switches or potentiometers, or require special configuration for standard Plug n' Go applications. The control units will include the following features:
    - 1) Automatic room configuration to the most energy-efficient sequence of operation based upon the devices in the room.
    - 2) Simple replacement – Using the default automatic configuration capabilities, a room controller may be replaced with an off-the-shelf.
    - 3) Multiple room controllers connected together in a local network must automatically prioritize each room controller, without requiring any configuration or setup, so that loads are sequentially assigned using room controller device ID's from highest to lowest.
    - 4) Device Status LEDs to indicate:
      - a) Data transmission
      - b) Device has power
      - c) Status for each load
      - d) Configuration status
    - 5) Quick installation features including:

- a) Standard junction box mounting
- b) Quick low voltage connections using standard RJ-45 patch cable
- 6) Based on individual configuration, each load shall be capable of the following behavior on power up following the loss of normal power:
  - a) Turn on to 100%
  - b) Remain off
  - c) Turn on to last level
- 7) Each load shall be configurable to operate in the following sequences based on occupancy:
  - a) Auto-on/Auto-off (Follow on and off)
  - b) Manual-on/Auto-off (Follow off only)
- 8) The polarity of each load output shall be reversible, via digital configuration, so that on is off and off is on.
- 9) BACnet object information shall be available for the following objects:
  - a) Load status
  - b) Electrical current
  - c) Total watts per controller
  - d) Schedule state – normal or after-hours
  - e) Demand response control and cap level
  - f) Room occupancy status
  - g) Total room lighting and plug loads watts
  - h) Total room watts/sq ft
  - i) Force on/off all loads
- 10) UL 2043 plenum rated
- 11) Manual override and LED indication for each load
- 12) Dual voltage (120/277 VAC, 60 Hz), or 347 VAC, 60 Hz (selected models only). 120/277 volt models rated for 20A total load, derating to 16A required for some dimmed loads (forward phase dimming); 347 volt models rated for 15A total load; plug load controllers carry application-specific UL 20 rating for receptacle control.
- 13) Zero cross circuitry for each load
- 14) All digital parameter data programmed into an individual room controller or plug load controller shall be retained in non-volatile FLASH memory within the controller itself. Memory shall have an expected life of no less than 10 years.
- b. On/Off Room Controllers shall include:
  - 1) One or two relay configuration
  - 2) Efficient 150 mA switching power supply
  - 3) Three RJ-45 DLM local network ports with integral strain relief and dust cover
  - 4) WattStopper product numbers: LMRC-101, LMRC-102
- c. On/Off/Dimming enhanced Room Controllers shall include:
  - 1) Real time current monitoring
  - 2) Multiple relay configurations
    - a) One, two or three relays (LMRC-21x series)
    - b) One or two relays (LMRC-22x series)
  - 3) Efficient 250 mA switching power supply
  - 4) Four RJ-45 DLM local network ports with integral strain relief and dust cover
  - 5) One dimming output per relay

- a) 0-10V Dimming - Where indicated, one 0-10 volt analog output per relay for control of compatible ballasts and LED drivers. The 0-10 volt output shall automatically open upon loss of power to the Room Controller to assure full light output from the controlled lighting. (LMRC-21x series)
  - b) Line Voltage, Forward Phase Dimming - Where indicated, one forward phase control line voltage dimming output per relay for control of compatible two-wire or three-wire ballasts, LED drivers, MLV, forward phase compatible ELV, neon/cold cathode and incandescent loads. (LMRC-22x series)
  - c) Each dimming output channel shall have an independently configurable minimum and maximum calibration trim level to set the dimming range to match the true dynamic range of the connected ballast or driver.
  - d) The LED level indicators on bound dimming switches shall utilize this new maximum and minimum trim.
  - e) Each dimming output channel shall have an independently configurable minimum and maximum trim level to set the dynamic range of the output within the new 0-100% dimming range defined by the minimum and maximum calibration trim.
  - f) Calibration and trim levels must be set per output channel.
  - g) Devices that set calibration or trim levels per controller are not acceptable.
  - h) All configuration shall be digital. Devices that set calibration or trim levels per output channel via trim pots or dip-switches are not acceptable.
- 6) Each load shall have an independently configurable preset on level for Normal Hours and After Hours events to allow different dimmed levels to be established at the start of both Normal Hours and After Hours events.
  - 7) Fade rates for dimming loads shall be specific to bound switch buttons, and the load shall maintain a default value for any bound buttons that do not specify a unique value.
  - 8) The following dimming attributes may be changed or selected using a wireless configuration tool:
    - a) Establish preset level for each load from 0-100%
    - b) Set high and low trim for each load
    - c) Set lamp burn in time for each load up to 100 hours
  - 9) Override button for each load provides the following functions:
    - a) Press and release for on/off control
    - b) Press and hold for dimming control
  - 10) WattStopper product numbers: LMRC-211, LRMC-212, LRMC-213, LMRC-221, LMRC-222
- d. Plug Load Room Controllers shall include:
- 1) One relay configuration with additional connection for unswitched load
  - 2) Configurable additive time delay to extend plug load time delay beyond occupancy sensor time delay (e.g. a 10 minute additive delay in a space with a 20 minute occupancy sensor delay)

- ensures that plug loads turn off 30 minutes after the space is vacated).
- 3) Factory default operation is Auto-on/Auto-off, based on occupancy
  - 4) Real time current monitoring of both switched and un-switched load (LMPL-201 only)
  - 5) Efficient switching power supply
    - a) 150mA (LMPL-101)
    - b) 250mA (LMPL-201)
  - 6) RJ-45 DLM local network ports
    - a) Three RJ-45 ports (LMPL-101)
    - b) Four RJ-45 ports (LMPL-201)
  - 7) WattStopper product numbers: LMPL-101, LMPL-201.
- e. Fixture Controllers shall include:
- 1) A form factor and product ratings to allow various OEM fixture manufacturers to mount the device inside the ballast/driver cavity of standard-sized fluorescent or LED general lighting fixtures.
  - 2) One 3A 120/277V rated mechanically held relay.
  - 3) Programmable behavior on power up following the loss of normal power:
    - a) Turn on to 100%
    - b) Turn off
    - c) Turn on to last level
  - 4) Requirement for 7 mA of 24VDC operating power from the DLM local network.
    - a) The Fixture Controller does not require a connection to a neutral conductor to operate, and unlike other types of Load Controllers it does not contribute power to the DLM local network to drive accessory devices.
    - b) Power to drive the LMFC Fixture Controller electronics can come from any Room or Plug Load Controller, LMPB-100 Power Booster and/or LMZC-301 Zone Controller (described later in the LMCP LIGHTING CONTROL PANELS specification section).
  - 5) 0-10V dimming capability via a single 0-10 volt analog output from the device for control of compatible ballasts and LED drivers. The 0-10 volt output shall automatically open upon loss of power to the Fixture Controller.
  - 6) Terminals to connect an RJ-45 adaptor with 24" leads, mountable in a ½" KO, for connection to the DLM local network.
    - a) The adaptor leads are insulated for use in a fixture cavity, and the lead length allows the OEM fixture manufacturer flexibility to position the Fixture Controller and the RJ45 jack in the best locations on each fixture.
  - 7) A complete set of dimming features described above in the section detailing On/Off/Dimming Enhanced Room Controllers.
  - 8) WattStopper product numbers: Fixture Controller: LMFC-011, DLM Cable Connector: LMFC-RJ-50-24, Power Booster: LMPB-100
10. DLM Local Network (Room Network)
- a. The DLM local network is a free topology lighting control physical connection and communication protocol designed to control a small area of a building.
  - b. Features of the DLM local network include:

- 1) Plug n' Go® automatic configuration and binding of occupancy sensors, switches and lighting loads to the most energy-efficient sequence of operation based upon the device attached.
  - 2) Simple replacement of any device in the network with a standard off the shelf unit without requiring commissioning, configuration or setup.
  - 3) Push n' Learn® configuration to change the automatic configuration, including binding and load parameters without tools, using only the buttons on the digital devices in the local network.
  - 4) Two-way infrared communications for control by handheld remotes, and configuration by a handheld tool including adjusting load parameters, sensor configuration and binding, within a line of sight of up to 30 feet from a sensor, wall switch or IR receiver.
  - c. Digital room devices connect to the local network using pre-terminated Cat 5e cables with RJ-45 connectors, which provide both data and power to room devices. Systems that utilize RJ-45 patch cords but do not provide serial communication data from individual end devices are not acceptable.
  - d. If manufacturer's pre-terminated Cat 5e cables are not used for the installation, the Electrical Subcontractor is responsible for testing each cable following installation and supplying manufacturer with test results.
  - e. WattStopper Product Number: LMRJ-Series
11. DLM Segment Network (Room to Room Network)
- a. The segment network shall be a linear topology, BACnet-based MS/TP subnet to connect DLM local networks (rooms) and LMCP relay panels for centralized control.
    - 1) Each connected DLM local network shall include a single network bridge (LMBC-300), and the network bridge is the only room-based device that is connected to the segment network.
    - 2) Network bridges, relay panels and segment managers shall include terminal blocks, with provisions for separate "in" and "out" terminations, for segment network connections.
    - 3) The segment network shall utilize 1.5 twisted pair, shielded, cable supplied by the lighting control manufacturer. The maximum cable run for each segment is 4,000 feet. Conductor-to-conductor capacitance of the twisted pair shall be less than 30 pf/ft and have a characteristic impedance of 120 Ohms.
    - 4) Network signal integrity requires that each conductor and ground wire be correctly terminated at every connected device.
    - 5) Substitution of manufacturer-supplied cable must be pre-approved: Manufacturer will not certify network reliability, and reserves the right to void warranty, if non-approved cable is installed, and if terminations are not completed according to manufacturer's specific requirements.
    - 6) Segment networks shall be capable of connecting to BACnet-compliant BAS (provided by others) either directly, via MS/TP, or through NB-ROUTERS, via BACnet/IP or BACnet/Ethernet. Systems whose room-connected network infrastructure require gateway devices to provide BACnet data to a BAS are unacceptable.
  - b. WattStopper Product Number: LM-MSTP, LM-MSTP-DB
12. Hand Held and Computer Configuration Tools
- a. A wireless configuration tool facilitates optional customization of DLM local

- networks using two-way infrared communications, while PC software connects to each local network via a USB interface.
- b. Features and functionality of the wireless configuration tool shall include but not be limited to:
- 1) Two-way infrared (IR) communication with DLM IR-enabled devices within a range of approximately 30 feet.
  - 2) High visibility organic LED (OLED) display, pushbutton user interface and menu-driven operation.
  - 3) Must be able to read and modify parameters for room controllers, occupancy sensors, wall switches, daylighting sensors, network bridges and relay panels, and identify room devices by type and serial number.
  - 4) Save up to eight occupancy sensor setting profiles, and apply profiles to selected sensors.
  - 5) Temporarily adjust light level of any load(s) on the local network, and incorporate those levels in scene setting. Set room mode for testing of Normal Hours (NH) and After Hours (AH) parameter settings.
  - 6) Adjust or fine-tune daylighting settings established during auto-configuration, and input light level data to complete configuration of open loop daylighting controls.
  - 7) Set room mode for testing of Normal Hours (NH) and After Hours (AH) parameter settings.
  - 8) Verify status of building level network devices.
- c. WattStopper Product Numbers: LMCT-100, LMCI-100/LMCS-100
13. Network Bridge
- a. The network bridge module connects a DLM local network to a BACnet-compliant segment network for communication between rooms, relay panels and a segment manager or BAS. Each local network shall include a network bridge component to provide a connection to the local network room devices. The network bridge shall use industry standard BACnet MS/TP network communication and an optically isolated EIA/TIA RS-485 transceiver.
- 1) The network bridge shall be provided as a separate module connected on the local network through an available RJ-45 port.
  - 2) Provide Plug n' Go operation to automatically discover room devices connected to the local network and make all device parameters visible to the segment manager via the segment network. No commissioning shall be required for set up of the network bridge on the local network.
  - 3) The network bridge shall automatically create standard BACnet objects for selected room device parameters to allow any BACnet-compliant BAS to include lighting control and power monitoring features as provided by the DLM room devices on each local network. BACnet objects will be created for the addition or replacement of any given in-room DLM device for the installed life of the system. Products requiring that an application-specific point database be loaded to create or map BACnet objects are not acceptable. Systems not capable of providing BACnet data for control devices via a dedicated BACnet Device ID and physical MS/TP termination per room are not acceptable. Standard BACnet objects shall be provided as follows:
    - a) Read/write the normal or after hours schedule state for

- the room
    - b) Read the detection state of each occupancy sensor
    - c) Read the aggregate occupancy state of the room
    - d) Read/write the On/Off state of loads
    - e) Read/write the dimmed light level of loads
    - f) Read the button states of switches
    - g) Read total current in amps, and total power in watts through the room controller
    - h) Read/write occupancy sensor time delay, PIR sensitivity and ultrasonic sensitivity settings
    - i) Activate a preset scene for the room
    - j) Read/write daylight sensor fade time and day and night setpoints
    - k) Read the current light level, in footcandles, from interior and exterior photosensors and photocells
    - l) Set daylight sensor operating mode
    - m) Read/write wall switch lock status
    - n) Read watts per square foot for the entire controlled room
    - o) Write maximum light level per load for demand response mode
    - p) Read/write activation of demand response mode for the room
    - q) Activate/restore demand response mode for the room
  - b. WattStopper product numbers: LMBC-300
- 14. Segment Manager
  - a. For networked applications, the Digital Lighting Management system shall include at least one segment manager to manage network communication. It shall be capable of serving up a graphical user interface via a standard web browser utilizing either unencrypted TCP/IP traffic via a configurable port (default is 80) or 256 bit AES encrypted SSL TCP/IP traffic via a configurable port (default is 443).
  - b. Each segment manager shall have integral support for at least three segment networks. Segment networks may alternately be connected to the segment manger via external routers and switches, using standard Ethernet structured wiring. Each router shall accommodate one segment network. Provide the quantity of routers and switches as shown on the plans.
  - c. Operational features of the Segment Manager shall include the following:
    - 1) Connection to PC or LAN via standard Ethernet TCP/IP via standard Ethernet TCP/IP with the option to use SSL encrypted connections for all traffic.
    - 2) Easy to learn and use graphical user interface, compatible with Internet Explorer 8, or equal browser. Shall not require installation of any lighting control software to an end-user PC.
    - 3) Log in security capable of restricting some users to view-only or other limited operations.
    - 4) Segment Manager shall provide two main sets of interface screens – those used to initially configure the unit (referred to as the config screens), and a those used to allow users to dynamic monitor the performance of their system, and provide a centralized scheduling interface. Capabilities using the Config Screens shall include:
      - a) Automatic discovery of DLM devices and relay panels on the segment network(s). Commissioning beyond

- activation of the discovery function shall not be required to provide communication, monitoring or control of all local networks and lighting control panels.
- b) Allow information for all discovered DLM devices to be imported into the Segment Manager via a single XML based site file from the WattStopper LMCS Software, significantly reducing the time needed to make a system usable by the end user. Importable information can include text descriptions of every DLM component and individual loads, and automatic creation of room location information and overall structure of DLM network. Info entered into LMCS should not have to be re-entered manually via keystrokes into the Segment Manager.
  - c) After discovery, all rooms and panels shall be presented in a standard navigation tree format. Selecting a device from the tree will allow the device settings and operational parameters to be viewed and changed by the user.
  - d) Ability to view and modify room device operational parameters. It shall be possible to set device parameters independently for normal hours and after hours operation including sensor time delays and sensitivities, and load response to sensor including Manual-On or Auto-On.
  - e) Provide capabilities for integration with a BAS via BACnet protocol. At a minimum, the following points shall be available to the BAS via BACnet IP connection to the segment manager: room occupancy state; room schedule mode; room switch lock control; individual occupancy sensor state; room lighting power; room plug-load power; load ON/OFF state; load dimming level; panel channel schedule state; panel relay state; and Segment Manager Group schedule state control. Any of above items shall be capable of being moved into an "Export Table" that will provide any integrator with only the data they need, and by using the Export Table effectively create a firewall between the integrator's request for info and the overall system performance.
- 5) Capabilities using the Segment Manager's Dashboard Screens shall include:
- a) A dynamic "tile" based interface that allows easy viewing of each individual room's lighting and plug load power consumption, and lighting and plug load power density (power consumption information requires Enhanced DLM Room and Plug Load Controllers with integral current transducers such as LMRC-21x). Tiles will be automatically organized according to location so a single tile for the building summarizes all information for tiles beneath it on every floor, in every area, in every room. Tiles shall be color coded based on three energy target parameters, allowing an owner to quickly identify rooms that are not performing efficiently. Tiles for rooms with occupancy sensors shall include an icon to indicate whether that room is occupied. Tiles shall be clickable,



- and when clicked the underlying hierarchical level of tiles shall become visible. The tile interface shall be accessible via mouse, or touch screen devices. Tiles shall be created automatically by the segment manager, based on the information found during the device discovery and/or information included in a file imported in from LMCS (such as tagged descriptions for each room) without any custom programming.
- b) Ability to set up schedules for rooms and panels, view and override current status of panel channels and relays, and assign relays to groups. Schedules shall automatically set controlled zones or areas to either a normal hours or after hours mode of operation. Support for a minimum of 100 unique schedules, each with up to four time events per day. Support for annual schedules, holiday schedules and unique date-bound schedules.
  - c) Ability to provide a simple time vs. power graph based on information stored in each Segment Manager's memory (typically two to three days' data).
  - d) Ability to group rooms and loads for common control by schedules, switches or network commands.
  - e) Ability to monitor connected load current and display power consumption for areas equipped with room controllers incorporating the integral current monitoring feature.
  - f) Provide capabilities for integration with a BAS via BACnet protocol. At a minimum, the following points shall be available to the BAS via BACnet IP connection to the segment manager: room occupancy state; room schedule mode; room switch lock control; individual occupancy sensor state; room lighting power; room plug-load power; load ON/OFF state; load dimming level; panel channel schedule state; panel relay state; and Segment Manager Group schedule state control.
- 6) If shown in the contract drawings, Segment Managers shall be integrated into a larger control network by the addition of a Network Supervisor package. The Supervisor is a server level computer running a version of the Segment Manager interface software with dedicated communication and networking capability, able to pull information automatically from each individual Segment Manager in the network. By using a Supervisor, information for individual Segment Managers can be accessed and stored on the Supervisor's hard drive, eliminating the risk of data being overwritten after a few days because of Segment Manager memory limits.
  - 7) The Segment Manager shall allow access and control of the overall system database via Native Niagara AX FOX connectivity. Systems that must utilize a Tridium Niagara controller in addition to the programming, scheduling and configuration server are not acceptable.
- d. Segment Manager shall support multiple DLM rooms as follows:
    - 1) Support up to 120 network bridges and 900 digital in-room devices (LMSM-3E).
    - 2) Support up to 300 network bridges and 2,200 digital in room

- devices, connected via network routers and switches (LMSM-6E).
- e. WattStopper Product Numbers: LMSM-3E, LMSM-6E, NB-ROUTER, NB-SWITCH, NB-SWITCH-8, NB-SWITCH-16.
15. Programming, Configuration and Documentation Software
- a. PC-native application for optional programming of detailed technician-level parameter information for all DLM products, including all parameters not accessible via BACnet and the handled IR configuration tool. Software must be capable of accessing room-level parameter information locally within the room when connected via the optional LMCI-100 USB programming adapter, or globally for many segment networks simultaneously utilizing standard BACnet/IP communication.
  - b. Additional parameters exposed through this method include but are not limited to:
    - 1) Occupancy sensor detection LED disable for performance and other aesthetic spaces where blinking LEDs present a distraction.
    - 2) Six occupancy sensor action behaviors for each controlled load, separately configurable for normal hours and after hours modes. Modes include: No Action, Follow Off Only, Follow On Only, Follow On and Off, Follow On Only with Override Time Delay, Follow Off Only with Blink Warn Grace Time, Follow On and Off with Blink Warn Grace Time.
    - 3) Separate fade time adjustments per load for both normal and after hours from 0 - 4 hours.
    - 4) Configurable occupancy sensor re-trigger grace period from 0 - 4 minutes separate for both normal hours and after hours.
    - 5) Separate normal hours and after hours per-load button mode with modes including: Do nothing, on only, off only, on and off.
    - 6) Load control polarity reversal so that on events turn loads off and vice versa.
    - 7) Per-load DR (demand response) shed level in units of percent.
    - 8) Load output pulse mode in increments of 1 second.
    - 9) Fade trip point for each load for normal hours and after hours that establishes the dimmer command level at which a switched load closes its relay to allow for staggered On of switched loads in response to a dimmer.
  - c. Generation of reports at the whole file, partial file, or room level. Reports include but are not limited to:
    - 1) Device list report: All devices in a project listed by type.
    - 2) Load binding report: All load controller bindings showing interaction with sensors, switches, and daylighting.
    - 3) BACnet points report: Per room Device ID report of the valid BACnet points for a given site's BOM.
    - 4) Room summary report: Device manifest for each room, aggregated by common BOM, showing basic sequence of operations.
    - 5) Device parameter report: Per-room lists of all configured parameters accessible via hand held IR programmer for use with O&M documentation.
    - 6) Scene report: All project scene pattern values not left at defaults (i.e. 1 = all loads 100%, 2 = all loads 75%, 3 = all loads 50%, 4 = all loads 25%, 5-16 = same as scene 1).

- d. Occupancy sensor report: Basic settings including time delay and sensitivity(ies) for all occupancy sensors.  
Network-wide programming of parameter data in a spreadsheet-like programming environment including but not limited to the following operations:
    - 1) Set, copy/paste an entire project site of sensor time delays.
    - 2) Set, copy/paste an entire project site of sensor sensitivity settings.
    - 3) Search based on room name and text labels.
    - 4) Filter by product type (i.e. LMRC-212) to allow parameter set by product.
    - 5) Filter by parameter value to search for product with specific configurations.
  - e. Network-wide firmware upgrading remotely via the BACnet/IP network.
    - 1) Mass firmware update of entire rooms.
    - 2) Mass firmware update of specifically selected rooms or areas.
    - 3) Mass firmware upgrade of specific products.
  - f. WattStopper Product Number: LMCS-100, LMCI-100
16. LMCP Lighting Control Panels and LMZC Zone Controller
- a. Provide lighting control panels in the locations and capacities as indicated on the plans and schedules. Each panel shall be of modular construction and consist of the following components:
    - 1) Enclosure/Tub shall be NEMA 1, sized to accept an interior with 1 - 8 relays, 1 - 24 relays and 6 four-pole contactors, or 1 - 48 relays and 6 four-pole contactors.
    - 2) Cover shall be configured for surface or flush wall mounting of the panel as indicated on the plans. The panel cover shall have a hinged and lockable door with restricted access to line voltage section of the panel.
    - 3) Interior assembly shall be supplied as a factory assembled component specifically designed and listed for field installation. The interior construction shall provide total isolation of high voltage (Class 1) wiring from low voltage (Class 2) wiring within the assembled panel. The interior assembly shall include intelligence boards, power supply, DIN rails for mounting optional Class 2 control devices, and individually replaceable latching type relays. The panel interiors shall include the following features:
      - a) Removable, plug-in terminal blocks with connections for all low voltage terminations.
      - b) Individual terminal block, override pushbutton, and LED status light for each relay.
      - c) Direct wired switch inputs associated with each relay shall support 2-wire momentary switches only.
      - d) Digital inputs (four RJ-45 jacks) shall support 1-, 2-, 3-, 4-, and 8-button digital switches; digital IO modules capable of receiving 0-5V or 0-10V analog photocell inputs; digital IO modules capable of receiving momentary or maintained contact closure inputs or analog sensor inputs; digital daylighting sensors; and digital occupancy sensors. Inputs are divided into two separate digital networks, each capable of supplying 250mA to connected devices.

- e) True relay state shall be indicated by the on-board LED and shall be available to external control devices and systems via BACnet.
  - f) Automatically sequenced operation of relays to reduce impact on the electrical distribution system when large loads are controlled simultaneously.
  - g) Group and pattern control of relays shall be provided through a simple keypad interface from a handheld IR programmer. Any set of relays can be associated with a group for direct on/off control or pattern (scene) control via a simple programming sequence using the relay override pushbuttons and LED displays for groups 1-8 or a handheld IR programmer for groups 1-99.
  - h) Relay group status for shall be provided through LED indicators for groups 1-8 and via BACnet for groups 1-99. A solid LED indicates that the last group action called for an ON state and relays in the group are on or in a mixed state.
- 4) Single-pole latching relays with modular plug-in design. Relays shall provide the following ratings and features:
- a) Electrical:
    - i. 30 amp ballast at 277V
    - ii. 20 amp ballast at 347V
    - iii. 20amp tungsten at 120V
    - iv. 30 amp resistive at 347V
    - v. HP motor at 120V
    - vi. 14,000 amp short circuit current rating (SCCR) at 347V
    - vii. Relays shall be specifically UL 20 listed for control of plug-loads
  - b) Mechanical:
    - i. Replaceable, 1/2" KO mounting with removable Class 2 wire harness.
    - ii. Actuator on relay housing provides manual override and visual status indication, accessible from Class 2 section of panel.
    - iii. Dual line and load terminals each support two #14 - #12 solid or stranded conductors.
    - iv. Tested to 300,000 mechanical on/off cycles.
- 5) Isolated low voltage contacts provide for true relay status feedback and pilot light indication.
- 6) Power supply shall be a multi-voltage transformer assembly with rated power to supply all electronics, occupancy sensors, switches, pilot lights, and photocells as necessary to meet the project requirements. Power supply to have internal over-current protection with automatic reset and metal oxide varistor protection.
- 7) Where indicated, lighting control panels designated for control of emergency lighting shall be provided with factory installed provision for automatic by pass of relays controlling emergency circuits upon loss of normal power. Panels shall be properly listed and labeled for use on emergency lighting circuits and shall meet the requirements of UL924 and NFPA 70 - Article

- 700.
- 8) Integral system clock shall provide scheduling capabilities for panel-only projects without DLM segment networks or BAS control.
- a) Each panel shall include digital clock capability able to issue system wide automation commands to up to (11) eleven other panels for a total of (12) twelve networked lighting control panels. The clock shall provide capability for up to 254 independent schedule events per panel for each of the ninety-nine system wide channel groups.
  - b) The clock capability of each panel shall support the time-based energy saving requirements of applicable local energy codes.
  - c) The clock module shall provide astronomic capabilities, time delays, blink warning, daylight savings, and holiday functions and will include a battery back up for the clock function and program retention in non-volatile FLASH memory. Clocks that require multiple events to meet local code lighting shut off requirements shall not be allowed.
  - d) The clock capability of each panel shall operate on a basis of ON/OFF or Normal Hours/After Hours messages to automation groups that implement pre-configured control scenarios. Scenarios shall include:
    - i. Scheduled ON / OFF
    - ii. Manual ON / Scheduled OFF
    - iii. Astro ON / OFF (or Photo ON / OFF)
    - iv. Astro and Schedule ON / OFF (or Photo and Schedule ON / OFF)
  - e) The user interface shall be a portable IR handheld remote control capable of programming any panel in the system (LMCT-100)
  - f) The clock capability of each panel shall employ non-volatile memory and shall retain user programming and time for a minimum of 10 years.
  - g) Schedules programmed into the clock of any one panel shall be capable of executing panel local schedule or Dark/Light (photocell or Astro) events for that panel in the event that global network communication is lost. Lighting control panels that are not capable of executing events independently of the global network shall not be acceptable.
- 9) The lighting control panel can operate as a stand-alone system, or can support schedule, group, and photocell control functions, as configured in a Segment Manager controller, via a segment network connection.
- 10) The lighting control panel shall support digital communications to facilitate the extension of control to include interoperation with building automation systems and other intelligent field devices. Digital communications shall be RS485 MS/TP-based using the BACnet® protocol.
- a) The panel shall have provision for an individual BACnet device ID and shall support the full 222 range (0 – 4,193,304). The device ID description property shall be

- writable via the network to allow unique identification of the lighting control panel on the network.
- b) The panel shall support MS/TP MAC addresses in the range of 0 – 127 and baud rates of 9600k, 38400k, 76800k, and 115.2k bits per second.
  - c) Lighting control relays shall be controllable as binary output objects in the instance range of 1 – 64. The state of each relay shall be readable and writable by the BAS via the object present value property.
  - d) Lighting control relays shall report their true on/off state as binary input objects in the instance range of 1 – 64.
  - e) The 99 group Normal Hours/After Hours control objects associated with the panel shall be represented by binary value objects in the instance range of 201 – 299. The occupancy state of each channel group shall be readable and writable by the BAS via the object present value property. Commanding 1 to a channel group will put all relays associated with the channel into the normal hours mode. Commanding 0 or NULL shall put the relays into the after hours mode.
  - f) Setup and commissioning of the panel shall not require manufacturer-specific software or a computer. All configuration of the lighting control panel shall be performed using standard BACnet objects or via the handheld IR programming remote. Provide BACnet objects for panel setup and control as follows:
    - i. Binary output objects in the instance range of 1 – 64 (one per relay) for on/off control of relays.
    - ii. Binary value objects in the instance range of 1 – 99 (one per channel) for normal hours/after hours schedule control.
    - iii. Binary input objects in the instance range of 1 – 64 (one per relay) for reading true on/off state of the relays.
    - iv. Analog value objects in the instance range of 101 – 199 (one per channel group) shall assign a blink warn time value to each channel. A value of 5 shall activate the blink warn feature for the channel and set a 5-minute grace-time period. A value of 250 shall activate the sweep feature for the channel and enable the use of sweep type automatic wall switches.
  - g) The description property for all objects shall be writable via the network and shall be saved in non-volatile memory within the panel.
  - h) The BO and BV 1 – 99 objects shall support BACnet priority array with a relinquish default of off and after hours respectively. Prioritized writes to the channel BV objects shall propagate prioritized control to each member relay in a way analogous to the BACnet Channel object.
  - i) Panel-aggregate control of relay Force Off at priority 2 shall be available via a single BV5 object. Force On at priority 1 shall be available via a single BV4 object.

- j) Lockout of all digital switch buttons connected to a given panel shall be command-able via a single BV2 object. The lock status of any connected switch station shall be represented as BV101-196.
- 11) In addition to the LMCP Relay Panels, an LMZC Zone Controller panel shall be available for zero-relay applications. The panel is designed for applications where LMFC-011 Fixture Controllers or other distributed load controllers are used to switch and/or dim the controlled loads. Key similarities to and differences from the LMCP panel design shall include:
  - a) The LMZC shall use the same intelligence board as the LMCP relay panel.
  - b) The LMZC shall not include relay driver boards or relays.
  - c) The LMZC shall have a removable interior section to facilitate installation, and a Tub/Cover. Cover is for surface mounting applications only.
  - d) The LMZC tub shall have two interior KOs to allow installation of LMPB-100 Power Boosters. Each installed Power Booster can provide an additional 150 mA for either of the two available DLM local networks provided by the LMZC.
  - e) All programming and networking (whether DLM Local Network and/or Segment Network) capabilities in the LMZC Zone Controller shall be similar to capabilities for LMCP relay panels, except for functions designed for panel-mounted HDR relays.
- 12) To aid in project start up, if LMFC Fixture Controllers are connected to an LMZC Zone Controller, Plug n' Go automatic configuration will establish a unique sequence of operation so that all LMFC-controlled fixtures will turn on to 50% output when any digital occupancy sensor detects motion.
- 13) WattStopper Product Number: Relay Panels: LMCP8, LMCP24 or LMCP48, Zone Controller: LMZC-301.
- b. User Interface
  - 1) Each lighting control panel system shall be supplied with at least (1) handheld configuration tool (LMCT-100). As a remote programming interface the configuration tool shall allow setup, configuration, and diagnostics of the panel without the need for software or connection of a computer. The user interface shall have the following panel-specific functions as a minimum:
    - a) Set network parameters including panel device ID, MS/TP MAC address, baud rate and max master range.
    - b) Relay Group creation of up to 99 groups. Group creation shall result in programming of all seven key relay parameters for member relays. The seven parameters are as follows: After-hours Override Time Delay, Normal Hours Override Time Delay, Action on Transition to Normal Hours, Action on Transition to After Hours, Sensor Action During Normal Hours, Sensor Action During After Hours, Blink-Warn Time for After Hours.
    - c) Program up to 254 separate scheduled events. Events shall occur on seven day intervals with each day selectable as active or inactive, and shall be

configurable as to whether the event is active on holidays. Holidays are also defined through the User Interface.

- d) Program up to 32 separate Dark/Light events. Events shall have a selectable source as either calculated Astro with delay, or a digital IO module with an integral 0-5V or 0-10V analog photocell. Dark/Light events shall occur on seven day intervals with each day selectable as active or inactive, and shall be configurable as to whether the event is active on holidays.
  - e) Button binding of digital switches to groups shall be accessible via the handheld IR remote and accomplished from the digital switch station.
  - f) Programming of panel location information shall be accomplished by the handheld IR remote and include at a minimum LAT, LON, DST zone, and an approximate city/state location.
  - g) An additional handheld IR remote may optionally be specified to be permanently mounted to the panel interior via a retractable anti-theft lanyard to allow for convenient programming of the panel while assuring that the handheld programmer is always present at that panel. An unlimited number of handheld IR remotes may also be purchased for facilities staff as determined by the end user's representative.
  - h) WattStopper Product Number: LMCT-100
17. Emergency Lighting Control Devices
- a. Emergency Lighting Control Unit – A UL 924 listed device that monitors a switched circuit providing normal lighting to an area. The unit provides normal ON/OFF control of emergency lighting along with the normal lighting. Upon normal power failure the emergency lighting circuit will close, forcing the emergency lighting ON until normal power is restored. Features include:
    - 1) 120/277 volts, 50/60 Hz, 20 amp ballast rating
    - 2) Push to test button
    - 3) Auxiliary contact for remote test or fire alarm system interface
  - b. WattStopper Product Numbers: ELCU-100, ELCU-200.

C. Part 3 – Execution

- 1. Pre-Installation Meeting
  - a. A factory authorized manufacturer's representative shall provide the Electrical Subcontractor a functional overview of the lighting control system prior to installation. The Electrical Subcontractor shall schedule the pre-installation site visit after receipt of approved submittals to review the following:
    - 1) Confirm the location and mounting of all digital devices, with special attention to placement of occupancy and daylighting sensors.
    - 2) Review the specifications for low voltage control wiring and termination.
    - 3) Discuss the functionality and configuration of all products, including sequences of operation, per design requirements.
    - 4) Discuss requirements for integration with other trades.
- 2. Electrical Subcontractor Installation Services



- a. Electrical Subcontractor to install all devices and wiring in a professional manner. All line voltage connections to be tagged to indicate circuit and switched legs.
  - b. Electrical Subcontractor to install all room/area devices using manufacturer's factory-tested Cat 5e cable with pre-terminated RJ-45 connectors. If pre-terminated cable is not used for room/area wiring, the Electrical Subcontractor is responsible for testing each field-terminated cable following installation, and shall supply the lighting controls manufacturer with test results. Electrical Subcontractor to install any room to room network devices using manufacturer-supplied LM-MSTP network wire. Network wire substitution is not permitted and may result in loss of product warranty per DLM SEGMENT NETWORK section of specification. Low voltage wiring topology must comply with manufacturer's specifications. Electrical Subcontractor shall route network wiring as shown in submittal drawings as closely as possible, and shall document final wiring location, routing and topology on as built drawings.
  - c. Install the work of this Section in accordance with manufacturer's printed instructions unless otherwise indicated. Before start up, Electrical Subcontractor shall test all devices to ensure proper communication.
  - d. Calibrate all sensor time delays and sensitivity to guarantee proper detection of occupants and energy savings.
    - 1) Adjust time delay so that controlled area remains lighted while occupied.
  - e. Provide written or computer-generated documentation on the configuration of the system including room by room description including:
    - 1) Sensor parameters, time delays, sensitivities, and daylighting setpoints.
    - 2) Sequence of operation, (e.g. manual ON, and Auto OFF)
    - 3) Load Parameters (e.g. blink warning)
  - f. Post start-up tuning – After 30 days from occupancy Electrical Subcontractor shall adjust sensor time delays and sensitivities to meet the Owner's requirements. Provide a detailed report to the Architect / Owner of post start-up activity.
3. Factory Services
- a. Upon completion of the installation, the manufacturer's factory authorized representative shall start up and verify a complete fully functional system.
    - 1) Lighting vendor shall provide a copy of its start-up protocol to the Electrical Subcontractor and the Commissioning Agent no later than three weeks prior to the start-up date.
  - b. The electrical Electrical Subcontractor shall provide both the manufacturer and the electrical engineer with three weeks written notice of the system start up and adjustment date.
    - 1) Lighting vendor shall conduct a field inspection of all lighting devices and verify their operation during start-up.
    - 2) Lighting vendor shall submit a written start-up report no later than one week after start-up completion and prior to system training.
  - c. Upon completion of the system start up, the factory-authorized technician shall provide the proper training to the owner's personnel on the adjustment and maintenance of the system.

## 2.10 DRY TYPE K-RATED TRANSFORMERS

- A. Description
1. This Specification describes the design of a copper wound, multi-shielded, three phase, K-factor rated, high efficiency, power conditioning isolation transformer. The power conditioning transformer specified must be a continuous duty rated, 600 volt class, convection cooled, dry type, isolation transformer to support harmonic rich non-linear loads while maintaining safe operating temperatures and shall include superior transverse and common mode noise attenuation. The power conditioning transformer shall meet NEMA TP 1-2002 dry type transformer efficiency standards. In addition, the transformer shall be designed to achieve NEMA TP 1-2002 Table 1-1 efficiencies under K-13 non-linear load at or between 35% to 50% of its rating, as outlined in Section G, 10, of this Specification Section.
- B. Standards
1. The power conditioning system shall be designed in accordance with applicable portions of the following standards:
    - a. NEMA TP 1-2002 Dry Type Distribution Transformer Efficiency Standards.
    - b. American National Standards Institute (ANSI C57.110 and C62.41-1991).
    - c. Institute of Electrical and Electronic Engineers (IEEE 519-1992).
    - d. National Fire Protection Association (NFPA) 70, National Electrical Code (NEC).
    - e. Federal Information Processing Standards Publication 94 (FIPS Pub 94).
    - f. UL Listed to Standard 1561.
    - g. C-UL listed to CSA Standard C22.2, No. 47-M90.
- C. Submittals
1. Manufacturer Requirements:
    - a. The manufacturer shall be ISO 9001:2008 “Quality Assurance Certified” and shall upon request furnish certification documents.
    - b. The manufacturer shall be a United States based manufacturer with at least 15 years’ experience in design and fabrication K-rated, shielded, power conditioning isolation transformers.
  2. Product Data:
    - a. The manufacturer shall supply documentation for the installation of the system, including wiring diagrams and cabinet outlines showing dimensions, weights, BTUs, input/output connection locations and required clearances.
    - b. Factory test results and design data shall be provided to show compliance with the requirements.
- D. Manufacturer’s
1. The equipment specified is the Ultra-K, Series 600K, manufactured by Controlled Power Company. Equipment shall be as manufactured by Controlled Power Company, Acme, Siemens, or equal.
- E. Input Specifications
1. The nominal AC input voltage rating of the power conditioner shall be 480 VAC 3 phase with sufficient margin to sustain a constant input of +10% without saturation.
  2. The nominal operating frequency shall be 60 hertz  $\pm$  3 hertz.
  3. The power conditioning transformer primary shall be configured in a three phase delta. Transformers below 500kVA shall include full capacity taps at 2½ % increments, two (2) above and four (4) below the nominal voltage tap.
  4. When energized, the current inrush shall not exceed a maximum of 10 times the full load input current for a 1/2 cycle.

F. Output Specifications

1. The nominal AC output voltage rating of the power conditioning transformer shall be 208 VAC wye derived, 60 hertz.
2. The output impedance of the power conditioning transformer shall be 3% - 4% typical.
3. The power conditioning transformer shall be K-13 rated in accordance with:  $K = \sum I_h(\text{pu})^2 h^2$
4. The power conditioning transformer shall provide a continuous duty, full load output power as indicated on Drawings.

G. Performance Specifications

1. The output voltage of the power conditioning transformer shall be maintained within  $\pm 2.5\%$  or less of nominal, from no load to full load.
2. The overload rating of the power conditioning transformer shall be 500% for 10 seconds, and 1,000% for one cycle.
3. The power conditioning transformer shall add no more than 1% total harmonic distortion to the output waveform under a linear load.
4. Output voltage shall remain sinusoidal with no flat topping when high crest factor (3.0:1), non-linear loads are present at the output.
5. The audible noise of the power conditioning transformer shall be no greater than measurements indicated below:
  - a. 50 dB for 15 KVA to 112.5 KVA units measured at 1 meter.
  - b. 55 dB for 150 KVA to 225 KVA units measured at 1 meter.
  - c. 60 dB for 300 KVA to 500 KVA units measured at 1 meter.
6. The power conditioning transformer shall incorporate a solid copper foil, triple electrostatic shield to minimize inner winding capacitance, transient and noise coupling between primary and secondary windings.
7. Transformer shall be triple-shielded and capable of 146dB common mode noise attenuation.
8. Transformer shall be capable of transverse mode noise attenuation of 3 dB down at 10kHz, decaying 20 dB per decade.
9. The power conditioning transformer shall have an efficiency of 98% typical and shall meet NEMA TP 1-2002 dry type transformer efficiency standards on models 15kVA and above.
10. The power conditioning transformer shall be designed to achieve NEMA TP 1-2002 Table 1-1 efficiencies listed below under a K-13 non-linear load at or between 35% to 50% load and at an operating temperature of 75 degrees C.

<u>kVA</u>	<u>Efficiency</u>
15*	97.00%
30	97.50%
45	97.70%
75	98.00%
112.5	98.20%
150	98.30%
225	98.50%
300	98.60%
500	98.70%

\*15kVA model efficiency applicable to K4 and K7 loading only.

11. The power conditioning transformer shall incorporate a fused (with front panel mounted, blown fuse lamp indicator) 3 phase, secondary connected, 6 mode spike suppression network. The suppressor shall be comprised of high energy metal

oxide varistors with less than a 5 nanosecond response time and a maximum peak current handling capability of 40,000 amps (8x20μsec) per mode. The suppression network system shall remain functional when subjected to ANSI/IEEE C62.41 Category B-3 waveforms. The spike suppression network will increase the transverse mode noise attenuation to 3 dB down at 10kHz, decaying 40 dB per decade.

H. Main Transformer Construction

1. The transformer windings shall be all copper conductor construction, with separate primary and secondary, isolated windings. The transformer shall conform to National Electrical Code that specifies a separately derived power source. The neutral conductor shall be provided at 2 times the ampacity of the phase conductor.
2. Terminals shall be provided for isolated three phase output conductors, neutral conductor and ground.
3. Output neutral shall be bonded to ground via a removable jumper wire or bus bar.
4. All leads, wires and terminals shall be labeled to correspond with the circuit wiring diagram.
5. Basic Impulse level shall be no less than 10,000 Volts.
6. Mean Time Between Failure (MTBF) shall be no less than 200,000 hours.
7. Grain oriented, M6 grade, silicon transformer steel shall be utilized to provide maximum efficiency. Flux density shall not exceed 15k gauss. Core losses shall be limited to 0.6% or less of the KVA rating.
8. Class N, 200 °C insulation system shall be utilized throughout with a maximum temperature rise above ambient of 115 °C under a linear load, not to exceed 130 °C under non-linear loading per UL 1561.
9. The transformer shall be designed for natural convection cooling.

I. Cabinet Construction

1. The cabinet shall be a NEMA type 2 general purpose, floor mounted, indoor enclosure. Dimensions shall not exceed TABLE 1-2 dimensions below.
2. Cabinets shall be manufactured from 14 gauge steel with base sub-structure suitable for fork lifting.
3. The cabinet shall have a baked on powder coat paint finish with proper pre-treatment.
4. Input and output power connections shall be hardwired to copper stand off bus located behind the front panel of the transformer cabinet. Input and output locations shall be available on either side of transformer cabinet.

J. Environment

1. Temperature: The power conditioning system shall be required to operate without overheating in an ambient temperature range of -20°C to +40°C.
2. Humidity: The power conditioning system shall operate in a relative humidity of 0 to 95% non-condensing.
3. Altitude: The power conditioning system shall operate up to 5000 feet above sea level without de-rating.

K. Warranty

1. Manufacturer shall guarantee the power conditioning transformer to be free from defects in material and workmanship for a period of 2 years following shipment from the factory.

2.11 DRY TYPE TRANSFORMERS

- A. Transformers shall have separate primary and secondary windings. Transformers shall be

UL listed insulation systems of 220 degrees C., with 150 degrees C. temperature rise above 40 degrees C. ambient, except sizes less than 10 KVA may be 185 degrees C., UL listed insulation system with 150 degrees C. temperature rise above an ambient of 40 degrees C. Transformers larger than 10 KVA shall be of ventilated type.

- B. Core and coil assembly shall be supported from the enclosure base and shall have sound insulation pads between core and coil assembly and the enclosure base. KVA and voltage ratings shall be as indicated on Drawings.
- C. Transformers shall be designed for natural draft cooling conforming to applicable ANSI and IEEE Standards. Six 2-1/2% full capacity taps shall be provided, two above and four below rated voltage. Noise level shall not exceed 45DB on 15 to 50 KVA, 50DB on 51 to 150 KVA transformers and 55 DB on transformers over 150 KVA.
- D. Connection to transformers shall be made with liquid-tight flexible conduit with grounding conductor. Transformers shall be installed in association with Korfund vibration isolation pads to reduce noise level to a minimum. Refer to schedule on Drawings for mounting arrangement. Transformers shall be manufactured by Square D, Cutler-Hammer, Siemens, or equal.

#### 2.12 ELECTRICAL SUPPORTING DEVICES

- A. All conduit and fittings on all work are to be secured by one or more of the following:
  - 1. Masonry - metal clips secured by toggle bolts or lead expansion sleeves.
  - 2. Woodwork - metal clips secured by wood screws.
  - 3. Bar joists - wedge hangers.
  - 4. Flanged beams - flange clips.
- B. All pipe hangers and equipment supports shall be constructed and installed in accordance with Seismic Zone requirements as outlined in the State Building Code. The Electrical Subcontractor shall submit one (1) copy of Shop Drawings and calculations detailing seismic hanger restraints to the local Building Authority and Architect, along with a letter of compliance signed by a registered structural engineer confirming that the piping hangers meet State Seismic Code requirements. Cable provided for seismic systems shall be color-coded and pre-stressed.

#### 2.13 ELECTRICAL SWITCHBOARD

- A. Furnish and install a NEMA One, Class One Switchboard. The equipment and major components shall be suitable for and certified by actual seismic testing to meet all applicable seismic requirements of the International Building Code (IBC) Site Classification as based on installed location zip code. The manufacturer shall provide the tested baseline mounting location information to the Electrical Subcontractor. The installing Electrical Subcontractor shall complete all required installation calculations and mount the unit based on the engineered to site plans.
- B. Switchboard shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.
- C. All sections of the switchboard shall be a maximum of 72 inches high and group distribution sections shall be no more than 30 inches deep. All vertical sections shall rear align.

- D. All switchboard components shall be either front or side accessible. Where space for future is called for, all necessary bus extensions except devices connecting straps shall be provided.
- E. The switchboard assembly and all circuit breakers shall be rated for short-circuited stresses as indicated on Drawings.
- F. Fully Rated equipment shall be provided; Series Rated equipment is not acceptable.
- G. All main bus bars shall be silver-plated copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on NEMA standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure). No portion of the horizontal bus shall extend within 8 inches of the bottom or within 8 inches of the front inside any vertical panel section of the switchboard structure.
- H. All exterior and interior steel surfaces of the switchboard shall be properly cleaned and finished with gray enamel over a rust-inhibiting phosphatized coating.
- I. The switchboard shall have an UL service entrance equipment label.
- J. The switchboard layout and rating shall be as indicated on the plans and shall have the following features:
  - 1. Service entrance shall be by means of conduit entering from the bottom.
  - 2. Provide a main molded case circuit breaker for ratings 1600 amperes and below. Provide main insulated case circuit breaker for all ratings 2000 amperes and above. Circuit breakers which are rated at 1200 amps or more shall have Arc Energy Reduction complying with National Electrical Code 240.87.
  - 3. Provide Digitrip or equal electronic trip unit with integral GF protection on all main breakers. Provide thermal magnetic or ETU for feeders as shown on Drawings.
  - 4. Provide National Electrical Code compliant arc reduction maintenance protection with separate maintenance settings, activation switch and light for all main breakers.
  - 5. Main section shall be equipped with a line side digital power quality meter, Eaton IQ 35M Series or equal. Unit shall monitor voltage, amperes, power usage, and harmonic content displayed on the board and available for interface to the BMS via BACnet communications. Mount the unit in a separate compartment with system rated AIC disconnect device and shorting block for Line mounted CT's.
  - 6. Each switchboard section shall have full ampere bussing with full neutral capacity. A ground bus bonded to each cubicle shall run throughout the switchboard and all buses shall be copper.
  - 7. Internal bussing and circuiting shall conform to the power riser diagram shown on the plans.
  - 8. Distribution sections shall consist of circuit breakers group mounted with bolted connectors to bus all front accessible. See schedule on Drawings for frame size and trip unit types.
  - 9. Where shown on drawings provide Electric Utility Company metering section that meets all local electric utility company requirements. Provide CT and PT units if required by the electric utility company. Provide all required documentation for electric utility company compliance review prior to construction of the switchboard.
- K. The switchboard shall be a Pow-R-Line C as manufactured by Eaton, Square D, Siemens, or equal.

2.14 EMERGENCY STANDBY SYSTEM (DIESEL)

- A. Furnish and install a complete and operating emergency power system as specified herein and as indicated on the Drawings.
- B. The system shall be arranged to provide automatic and instantaneous power upon loss of normal power. This system shall meet all Code requirements for emergency lighting and power.
- C. Furnish complete, install and leave in good running condition a 300 KW diesel fueled engine driven generating set continuously rated for standby service. The KW rating shall be continuously available during any power outage. The unit shall be as hereinafter described and as shown on the Drawings, complete with all controls, attachments, accessories, fuel and exhaust systems.
- D. The unit shall be the product of a manufacturer regularly engaged in the production of this type of equipment as manufactured by Kohler Company, Caterpillar Corporation, Onan Corporation, Generac, or equal.
- E. The unit shall be capable of accepting the incoming loads of the Automatic Transfer Switches.
- F. Operation:
  - 1. The operation of this unit shall be automatic and upon the closing of a remote starting contact in Automatic Transfer Switch, the engine shall start and attain rated voltage and frequency within ten (10) seconds.
  - 2. All necessary accessories shall be provided to assure starting within the time described above under the ambient conditions described herein.
  - 3. Furnish and install all electrical work and equipment required for the proper operation of this system. The General Contractor will provide the necessary structured supports for the emergency generator. The Electrical Subcontractor shall provide weight information, as well as dimensional information of the generator to the General Contractor, prior to installing the supports, if necessary.
- G. Emissions:
  - 1. The proposed generator set shall be factory EPA certified for Stationary Emergency use and be in compliance with the Commonwealth of Massachusetts Emission regulations at the time of installation/commissioning. Actual engine emissions values must be in compliance with EPA Tier 2 emissions standard per ISO 8178 – D2 Emissions Cycle at specified kW/bHP rating. Utilization of the “Transition Program for Equipment Manufacturer’s” also known as “Flex Credits” to achieve Tier 3 certification is not in compliance with MA Regulations “310 CMR 7.02 U Plan Approval and Emission Limitations” and will not be accepted.
- H. Engine:
  - 1. The engine shall be unit-mounted radiator cooled, 4 cycle, industrial type, heavy duty, diesel fueled, and a maximum RPM of 1800. Ratings shall be for standard conditions of 29.92 barometer and 60 degrees air temperature.
  - 2. Lubrication shall be a full pressure system using an engine driven gear-type lube oil pump with replacement element full flow lube oil filter. Oil cooler shall be required.
  - 3. Base Mounted Fuel Tank:  
There shall be a double wall diesel fuel storage tank and rupture alarm supplied

as an integral part of the base of the unit. The tank shall be furnished and constructed in accordance with Commonwealth of Massachusetts and City requirements for fuel storage. The fuel tank shall be installed in the generator manufacturer's factory and all fuel connections, vents, returns and fills shall be installed and tested prior to shipment. Field or dealer installed tank installations are not acceptable. Tank shall be sized to provide 48 hours of usable run time, at 100% load.

The fuel tank shall meet all CMR 527 and Board of Fire Preventions Regulations and be accompanied with approval seal.

This installation shall include but shall not be limited to the following:

- Double wall steel fuel tank of the rated capacity
- Enlarged steel skid base
- Fuel lines including supply, return and vent lines
- Fuel fill
- Fuel level gauge
- Low fuel warning float switch
- Rupture basin and alarm
- Low fuel level alarm relay

All required appurtenances recommended or required by the manufacturer for a complete and correct installation shall be supplied and the entire assembly shall be factory primed and painted in the manufacturer's standard color to protect against corrosion.

4. Diesel Fuel System

- a. The engine fuel system shall include all equipment normally supplied and recommended by the generator set manufacturer for standby generator service. The fuel engine system equipment shall include (but not be limited to) the following:
- fuel injection system
  - fuel line solenoid valve
  - flexible fuel connections

5. Governor:

- a. The engine shall be equipped with a isochronous governor capable of +/- 0.25% steady-state frequency regulation.

6. Starting System:

- a. The engine shall have a 24 V.D.C. starting system with 24 volt positive engagement solenoid shift starting motor and 35-ampere minimum automatic battery charging alternator with solid state regulation.
- b. Batteries - One set of starting batteries with cables and steel battery rack, shall be included, capable of delivering the manufacturer's recommended minimum cold-cranking amps required at 0°F, per SAE Standard J-537.
- c. Float type battery charger shall be supplied to maintain the starting batteries at full charge. The charger shall be a 10-ampere automatic float and equalize battery charger with +/- 1% constant voltage regulation from no load to full load over +/- 10% AC input line variation, current limited during engine cranking and short circuit conditions, temperature compensated for ambients from -40°C to +60°C, 5% accurate voltmeter and ammeter, fused, reverse polarity and transient protected. Alarm circuit board to meet the requirements of NFPA 110 for low battery voltage, high battery voltage, and battery charger malfunction shall be provided.
- d. There shall be a belt driven battery charging alternator with regulator and charge rate ammeter for charging the batteries while the engine is running



or the float type battery charger may be arranged to charge the batteries from the normal source when the engine is shut down and from the generator output when the generator is operating. This shall be accomplished by a relay energized from the generator output.

7. Jacket Water Heater:
    - a. An engine jacket water heater shall be provided to maintain the engine jacket at a temperature high enough to assure starting the engine and attaining rated voltage and frequency within ten (10) seconds. The jacket water heater shall be of the capacity recommended by the generator set manufacturer to meet the above conditions. Input to the voltage heater shall be 208 volt, single phase.
  8. Safety Shutdown:
    - a. The engine shall be equipped with safety contacts for:
      - Low lube oil pressure
      - High jacket water temperature
      - Overspeed
      - Overcrank
  9. Engine Instruments:
    - a. The following engine instruments shall be connected either in an engine instrument panel or in the generator control panel:
      - Lube oil pressure
      - Water temperature
      - D.C. ammeterAny other instruments considered necessary by the manufacturer shall be included.
  10. Exhaust System:
    - a. A critical grade exhaust silencer suitable for residential type silencing complete with condensate drains shall be supplied of the size recommended by the generator set manufacturer, but in no case less than 4 inches. Silencer shall be as manufactured by Kettell, Maxim or Burgess Manning. An octave band center frequently in Hertz data sheet shall accompany all muffler shop Drawings. A section of seamless, flexible stainless steel exhaust connection of the size and type recommended by the generator set manufacturer, but in no case less than 4-inch diameter and eighteen (18) inches long shall be supplied. If the engine is Vee type, a single exhaust outlet header shall be supplied. The generator stack shall comply with 310 CMR 7.26 (42). Stack height shall be a minimum of 10'-0" above the emergency generator weather housing for generators rated equal to or greater than 300KW but less than 1MW.
  11. Mounting:
    - a. The engine and generator shall be close coupled and mounted on a structural steel base designed to maintain proper alignment of the unit.
    - b. The unit shall be certified by the manufacturer to be free from any critical torsional vibrations within a range of plus or minus 10% of synchronous speed.
    - c. Vibration isolators of the type shall be supplied with the unit. The number of isolators shall be as recommended by the generator set manufacturer.
- I. Generator:
1. Rating - 300 KW, 437.5 KVA, 0.8 P.F., 3 phase, 60 cycle, 208/120 volts.
  2. Type - Revolving field, 4 pole, single bearing, drip-proof.
  3. Exciter - Brushless, direct connected, fully tropicalized, SCR rectifiers, static voltage regulator, rheostat, excellent motor starting capability.
  4. Voltage Regulation - Plus or minus 1% of any preset value over the three (3) phase

- load range. Instantaneous voltage dip or rise, when measured with an oscilloscope, will not exceed 20% upon full load applications or rejection, and will return to preset value within 0.5 seconds.
5. Waveform - Deviation factor of output voltage will not exceed 5% and the value of any individual harmonic will not exceed 2% of the fundamental when operating with an unbalanced load.
  6. Temperature Rise - Temperature rise of any component will not exceed the rise permitted by NEMA standards.
  7. Rotor - One (1) piece laminations welded and secured to shaft by a key and press fit. Armortisseur windings installed and connected between poles as an aid to parallel operation and improved waveform during unbalanced loads. Field coils machine would on insulated pole body and securely braced. Rotor statically and dynamically balanced.
  8. Stator - One (1) piece laminations welded together. Stator coils random wound and placed in insulation slots. Stator pressed and welded in a rigid steel frame.
  9. Bearing - Double sealed ball bearing, lubricated for life.
  10. Insulation - NEMA Class F insulation.
  11. Varnish - Three (3) coats modified polyester type, will not support fungus growth.
  12. Cooling - Cast aluminum fan mounted on generator shaft.
  13. Radio Suppression - Radiated or conducted radio interference will not affect normal commercial apparatus.
  14. Controls:
    - a. Unit Mounted - The engine generator set shall include a combination engine generator control panel shock mounted at the generator end of the unit. This unit mounted panel shall include (but not be limited to) the following:
      - Water temperature gauge
      - Oil pressure gauge
      - D.C. battery charge rate ammeter
      - A.C. voltage regulator
      - Voltage adjusting rheostat
      - Start-stop switch
      - A.C. voltmeter
      - A.C. ammeter with current transformers
      - Combination VM-AM phase selector switch
      - Frequency meter
      - Elapsed time meter
      - Automatic start stop control with:
        - overcrank protection (manual reset)
        - high water temperature
        - overspeed
        - overcrank
        - selector switch - "off, auto, manual"
      - Common failure relay (wire to fire alarm control panel as trouble alarm)
      - Manual reset line circuit breakers shall be provided with electronic trip and LSI settings, sized as indicated on Drawings, as furnished with generator, 208/120 volts. Mounted in NEMA 1 enclosures with interrupting capacity of 65,000 amps symmetrical. Circuit breakers which are rated at 1200 amps or more shall have Arc Energy Reduction complying with National Electrical Code 240.87. Fully Rated equipment shall be provided; Series Rated equipment is not acceptable. The NEC Article 700 Emergency circuit breaker(s) shall be installed barrier separated from all other generator circuit breakers.
    - b. The control shall be designed to start the engine upon a closure of a

remote contact, arm all safeties, and shutdown the engine when the remote contact is reopened.

- c. The control must be manually reset following any fault condition.
- d. Control power shall be from the engine start battery.
- e. *The engine generator control panel shall monitor the integrity of the automatic transfer switch(es) and fire pump controller (if applicable) "engine start" contact wiring, by independently monitoring both a normally open (NO) contact and a normally closed (NC) contact. The NO contacts shall be wired in parallel with one another and the NC contacts shall be wired in series with one another. Should the controller fail to see a change in state to both of the monitored ATS inputs, the engine shall be started and an "ATS wiring failure" alarm and indicator shall be activated on both the local and remote annunciators.*

J. Annunciator Panel:

- 1. A remote mounted engine generator annunciator panel shall be built, tested and supplied by the generator supplier. The annunciator panel shall monitor, visually and audibly, the following:
  - Alarm Silence
  - Generator Test
  - Line Power
  - Generator Power
  - System Ready
  - Alarm Switch off
  - Generator Switch off
  - Overcrank
  - Low Battery Voltage
  - High Battery Voltage
  - Overspeed
  - Emergency Stop
  - Low Oil Pressure
  - High Water Temperature
  - Low Fuel
  - Low Water Temperature
  - Approach Low Oil Pressure
  - Approach High Water Temperature
  - Main Tank Rupture

K. Automatic Load Transfer Switches:

- 1. Automatic transfer switches shall be furnished with full load current rating as indicated on Drawings, 208/120 volts, 3 phase, 4 wire, 4 pole, 60 Hertz, A.C. normal and emergency. Minimum AIC rating shall be 65,000. The transfer switches shall be capable of switching all classes of load, and shall be rated for continuous duty when installed in a non-ventilated enclosure that is constructed in accordance with Underwriters' Laboratories, Inc., standard UL-1008. Emergency loads (ATS-2) shall be Step 1, while Optional Standby loads (ATS-1) shall be Step 2.
- 2. The transfer switches shall be double throw, actuated by a single electrical operator momentarily energized; and connected to the transfer mechanism by a simple overcenter type linkage with a total transfer time not-to-exceed one-half (1/2) second. The transfer switches shall be capable of transferring successfully in either direction with 70% of rated voltage applied to the switch terminals.
- 3. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be

mechanically locked in position without the use of hooks, latches, magnets, or springs; and shall be silver-tungsten alloy protected by arcing contacts, with magnetic blowouts on each pole.

4. The transfer switches shall be equipped with a manual operator that is designed to prevent injury to the operating personnel, if the electrical operator should suddenly become energized during manual transfer. The manual operator shall provide the same contact-to-contact transfer speed as the electrical operator to prevent a flash-over from switching the main contacts slowly.
5. The transfer switches shall be equipped with an elevator pre-signal contact.
6. Engine starting contacts shall be provided to start the generating plant, if any phase of the normal source drops below 70% of rated voltage, after an adjustable time delay period of three (3) to thirty (30) seconds, to allow for momentary dips. The transfer switches shall transfer to emergency, as soon as the voltage and frequency have reached 90% of rated voltage. After restoration of normal power on all phase to 90% of rated voltage, an adjustable time delay period of 0-30 minutes shall delay re-transfer to normal power, until it has had time to stabilize. If the emergency power source should fail during the time period, the time delay shall be by-passed, and the switches shall return immediately to the normal source. After the switches have retransferred to normal, the engine generator shall be allowed to operate at no load for an adjustable period of time (0-5 minutes) to allow it to cool before shutdown. The transfer switches shall include a test switch to simulate normal power failure pilot lights on the cabinet door to indicate the switch closed on normal or emergency and four (4) auxiliary contacts on the main shaft; two (2) closed on normal, the other two (2) closed on emergency. Included engine exerciser with 0-168 hours' timer.
7. Load transfer switches shall be as manufactured by Russelectric, ASCO, Westinghouse, or equal.
8. *Provide two hour rated stop/start circuits from the generator control panel to all automatic transfer switches as per Drawings.*
9. *Upon loss of normal power as sensed by the ATS controller and the expiration of the engine start time delay, a normally open and normally close engine starting contact shall change state simultaneously to initiate starting of the generator.*
10. *Upon restoration of normal power as sensed by the ATS controller, the expiration of the return to normal time delay, and a transfer back to normal power, the engine starting contacts shall simultaneously return to their normal state.*

L. Test:

1. The supplier of the equipment shall provide at no additional charge, any information or supervision required for the proper installation of the equipment. Upon completion of the installation of this unit, a test run of four hours shall be conducted by the equipment manufacturer's factory trained serviceman in the presence of the City Electrical Inspector and in full compliance with the latest edition of NFPA-110. Using load banks to test full generator KW, at this time adjustments shall be made for correct operation of the equipment and the following readings taken at 15-minute intervals.
  - Engine jacket water temperature
  - Generator temperature
  - Oil pressure
  - Battery charge rate
  - A.C. volts
  - A.C. amps (all legs)
  - Engine air exhaust temperature
  - Engine oil temperature
2. The unit test shall also be made by utilizing available connected load. The supplier

of this equipment shall also furnish and install lube oil in the engine and also drain and refill the engine with new lube oil after the engine-generator test has been completed. If the engine-generator unit should fail this initial test run, as determined by the representative of the Owner, after proper corrective measures have been implemented, replace engine lube oil again after the second test. If any additional tests are required to prove the performance of the engine-generator unit, lube oil shall be replaced after each test run.

3. Prior to shipment of generator to the job site, conduct a 3-hour full load shop test utilizing inductive load to attain full rated load. A written report of this test shall be forwarded to the Engineer for approval prior to shipment. All expense for these tests shall be carried by the Electrical Subcontractor.
4. A power outage test will be conducted by the Electrical Subcontractor, witnessed by the Commissioning Agent, using the Building load when all systems are completed. Electrical Subcontractor shall demonstrate proper operation of the emergency system to supply power to all emergency equipment during the simulated power outage and return back to normal utility service.
5. The Electrical Subcontractor shall pay for all fuel required for testing and shall leave the fuel tank full of fuel and the radiator full of antifreeze at the completion of testing and acceptance of the emergency generator.

M. Weather Housing

1. Weather housing shall be constructed of a minimum 16 gauge steel material. Fixed louvers shall be installed front and back to prevent blowing snow or rain from entering the housing. Roof shall have a crease down the length to prevent water from standing. Roof shall be braced, if necessary, to support the weight of silencer. Side panels and rear panels shall be lockable and removable for access to junction box. Locks must be heavy duty. Housing shall be free of any manufacturer's stickers and logos.
2. The enclosure shall be fabricated and mounted by the generator set manufacturer so as to insure compatibility of all systems. Seller-installed enclosures and enclosures provided by other than the manufacturer of the generator will not be acceptable. The complete assembly shall be factory finished and painted inside and out in the standard color of the manufacturer to help prevent against weathering and corrosion and to maintain an aesthetically pleasing appearance.
3. The enclosure shall be completed lined with a sound insulation barrier. This barrier must be not less than 1" thick and have a minimum density of 2 lbs. /3 cu. ft. In addition, material must meet UL-94 classification HF-1. This material is intended to absorb airborne noise within the enclosure.
4. The enclosure shall be sized such that all accessories specified herein including but not limited to:
  - Engine/Generator
  - Jacket heaters
  - Batteries
  - Battery charger
  - Base fuel tank
  - Exhaust
  - Line circuit breakers shall be housed within the enclosure.
5. Provide an exterior mounted vandal proof EPO station pre-wired into the generator control panel.

- N. Provide a cantilevered catwalk and railing assembly with a single stair that will attach to the base mounted diesel fuel tank that provides access to all enclosure doors and maintenance compartments. The catwalk, railing and stair assembly shall be manufactured of a non-rusting metal material and shall have grating on all walking surfaces. Stairs and

railings shall conform to all federal and local building/safety codes. The entire assembly shall be epoxy painted. The assembly shall be shipped loose for installation on site.

- O. Provide generator relay output to annunciate generator failure. The Electrical Subcontractor shall provide wiring from the generator relay output to the MDF Room. Provide 30 feet of extra wiring coiled in the MDF Room. The coil will need to be clearly labeled. The Communications Contractor will take the coiled wire, attach it and program it into the system as directed by the Owner.
- P. Communications between BMS system and generator shall be via Bacnet.

## 2.15 FIRE ALARM AND MASS NOTIFICATION SYSTEM

- A. Furnish and install an addressable combination fire alarm and mass notification system (MNS) as indicated on the Drawings and as herein described. The equipment and installation shall comply with the current applicable provisions of the following standards:
  - 1. NFPA 70 National Electrical Code
  - 2. NFPA 71 Central Station Signaling Systems-Protected Premises Unit.
  - 3. NFPA 72 National Fire Alarm Code
  - 4. State Building Codes.
  - 5. All requirements of the Local Authority Having Jurisdiction.
  - 6. Underwriters Laboratories, Inc.
  - 7. Massachusetts Electrical Code.
  - 8. NFPA 101 Life Safety Code
  - 9. Americans with Disabilities Act
- B. The system and all components shall be listed by Underwriters Laboratories, Inc. for use in Fire Protective Signaling Systems under the following standards as applicable:
  - 1. UL864 Control Units for Fire Protective Signaling Systems.
  - 2. UL268 Smoke Detectors for Fire Protective Signaling Systems.
  - 3. UL 268A Smoke Detectors for Duct Applications.
  - 4. UL 217 Smoke Detectors, Single and Multiple Station.
  - 5. UL 521 Heat Detectors for Fire Protective Signaling Systems.
  - 6. UL 228 Door Closers-Holders for Fire Protective Signaling Systems.
  - 7. UL 464 Audible Signaling Appliances.
  - 8. UL 1638 Visual Signaling Appliances.
  - 9. UL 38 Manually Actuated Signaling Boxes.
  - 10. UL 1481 Power supplies for Fire Protective Signaling Systems.
  - 11. City Fire Alarm Regulations.
- C. General Requirements
  - 1. Submittals
    - a. Submit complete documentation for the Fire Alarm/Life Safety System showing the Model Number, type, rating, size, style, Manufacturer's Names, and Manufacturer's Catalog Data Sheets for all items to ensure compliance with these Specifications. Submittals shall be prepared by a NICET level III and reviewed signed and dated by a NICET IV.
    - b. Upon Contract Bid approval, and prior to start of system installation, submit Shop Drawings to and obtain written approval from the Fire Department, prior to ordering fire alarm equipment. General requirements are as follows:
      - 1) Submittal of fire rated sealant for penetrations.
      - 2) A complete point to point riser diagram of the fire alarm system. (Typical riser diagrams are not acceptable).

- 3) A complete point to point installation diagram. (Typical installation diagrams are not acceptable).
  - 4) A complete list of current drain requirements during normal supervisory, trouble, and alarm condition.
  - 5) Battery standby calculations showing total standby power required to meet the specified system requirements.
  - 6) Supplier's qualifications indicating years in business, service policies, warranty definitions, and list of similar installations.
  - 7) Electrical Subcontractor qualifications, indicating years in business, prior experience with installations that include the type of equipment that is to be supplied, and installers license number and type of license.
  - 8) Circuit calculations for all Notification Appliance Circuits. Calculations shall conform to UL864 10<sup>th</sup> edition and shall be performed using 19vdc starting voltage with a drop allowance to minimum nameplate voltage for the devices on each circuit. Amplifiers shall be calculated based on the following tap settings".
    - a) Unless otherwise indicated, set to .5 watt.
    - b) Gymnasium, Cafeteria/Student Dining, rooms greater than 1,000 square feet and Mechanical rooms shall be set at 2 watts.
    - c) Corridors shall be set at .5 watt.
    - d) Classrooms shall be set at 1 watt.
    - e) Offices shall be set at .25 watt.
    - f) Provide one back up amplifier for each 50 watts provided to support the system. Provide 25% spare capacity.
- c. All substitute equipment proposed as equal to the equipment specified herein, shall meet or exceed the fire alarm and mass notification system equipment standards. For equipment other than that specified, the Electrical Subcontractor shall supply proof that such substitute equipment does in fact equal or exceed the features, functions, performance, and quality of the specified equipment. Submit this information for approval by the engineer at least ten (10) days prior to bid.
2. Equipment Manufacturer's
    - a. All references to manufacturer's or supplier's model numbers and other pertinent information herein is intended to establish minimum standards of performance, function and quality. Equivalent equipment (compatible UL Listed) from other manufacturers may be substituted for the specified equipment. Equipment substitution does not relieve the Electrical Subcontractor of operating and performance requirements specified herein.
  3. General Equipment and Material Requirements
    - a. All equipment and components shall be supplied by a factory authorized Autocall affiliate. All equipment and material shall be new and unused and listed by Underwriter's Laboratories for the specific intended purpose. All control panel components and field peripherals shall be designed for continuous duty without degradation of function or performance. All equipment covered by this Specification or noted on Installation Drawings shall be the best equipment suited for the application and shall be provided by a single manufacturer or be recognized and U.L. listed as compatible by both manufacturers.
    - b. Furnish and install a fully microprocessor based, fire alarm and mass notification system according to the following Specifications and as shown on the Drawings.

- c. The system will permit maximum system expansion and owner flexibility with a minimum of additional field wiring. The system shall be wired, connected, tested, and left in first class operating condition.
- d. The system shall be totally solid state, microprocessor based, to ensure reliable operation, low maintenance costs, and long life.
- e. The equipment and completed installation shall meet the approval of the Fire Department, the Authorities having jurisdiction, and in accordance with applicable Sections of NFPA 72 for Auxiliary Fire Alarm Systems, and National Fire Codes.
- f. All fire alarm control panels shall be predominately red in color and have a white label with the words FIRE ALARM CONTROL PANEL on the front of the panel with a minimum four (4) inch letter size. No other functions shall be allowed in the panel (e.g. security system).
- g. All fire alarm control panels shall provide 30% excess power supply capacity for future expansion.
- h. All equipment shall be listed by Underwriters Laboratories.
- i. Approved Equipment Suppliers
  - 1) Equipment and materials shall be as manufactured by Autocall or approved equal as manufactured by Edwards or Notifier. Equipment designations and model numbers herein specified are those of Autocall. It will be the responsibility of the Engineered System Distributor to ensure proper Specification adherence for system operation, final connection, test, turnover, warranty compliance, and after-market service. The distributor of the equipment specified shall be factory trained and certified.
- j. All equipment shall be provided by one manufacturer, Autocall, Edwards, or Notifier. Manufacturers listed shall insure compliance with the functional operating requirements specified herein.

D. System Operation

- 1. The system shall provide means to detect fire conditions within a protected property, transmit the alarm to the Fire Department via a Digital Alarm Communicating Transmitter to a UL listed Central Station, alert Building occupants in which the alarm occurred, supervise the entire system for conditions which would impair proper system operation and to annunciate such abnormal conditions in accordance with applicable codes.
- 2. The system shall provide means to initiate lock down emergency messaging via seamless integration with the buildings security management system within the protected property, transmit the condition to the Police Department via a Digital Alarm Communicating Transmitter to a UL listed Central Station, alert building occupants via custom voice and textural messaging with specific instructions, supervise the entire system for conditions which would impair proper system operation and to annunciate such emergency conditions in accordance with the Owners mass notification system plan.
- 3. Except as alternately required by the Fire Marshal, the operation of any alarm-initiating device shall cause the evacuation alarm to sound and be displayed on all evacuation signaling devices in all areas of the Building.
- 4. Alternate systems designed to sound/display evacuation signals only in designated areas shall be provided with means to sound/display the evacuation signal on any individual signaling device, group of devices or all connected devices. This means shall be field programmable and operated via selection switches provided at the control panel and mass notification system incident commander. There shall be no limit to the quantity of signaling zones and circuit wiring shall not dictate signaling zones. During a lockdown condition the system



- shall be capable of delivering live or recorded messages to any speaker or group of speakers via custom programming.
5. Audible/Visual devices shall be speaker/strobes listed for fire alarm service except as otherwise permitted. Addressable signal modules shall be utilized to accomplish field programmable signaling zones.
  6. Visual signaling devices shall be approved for the purpose and shall operate only in those areas where the evacuation signaling is required to be sounded and shall have the word "FIRE" permanently inscribed on their surfaces. Visual signaling zones shall also be field programmable.
  7. Mass notification system visual signaling devices shall be approved for the purpose and shall operate only in those areas where the emergency signaling is required to be sounded. Devices shall be amber and shall have the word "ALERT" permanently inscribed on their surfaces. Visual signaling zones shall also be field programmable.
  8. The system shall be electrically/electronically supervised against component failure of the entire audio path including wiring, switches and electrical contacts and shall detect opens, shorts, grounds or loss of signal, which might impair the function of the system.
- E. Main Fire Alarm Control Panel:
1. The FACP shall be an Autocall 4100ES or equal as manufactured by Edwards, or Notifier and shall contain a microprocessor based Central Processing Unit (CPU). The CPU shall communicate with and control the following types of equipment used to make up the system: addressable detectors, addressable notification devices, addressable modules, printer, annunciators, and other system controlled devices.
    - a. General: Comply with UL 864, "Control Units and Accessories for Fire Alarm Systems".
    - b. Network Communications shall be fiber optic interconnection of panels for data, voice and two-way communications via Modular Network Communications Cards
    - c. Alphanumeric Display and System Controls: Panel shall include an 854 character, expanded content multi-line QVGA LCD display to indicate alarm, supervisory, and component status messages and shall include a keypad for use in entering and executing control commands.
    - d. Nodes shall be interconnected via fiber-optic cable in minimum of 2" conduit.
    - e. Network node communication shall be through a token ring, hub, or star topology configuration, or combination thereof
    - f. A single open, ground or short on the network communication loop shall not degrade network communications. Token shall be passed in opposite direction to maintain communications throughout all network nodes. At the same time the status of the communication link shall be reported
    - g. If a group of nodes becomes isolated from the rest of the network due to multiple fault conditions, that group shall automatically form a sub-network with all common interaction of monitoring and control remaining intact. The network shall be notified with the exact details of the lost communications
    - h. The communication method shall be NFPA 72 style 7
  2. Network Synchronization of Notification Appliances
    - a. The fire alarm and emergency communications network shall be capable of providing UL Listed synchronization across all the notification appliance circuits for all panels on a network loop in accordance with the requirements of UL 1971
    - b. Systems that require all notification appliances to be connected to a single

- panel for synchronization thus creating a potential single point of failure shall not be acceptable
- c. Up to 99 panels on a network loop shall be capable of UL Listed synchronization of all notification appliance circuits across the network loop in accordance with the requirements of UL 1971
  - d. Should network communications be disrupted, re-synchronization shall occur across all nodes that continue to communicate together after network re-initialization is completed and restored to affected nodes
3. System Capacity and General Operation
- a. The control panel shall provide 3,000-point capacity where (1) point equals (1) monitor (input) or (1) control (output).
  - b. 2000 points of annunciation where one (1) point of annunciation equals 1 LED driver output on a graphic driver or 1 switch input on a graphic switch input module, 1 LED on panel or 1 switch on panel.
  - c. Alphanumeric Display and System Controls: Panel shall include an 854 character, expanded content multi-line QVGA LCD display to indicate alarm, supervisory, and component status messages and shall include a keypad for use in entering and executing control commands.
  - d. Software: The fire alarm system shall allow for loading and editing instructions and operating sequences as necessary
    - 1) The system shall be capable of on-site programming to accommodate system expansion and facilitate changes in operation
    - 2) All software operations shall be stored in a non-volatile programmable memory within the fire alarm control unit. Loss of primary and secondary power shall not erase the instructions stored in memory
    - 3) Panels shall be capable of full system operation during new site-specific configuration download, master exec downloads, and slave exec downloads. Panels shall be fully operational during program modifications
    - 4) Remote panel site-specific software and executive firmware downloads shall be capable of being performed over proprietary fire alarm network communications, and via TCP/IP Ethernet network communications. Ethernet access to any fire alarm panel shall be capable of providing access only to authenticated users through a cryptographically authenticated and secure SSL tunnel
    - 5) Panels shall automatically store all program changes to the panel's non-volatile memory each time a new program is downloaded. Panels shall be capable of storing the active site-specific configuration program and no less than 9 previous revisions in reserve. A compare utility program shall also be available to authorized users to compare any two of the saved programs. The compare utility shall provide a deviation report highlighting the changes between the two compared programs.
    - 6) Panels shall provide electronic file storage with a means to retrieve a record copy of the site-specific software and up to 9 previous revisions. Sufficient file storage shall be provided for other related system documentation such as record drawings, record of completion, owner's manuals, and testing and maintenance records.
    - 7) The media used to store the record copy of site-specific software and other related system documentation shall be electrically supervised. If the media is removed a trouble shall be reported on

- the fire alarm control unit.
- e. The FACP shall provide the following features:
- 1) History Logs: The system shall provide a means to recall alarms and trouble conditions in chronological order for the purpose of recreating an event history. A separate alarm and trouble log shall be provided.
  - 2) Fire Alarm Control Panel (FACP) shall provide the necessary hardware to provide supplemental notification and remote user access to the FACP using Ethernet and TCP/IP communications protocol compatible with IEEE Standard 802.3.
  - 3) The means of providing supplemental email and SMS text messaging notification shall be agency listed for specific interfaces and for the purpose described in this section. The use of non-listed external third-party products and interfaces is not acceptable.
  - 4) The fire panel internet interface shall be capable of sending automated notification of discrete system events via email and SMS text messaging to up to 50 individual user accounts and via email to up to 5 distribution lists.
  - 5) Each user account and distribution list shall be capable of being configurable for the specific type of events to be received. Each account shall be configurable to receive notification upon any combination of the following types of events:
    - a) Fire Alarm
    - b) Priority 2
    - c) Supervisory
    - d) Trouble
    - e) Custom Action Messages
    - f) Maintenance Alerts to warn of excessive compensation
- f. Required Functions: The following are required system functions and operating features:
- 1) Priority of Signals: Fire alarm events have highest priority. Subsequent alarm events are queued in the order received and do not affect existing alarm conditions. Priority Two, Supervisory and Trouble events have primary, based upon emergency condition-, third-, and fourth-level priority, respectively. Signals of a higher-level priority take precedence over signals of lower priority even though the lower-priority condition occurred first. Annunciate all events regardless of priority or order received.
  - 2) Noninterfering: An event on one zone does not prevent the receipt of signals from any other zone. All zones are manually resettable from the FACP after the initiating device or devices are restored to normal. The activation of an addressable device does not prevent the receipt of signals from subsequent addressable device activations.
  - 3) Transmission to an approved Supervising Station: Automatically route alarm, supervisory, and trouble signals to an approved supervising station service provider, under another contract.
  - 4) Annunciation: Operation of alarm and supervisory initiating devices shall be annunciated at the FACP and the remote annunciator, indicating the type of device, the operational state of the device (i.e. alarm, trouble or supervisory) and shall display the custom label associated with the device.
  - 5) Selective Alarm: A system alarm shall include: Indication of alarm

- condition at the FACP and the annunciator(s). Identification of the device /zone that is the source of the alarm at the FACP and the annunciator(s).
- 6) Operation of audible and visible notification appliances until silenced at FACP.
  - 7) Closing doors normally held open by magnetic door holders.
  - 8) Unlocking designated doors.
  - 9) Shutting down supply and return fans serving zone where alarm is initiated.
  - 10) Closing smoke dampers on system serving zone where alarm is initiated.
  - 11) Initiation of smoke control sequence.
  - 12) Transmission of signal to the supervising station.
  - 13) Initiation of elevator Phase I functions (recall, shunt trip, and illumination of indicator in cab) in accordance with ANSI/ASME A17.1 / CSA B44, Safety Code for Elevators and Escalators, when specified detectors or sensors are activated, as appropriate.
  - 14) Supervisory Operations: Upon activation of a supervisory device such as a fire pump power failure, low air pressure switch, and tamper switch, the system shall operate as follows:
  - 15) Activate the system supervisory service audible signal and illuminate the LED at the control unit and the remote annunciator.
  - 16) Pressing the Supervisory Acknowledge Key will silence the supervisory audible signal while maintaining the Supervisory LED "on" indicating off-normal condition. Record the event in the FACP historical log.
  - 17) Transmission of supervisory signal to the supervising station.
  - 18) Restoring the condition shall cause the Supervisory LED to clear and restore the system to normal.
  - 19) Alarm Silencing: If the "Alarm Silence" button is pressed, all audible alarm signals shall cease operation.
  - 20) Priority Two Operations: Upon activation of a priority two condition such as gas detection, chemical leak detection, intrusion alert, weather alert, the system shall operate as follows:
    - a) Activate the system priority two audible signal and illuminate the LED at the control unit and the remote annunciator.
    - b) Pressing the Priority 2 Acknowledge Key will silence the audible signal while maintaining the Priority 2 LED "on" indicating off-normal condition.
    - c) Record the event in the FACP historical log.
    - d) Transmission of priority two signal to the supervising station.
    - e) Restoring the condition shall cause the Priority 2 LED to clear and restore the system to normal.
    - f) System Reset: The "System Reset" button shall be used to return the system to its normal state. Display messages shall provide operator assurance of the sequential steps ("IN PROGRESS", "RESET COMPLETED") as they occur. The system shall verify all circuits or devices are restored prior to resetting the system to avoid the potential for re-alarmed the system. The display message shall indicate "ALARM PRESENT, SYSTEM RESET ABORTED."

- g) "Should an alarm condition continue, the system will remain in an alarmed state. A manual evacuation (drill) switch shall be provided to operate the notification appliances without causing other control circuits to be activated.
- h) WALKTEST: The system shall have the capacity of 8 programmable passcode protected one person testing groups, such that only a portion of the system need be disabled during testing. The actuation of the "enable one person test" program at the control unit shall activate the "One Person Testing" mode of the system as follows:
  - i) The city circuit connection and any suppression release circuits shall be bypassed for the testing group.
  - j) Control relay functions associated with one of the 8 testing groups shall be bypassed.
  - k) The control unit shall indicate a trouble condition.
  - l) The alarm activation of any initiating device in the testing group shall cause the audible notification appliances assigned only to that group to sound a code to identify the device or zone.
  - m) The unit shall automatically reset itself after signaling is complete.
  - n) Any opening of an initiating device or notification appliance circuit wiring shall cause the audible signals to sound for 4 seconds indicating the trouble condition.
  - o) Install Mode: The system shall provide the capability to group all non-commissioned points and devices into a single "Install Mode" trouble condition allowing an operator to clearly identify event activations from commissioned points and devices in occupied areas.
  - p) It shall be possible to individually remove points from Install Mode for phased system commissioning.
  - q) It shall be possible to retrieve an Install Mode report listing that includes a list of all points assigned to the Install Mode. Panels not having an install mode shall be reprogrammed to remove any non-commissioned points and devices.
  - r) Module Distribution: The fire alarm control unit shall be capable of allowing remote location of modules; interface of such modules shall be through a Style 7 (Class A) supervised serial communications channel (SLC): Initiating Device Circuits Notification Appliance Circuits Auxiliary Control Circuits Graphic Annunciator LED/Switch Control Modules
  - s) In systems with two or more Annunciators and/or Command Centers, each Annunciator/Command Center shall be programmable to allow multiple Annunciators/Command Centers to have equal operation priority or to allow hierarchal priority control to be assigned to individual Annunciator/Command Center locations.

- F. System Functional Operation
  - 1. System Alarm Detection and Reporting.

- a. When a fire alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:
  - 1) The System Alarm LED shall flash.
  - 2) A local Piezo-Electric signal in the control panel shall sound.
  - 3) The LCD display shall indicate all information associated with the Fire Alarm condition, including: type of alarm point, its location within the protected premises, and the time and date of that activation.
  - 4) All system output programs assigned via control-by-event equations to be activated by the particular point in alarm shall be executed, and the associated System Outputs (Alarm Indicating Appliances and/or relays) shall be activated.
    - a) A signal shall be sent to the Fire Department via telephone dialer/cellular fire alarm communicator.  
Installation shall meet all Fire Alarm system requirements for masterbox connections as provided by the Fire Department.  
A signal shall be sent to a central station via telephone dialer. Provide (2) Cat 5E cable to Building telephone terminal board.  
A signal shall be sent to a central station via single or dual path cellular commercial fire alarm communicator.
    - b) Close all fire doors.
    - c) Capture the elevator.
    - d) Shut down all HVAC units equipped with duct smoke detectors.
  - 5) Unacknowledged alarm messages shall have priority over trouble messages, and if such an Alarm occurs during a Trouble sequence, the Alarm condition will have display priority.
2. System Trouble Detection: When a trouble condition is detected and reported by one of the system initiating devices, the following functions shall immediately occur:
  - a. The System Trouble LED shall flash.
  - b. A local Piezo electric signal in the control panel shall sound.
  - c. The LCD display shall indicate all information associated with the Fire Alarm trouble condition, including: type of trouble point, its location within the protected premises, and the time and date of that activation.
  - d. If any of the available optional serially connected equipment is being used, then each of the connected peripherals will display/print the information associated with the Fire Alarm Control Panel condition, including the time/date stamping of the change of status event.
  - e. If applicable, all system output programs assigned via control-by-event equations to be activated by the particular point in trouble shall be executed, and the associated System Outputs (Trouble Indicating Appliances and/or relays) shall be activated.
  - f. Unacknowledged alarm messages shall have priority over trouble messages, and if such an Alarm occurs during a Trouble sequence, the Alarm condition will have display priority.
3. When a mass notification system condition is initiated and reported by one of the system initiating devices, the following functions shall immediately occur:
  - a. The FACP priority 2 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 mass notification system alarm condition, including the 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 mass notification system 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 (notification appliances and/or relays) shall be activated on either local outputs or points located on other network nodes.
  - f. Owner defined prerecorded messages shall be sounded throughout the building or to groups of speakers as defined by the Owner.
  - g. The digital alarm communicating transmitter shall summons the Police Department via a UL listed central station.
  - h. Activate message boards in common areas to display any one of 32 user defined messages.
  - i. Signals shall be sent to the integrated security alarm system to lock doors in accordance with the Owners Mass Notification procedures.
  - j. Activate predefined cameras for display and recording as defined by the Owner.
4. Voice Alarm: Provide an emergency communication system, integral with the FACP, including voice alarm system components, microphones, amplifiers, and tone generators. Features include:
    5. The evacuation alarm and alert signals shall be capable of being initiated automatically from the fire alarm control panel (FACP) and transmitted to any programmable speaker circuit, selected speaker circuits or all speaker circuits. Speaker circuits shall be fully programmable from the FACP. It shall be possible to create signaling/paging circuits without the need to rewire. Additional compensation shall not be awarded should the AHJ require additional signaling zones. This shall be accomplished via addressable signal control modules for each speaker/strobe shown on the drawings
    6. 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. The system shall not limit the quantity of circuits that may be programmed and shall not be contingent on wiring
    7. Live voice announcements, via the hand-held microphone or by the incident commander remote control microphone, 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
    8. Alarm speaker amplification equipment shall be sized, as a minimum, to provide the following wattage levels for each location type of alarm speaker:
      - a. Unless otherwise indicated, set to .5 watt.
      - b. Gymnasium, Cafeteria/Student Dining, rooms greater than 1,000 square feet and Mechanical rooms shall be set at 2 watts.
      - c. Corridors shall be set at .5 watt.
      - d. Classrooms shall be set at 1 watt.
      - e. Offices shall be set at .25 watt.
      - f. 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 twenty-five percent (25 percent) spare capacity to permit the addition of future alarm speakers.

- g. 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 dedicated backup amplifier. Provide dedicated power amplifiers for each speaker circuit (4 min.) with one dedicated backup per amplifier (one to one backup).
- h. Alarm tone and alert tone oscillators and pre-amplifiers shall be paired to provide 100 percent redundancy.
- i. As a minimum, each stairwell shall be provided with a dedicated notification appliance circuit.
- j. As a minimum, the system shall be configured as an eight-channel digital voice system. Eight (8) channels shall be available at all amplifiers for distribution of emergency messages to any speaker or group of speakers.
- k. 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.
- l. Deliver a field programmable, digitized custom evacuation message to the occupants, detailing evacuation instructions.
- m. 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.
- n. Perform all control functions as detailed elsewhere in this specification.
- o. 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.

G. Field Devices

1. Addressable Circuit Interface Modules

- a. Addressable Circuit Interface Modules: Arrange to monitor or control one or more system components that are not otherwise equipped for addressable communication. Modules shall be used for monitoring of waterflow, valve tamper, non-addressable devices, and for control of AHU systems.
- b. Addressable Circuit Interface Modules will be capable of mounting in a standard electric outlet box. Modules will include cover plates to allow surface or flush mounting. Modules will receive their operating power from the signaling line circuit or a separate two wire pair running from an appropriate power supply.
- c. There shall be the following types of modules:
  - 1) Type 1: Monitor Circuit Interface Module:
    - a) For conventional 2-wire smoke detector and/or contact device monitoring with Class B or Class A wiring supervision. The supervision of the zone wiring will be Class B. This module will communicate status (normal, alarm, trouble) to the FACP.
    - b) For conventional 4-wire smoke detector with Class B wiring supervision. The module will provide detector reset capability and over-current power protection for the 4-wire detector. This module will communicate status (normal, alarm, trouble) to the FACP.
  - 2) Type 2: Line Powered Monitor Circuit Interface Module



- a) This type of module is an individually addressable module that has both its power and its communications supplied by the two wire signaling line circuit. It provides location specific addressability to an initiating device by monitoring normally open dry contacts. This module shall have the capability of communicating four zone status conditions (normal, alarm, current limited, trouble) to the FACP.
- b) This module shall provide location specific addressability for up to five initiating devices by monitoring normally closed or normally open dry contact security devices. The module shall communicate four zone status conditions (open, normal, abnormal, and short). The two-wire signaling line circuit shall supply power and communications to the module.
- 3) Type 3: Single Address Multi-Point Interface Modules
  - a) This multipoint module shall provide location specific addressability for four initiating circuits and control two output relays from a single address. Inputs shall provide supervised monitoring of normally open, dry contacts and be capable of communicating four zone status conditions (normal, open, current limited, and short). The input circuits and output relay operation shall be controlled independently and disabled separately.
  - b) This dual point module shall provide a supervised multi-state input and a relay output, using a single address. The input shall provide supervised monitoring of two normally open, dry contacts with a single point and be capable of communicating four zone status conditions (normal, open, current limited, and short). The two-wire signaling line circuit shall supply power and communications to the module.
  - c) This dual point module shall monitor an unsupervised normally open, dry contact with one point and control an output relay with the other point, using a single address. The two-wire signaling line circuit shall supply power and communications to the module.
- 4) Type 4: Line Powered Control Circuit Interface Module
  - a) This module shall provide control and status tracking of a Form "C" contact. The two-wire signaling line circuit shall supply power and communications to the module.
- 5) Type 5: 4-20 mA Analog Monitor Circuit Interface Module
  - a) This module shall communicate the status of a compatible 4-20 mA sensor to the FACP. The FACP shall annunciate up to three threshold levels, each with custom action message; display and archive actual sensor analog levels; and permit sensor calibration date recording.
- 6) All Circuit Interface Modules shall be supervised and uniquely identified by the control unit. Module identification shall be transmitted to the control unit for processing according to the program instructions. Modules shall have an on-board LED to provide an indication that the module is powered and communicating with the FACP. The LEDs shall provide a troubleshooting aid since the LED blinks on poll whenever the peripheral is powered and communicating.

2. Isolator Module: Isolator modules shall be provided every between every 25 devices and between floors to provide short circuit isolation for addressable notification appliance SLC wiring. Isolator shall be listed to UL 864. The Isolator shall mount directly to a minimum 2 1/8" deep, standard 4" square electrical box, without the use of special adapter or trim rings. Power and communications shall be supplied by the Addressable Controller channel SLC; dual port design shall accept communications and power from either port and shall automatically isolate one port from the other when a short circuit occurs. The following functionality shall be included in the Isolator module:
  - a. Report faults to the host FACP.
  - b. On-board Yellow LED provides module status.
  - c. After the wiring fault is repaired, the Isolator modules shall test the lines and automatically restore the connection.

H. Addressable Manual Pull Stations

1. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
2. Description: Addressable double- action type, red LEXAN. Station shall mechanically latch upon operation and remain so until manually reset by opening with a key common with the control units. Station shall be pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit. Where double-action stations are provided, the mechanism shall require two actions push top activation door to initiate an alarm.
3. Provide with a front showing red LED showing that will flash each time it is scanned by the Control Unit (once every 4 seconds). In alarm condition, the station LED shall be on steady.
4. Provide a factory-fabricated, tamperproof, clear LEXAN enclosure shield and red frame that easily fits over manual pull stations which shall be hinged at the top to permit lifting for access to initiate a local alarm. Unit shall be NRTL listed. Lifting the cover shall actuate an integral battery-powered audible horn intended to discourage false-alarm operation. The horn shall be silenced by lowering and realigning the shield. The horn shall provide 85dB at 10 feet and shall be powered by a 9 VDC battery.
5. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

I. Addressable Analog Smoke Sensors

1. General Requirements for System Smoke Detectors:
2. Comply with UL 268, "Smoke Detectors for Fire Protective Signaling Systems." Include the following features:
  - a. Factory Nameplate: Serial number and type identification.
  - b. Operating Voltage: 24 VDC, nominal and shall be two-wire type.
  - c. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore normal operation.
  - d. Plug-In Arrangement: Sensor and associated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection. Base shall provide break-off plastic tab that can be removed to engage the head/base locking mechanism. Provide terminals in the fixed base for connection to building wiring. No special tools shall be required to remove head once it has been locked. Removal of the detector

head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the control unit. Sensors shall include a communication transmitter and receiver in the mounting base having a unique identification and capability for status reporting to the FACP. Sensor address shall be located in base to eliminate false addressing when replacing sensors. Integral Addressable Module shall be arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit. Each sensor base shall contain an integral visual-indicating LED

- e. Each sensor base shall contain a magnetically actuated test switch to provide for easy pre-certification alarm testing at the sensor location.
- f. Each sensor shall be scanned by the Control Unit for its type identification to prevent inadvertent substitution of another sensor type. Upon detection of a "wrong device", the control unit shall operate with the installed device at the default alarm settings for that sensor; 2.5% obscuration for photoelectric sensor, 135-deg F and 15-deg F rate-of-rise for the heat sensor, but shall indicate a "Wrong Device" trouble condition.
- g. Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit. Provide multiple levels of detection sensitivity for each sensor.
- h. Environmental compensation, programmable sensitivity settings, status testing, and monitoring of sensor dirt accumulation for the duct smoke sensor shall be provided by the FACP.
- i. The sensor's electronics shall be immune from nuisance alarms caused by EMI and RFI. Removal of the sensor head for cleaning shall not require the setting of addresses.
- j. Bases: CO Sensor, relay output, sounder and isolator bases shall be supported alternatives to the standard base.

J. Addressable Sensor Bases

- 1. Standard base - Twist lock addressable base with address selection DIP switch accessible from front with sensor removed. Integral red LED for power-on (pulsing), or alarm or trouble (steady on). Locking anti-tamper design mounts on standard outlet box.
- 2. Sensor Base with remote device connection - All standard base features with wired connection for either a Remote LED alarm indicator or remote relay (relay is unsupervised and requires separate 24VDC)
- 3. Supervised Relay Bases - All standard base features and shall be available in either a 4-Wire Sensor Base to use with remote or locally mounted relay; requires separate 24 VDC, or as a 2-Wire Sensor Base to use with remote or locally mounted relay; no separate power required. Supervised relay operation shall be programmable and shall be manually operated from control panel.
- 4. Sensor base with built-in electronic alarm sounder - All standard base features and piezoelectric sounder shall provide high output (88 dBA) with low current requirements (20 mA). Sounder shall be synchronized via SLC communications or by the NAC if NAC powered, sounder shall operation shall be programmable and shall be manually operated from control panel.
- 5. 520 Hz Sensor base with built-in electronic low frequency sounder - All standard base features and piezoelectric sounder shall provide a low frequency 520 Hz Square Wave (85 dBA) with nominal current requirements (115 mA). Sounder shall be synchronized via SLC communications or by the NAC if NAC powered, sounder operation shall be programmable and shall be manually operated from control

- panel.
6. Emitted tone shall be a 520Hz Square Wave signal in compliance with the requirements of the 2010 edition of NFPA 72 for sleeping areas.
  7. The 520Hz Sounder base shall be listed to UL 268 and UL464, Audible Signal Appliances.
- K. Addressable Duct Smoke Sensor
1. Standard Addressable Duct Smoke Sensor Unit. Photoelectric type, with sampling tube of design and dimensions as recommended by the manufacturer for the specific duct size and installation conditions where applied. Duct housing shall include relay or relay driver for fan shutdown.
  2. Environmental compensation, programmable sensitivity settings, status testing, and monitoring of sensor dirt accumulation for the duct smoke sensor shall be provided by the FACP.
  3. The Duct Housing shall provide a supervised relay driver circuit for driving up to 15 relays with a single "Form C" contact rated at 7A@ 28VDC or 10A@ 120VAC. This auxiliary relay output shall be fully programmable independent of the sensor head for activation by other alarm initiating devices within the fire alarm system. Relay shall be mounted within 3 feet of HVAC control circuit.
  4. Duct Housing shall provide a magnetic test area and Red sensor status LED and Duct Housing shall provide a relay control Yellow LED trouble indicator.
  5. Duct Housing shall have a transparent cover to monitor for the presence of smoke. Cover shall secure to housing by means of four (4) captive fastening screws.
  6. Duct Housing shall provide two (2) Test Ports for measuring airflow and for testing. These ports will allow aerosol injection in order to test the activation of the duct smoke sensor.
  7. For maintenance purposes, it shall be possible to clean the duct housing sampling tubes by accessing them through the duct housing front cover.
  8. Each duct smoke sensor shall be provided with a Remote Test Station with an alarm LED and test switch.
  9. Where indicated provide a NEMA 4X weatherproof duct housing enclosure that shall provide for the circulation of conditioned air around the internally mounted addressable duct sensor housing to maintain the sensor housing at its rated temperature range. The housing shall be UL Listed to Standard 268A.
- L. Addressable Heat Sensors
1. General Requirements for Heat Detectors: Comply with UL 521.
  2. Thermal Sensor Combination type: Fixed-temperature and rate-of-rise unit with plug-in base and alarm indication lamp; Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.
  3. Thermal sensor shall be of the epoxy encapsulated electronic design. It shall be thermistor-based, rate-compensated, self-restoring and shall not be affected by thermal lag. Selectable rate compensated, fixed temperature sensing with or without rate-of-rise operation.
  4. Mounting: Twist-lock base interchangeable with smoke-sensor heads.
  5. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
  6. Sensor fixed temperature sensing shall be independent of rate-of-rise sensing and programmable to operate at 135-deg F or 155-deg F. Sensor rate-of-rise temperature detection shall be selectable at the FACP for either 15-deg F or 20-deg F per minute.
  7. Sensor shall have the capability to be programmed as a utility monitoring device to monitor for temperature extremes in the range from 32-deg F to 155-deg F.

8. Unless otherwise indicated, sensors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for temperature by fire-alarm control unit.
  9. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
  10. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).
- M. Addressable CO Sensor
1. Addressable CO Sensor
  2. The CO Sensor shall be an addressable carbon monoxide (CO) sensing module providing both CO toxic gas detection and enhanced fire detection, and shall be listed to UL 268, Smoke Detectors for Fire Alarm Signaling Systems and UL 2075, Gas and Vapor Detectors and Sensors; allowing systems to be listed to UL 2034, Single and Multiple Station Carbon Monoxide Alarms.
  3. The CO Sensor shall include CO sensor element mounted in the sensor base which can be easily replaced without replacing the complete sensor base assembly.
  4. The CO Sensor base shall provide address selection in the base allowing the address to remain with its location when the sensor is removed for service or type change.
  5. The CO Sensor base shall include an integral red LED to indicate the power-on, trouble, test mode or alarm status.
  6. CO sensor shall provide enhanced fire detection with the addition of two selectable modes of operation: Nuisance Alarm Reduction Mode and Faster Fire Detection.
  7. The CO Sensor shall provide a 10 year life expectancy before replacement is necessary or required.
  8. The CO Sensor base shall report the following CO Sensor troubles: Communication loss, Disabled, Almost Expired 12 Months, Almost Expired 6 Months, Expired (End of Life), and Sensor Missing/Failed.
- N. Addressable CO Sounder Base
1. The CO Sensing element shall support operation with a Sounder base; the CO Sensor Sounder base shall provide temporal code 3 (TC3) for fire, or temporal code 4 (TC4) for toxic carbon monoxide alarms.
  2. The CO Sensor Sounder base shall be listed to UL464, Audible Signal Appliances.
  3. CO sensor shall provide enhanced fire detection with the addition of two selectable modes of operation: Nuisance Alarm Reduction Mode and Faster Fire Detection.
  4. The CO Sensor Sounder Base shall include CO sensor element mounted in the sounder base which can be easily replaced without replacing the complete sensor base assembly.
  5. The CO Sensor Sounder base shall provide address selection in the base allowing the address to remain with its location when the sensor is removed for service or type change.
  6. The CO Sensor Sounder Sensor base shall include an integral red LED to indicate the power-on, trouble, test mode or alarm status.
  7. The CO Sensor Sounder base shall report the following CO Sensor troubles: Communication loss, Disabled, Almost Expired 12 Months, Almost Expired 6 Months, Expired (End of Life), and Sensor Missing/Failed.
  8. The CO Sensor Sounder Base shall be interchangeable with the CO Sensor 520 Hz Sounder Base.

O. Notification Appliances

1. Notification appliances shall be fully addressable to allow for maximum flexibility in the creation of signaling zones. Systems that utilize conventional technology for notification appliances shall furnish and install an addressable module at each device to facilitate the desired operation specified. Systems that require addressable modules to support the desired operation shall insure ADA compliance.
2. Addressable Visible/Only: Addressable strobes shall be listed to UL 1971. The Visible/Only device shall consist of two xenon flash tubes one clear lens/reflector and one amber lens/reflector, cover shall have the lettering "FIRE" for the clear lens and "ALERT" for the amber lens, and a mounting plate. For ease of installation the mounting plate shall mount directly to a vertically mounted four gang electrical box, without the use of special adapters or trim rings. When the appliance is connected to an active circuit, the front cover of the appliance shall be removable without causing a trouble indication on the fire alarm control unit. Appliances shall be wired with UTP conductors, having a minimum of 3 twists per foot. The Visible/Only appliance shall be provided with multiple minimum flash intensities of 15cd, 30cd, 75cd, 110cd, 135cd and 185cd. The candela levels shall be settable from the fire alarm control unit or by using a hardware selector on the appliance. Clear and amber strobes shall be served by the same addressable notification circuit.
3. Addressable Weatherproof Visible/Only: Addressable weatherproof strobe shall be UL 1971 listed for indoor applications with strobe intensity selectable as 15 or 75 cd or UL 1638 listed for outdoor applications with strobe rated at 75 cd (WP75) or 185 cd (WP185). The appliances shall be acceptable for indoor and outdoor, extended temperature and extended humidity applications. The Visible/Only device shall consist of a xenon flash tube and associated lens/reflector system, weatherproof cover and weatherproof mounting box. The Visible/Only appliance shall be provided with multiple minimum flash intensities of 15, 75, WP 75, or WP 185 candela. The Candela levels shall be settable from the fire alarm control unit or by using a hardware selector on the appliance.
4. Addressable Speaker: Addressable Speaker notification appliances shall be listed to UL 1480. Individual device level supervision and activation control shall be provided by the fire alarm control unit.
  - a. Speakers shall be individually powered, addressed, and controlled from a compatible fire alarm control unit Signaling Line Circuit (SLC) using Unshielded Twisted Pair (UTP) cable and T-taps shall be allowed for Class B installation reducing wiring costs and wiring distances. Shielded cable shall not be required.
  - b. Speakers shall provide for Fire Alarm and General Signaling functionality in a single unit, eliminating additional devices. Device "Self-Test" shall be supported by a compatible fire alarm control unit and shall be UL listed and NFPA 72 compliant. Speakers shall be UL listed to provide a 520Hz audio tone in compliance with NFPA 72 for sleeping areas.
  - c. The speaker audio shall be provided by a standard 25VRMS or 70.7VRMS audio circuit using Unshielded Twisted Pair (UTP) cable. Shielded cable shall not be required.
  - d. Speaker power taps shall be at a minimum of 0.25W, 0.50W, 1.0W and 2.0W. At the 1.0W tap, the speaker shall have a minimum UL rated sound pressure level of 86dBA at 10 feet for the Standard Output version and 84dBA at 10 feet for the High Fidelity version.
  - e. Speakers shall be available in either "Standard Output" with a minimum frequency response of 400 to 4000 Hz or in "High Fidelity Output" with a minimum frequency response of 200 to 10,000 Hz. Standard Output

- speakers shall use a multi-tapped speaker for audio/tone notification.
- f. Wall mount appliances shall be available in White and Red and ceiling mount appliances shall be available in White, Red, and Black. Labeling shall be available as either "FIRE", "ALERT" or no labeling.
  - g. The speaker shall install directly to a 4" square, 2 1/8" deep electrical box. Extensions for these boxes shall not be required. Units shall be modular in design to allow for easy installation and for easy changing of device color and labeling.
5. Addressable Speaker/Visible: Combination Speaker/Visible (S/V) units combine the speaker and visible functions into a common housing. The S/V shall be listed to UL 1971 and UL 1480. Addressable functionality controls visible operation, while the speaker shall operate on a 25VRMS or 70.7VRMS NAC.
- a. Operational functions and features of Addressable Speaker above shall apply to this section. Operational functions and features of Addressable Strobe above shall apply to this section.
  - b. Wall mount appliances shall be available in White and Red and ceiling mount appliances shall be available in White, Red, and Black. Labeling shall be available as either "FIRE", "ALERT" or no labeling.
  - c. The speaker shall install directly to a 4" square, 2 1/8" deep electrical box. Extensions for these boxes shall not be required. Units shall be modular in design to allow for easy installation and for easy changing of device color and labeling.
6. Addressable Notification appliance operation shall provide power, supervision and separate control of speakers/horns/strobes and combination devices over a single pair of wires. The controlling channel (SLC) digitally communicates with each appliance and receives a response to verify the appliance's presence on the channel. The channel provides a digital command to control appliance operation. SLC channel wiring shall be unshielded twisted pair (UTP), with a capacitance rating of less than 60pf/ft and a minimum 3 twists (turns) per foot.
7. All Notification Appliances shall operate as a completely independent device allowing for specific location alerting of both fire alarm and Mass Notification functions. Each visible device (both clear fire alarm and amber mass notification) shall be capable of operating on multiple notification zones or completely separate from all other notification devices, this allows "On the fly" program operation changes for Mass Notification alerting and fire alarm notification.
8. All Notification Appliances shall operate as a completely independent device allowing for appliances in handicap accessible rooms and other locations to operate on the same SLC and to activate individually based on an alarm condition in a room or as part of a general alarm condition where all appliances activate together.
9. Individual Notification Appliances shall be able to be grouped into zones (or operational groups) by central programming at the main fire alarm control unit.
10. Notification Appliances shall provide for "unobtrusive" testing. Each Notification Appliance shall be tested for audible and visible operation on an individual basis at the device or from the main fire alarm control unit, allowing for minimal invasive impact.
11. Each Addressable notification appliance shall contain an electronic module and a selectable address setting to allow it to occupy a unique location on the channel. This on-board module shall also allow the channel to perform appliance diagnostics that assist with installation and subsequent test operations. A visible LED on each appliance shall provide verification of communications and shall flash with the appliances address setting when locally requested using a magnetic test tool.
12. Each addressable notification appliance shall have electrical test point access

without removing the device cover.

- P. Exterior Strobe Light
1. Maxi-Signal 490S series. The exterior strobe shall also be of weather-resistant rain tight construction.
  2. Provide weatherproof backbox.
  3. Weatherproof strobe shall be installed where directed by the Fire Department.
  4. Color of device shall be red.
- Q. Addressable Textual Notification Appliance (MNS): Textual Notification Appliance is to operate on a compatible Signaling Line Circuit (SLC) and is to provide a high visibility, multi-color LED text message display.
1. Textual Notification Appliance shall be Listed to UL 1638 Visual Signaling Appliances.
  2. Appliance shall be capable of up to thirty two (32) pre-programmed message selections that can be activated in response to pre-defined emergency situations or linked to specific system point status conditions.
  3. Textual Notification Appliance shall be capable of displaying dual or single line emergency instructions. Instructions can show as static, flashing, or scrolling with a variety of appearance/transition options. Instructions shall be capable of displaying using multi-colors to emphasize instructions content.
  4. Textual Notification Appliance shall be capable of providing non-emergency information during non-emergency conditions. Emergency conditions will override non-emergency message/instructions and display emergency instructions.
  5. Textual Notification Appliance shall be capable of scrolling instructions of at least 512 characters in length.
  6. Textual Notification Appliance shall be viewable from a distance of 100 feet.
  7. Textual Notification Appliance shall be powered by the fire alarm MNS power supply at 24VDC with battery back-up included if system battery calculations.
  8. Textual Notification Appliance shall be capable of wall or ceiling mounting options.
  9. Accessories: The Electrical Subcontractor shall furnish the necessary accessories.
- R. Magnetic Door Holders
1. Furnish and install, where shown on the plans, magnetic door holders, Autocall Model FM series. Magnetic door holders shall operate from 120VAC.
  2. The housing and contact plates shall be brushed zinc finish. Units shall have a holding force of approximately 35 pounds.
- S. Stopper Covers
1. Provide stopper covers on all manual pull stations. The protective shield shall be tamper proof, clear lexan with red frame installed over the fire alarm pull station. When the protective shield is lifted to gain access to the manual pull station, the protective shield shall sound a loud, piercing warning horn. The horn shall be battery powered and may be silenced by lowering and re-aligning the protective shield. Each stopper cover shall include a battery and the Electrical Subcontractor shall furnish two dozen spare batteries for replacement parts.
- T. Remote Annunciator with Microphone and Speaker Select
1. Provide remote alpha numeric, LCD Annunciator(s). Each annunciator will have a backlit LCD display with message scrolling buttons, System Status LED's for Power, Fire Alarm, Supervisory, System Trouble, Signal Silence, and Point Disabled, and key-enabled common control switches for Acknowledge, System



Reset, Signal Silence, Drill, and Lamp Test. The LCD annunciators shall display all alarm and trouble conditions in the system. The annunciators shall connect to an Remote Unit interface.

2. Remote Microphone with Power and Trouble LED's, two (2) form C contacts with one activating when microphone is in use.
3. Speaker circuit annunciator control module for manual control of twenty four (24) individual programmable speaker circuits. Each speaker circuit button to have corresponding Alarm and Trouble indicator.
4. Remote annunciator, Speaker control module and Remote microphone to be housed in a single cabinet with glass door and lock.
5. Provide a graphic zone map adjacent to each LCD annunciator. The graphic zone map shall conform to Fire Department requirements.

U. Incident Command Center

1. The Panel Mounted Graphical Workstations shall consist of:
  - a. UL 864 Listed for Annunciation and Control of all MNS system devices and functions.
  - b. Panel Mounted touchscreen computer/monitor powered from FACU and backed up for 60 hours standby with 15 minutes of alarm.
  - c. Industrial Grade i7 2.4 GHZ All-in-One Panel Mount.
  - d. Remote Ethernet Client Support: The Graphical Workstation server shall be capable of supporting up to 20 Simultaneous Remote Client Connections over Ethernet. When the maximum simultaneous client connections have been reached a notice shall be communicated to any additional client connection attempts indicating the connection capacity limit has been reached
  - e. Each Remote Client shall be configurable for Supervised or Unsupervised operation. Loss of communication with a Supervised client shall be indicated at both the server and the remote supervised client. Loss of communication to an Unsupervised client shall be indicated at the remote client only.
  - f. The Graphical Workstation server shall be capable of supporting both Agency Listed Fire Alarm Ethernet LAN Applications and Supplemental Annunciation over the Customer's Ethernet LAN/WAN. Where a Fire Alarm Ethernet LAN is specified only Agency Listed Ethernet hardware shall be installed.
  - g. Mobile Client Support. The Graphical Workstation shall support both Apple iPhones and iPads, and Android phones and tablets. This support shall include providing fire alarm network annunciation and limited control through a compatible 3G and 4G cellular service via VPN (virtual private network) connection. Mobile Client Support shall connect an essentially unlimited number of TSW Mobile Clients for simultaneous status information access. Limited control function shall be accessible by password-controlled login and by designated mobile device.
  - h. Email Support. The graphical workstation shall have the ability to transmit email notifications when events occur on the graphical workstation.
    - 1) Up to 50 user email accounts shall be supported.
    - 2) Each email user account shall be configurable to receive one or more types of events (Fire, Priority 2, Supervisory, and/or Trouble).
    - 3) The email content shall be selectable to include or exclude pre-defined message content allowing the size and content of the email message to be managed.

- V. Mass Notification Local Operator Console
1. Local Operator Console is designed for indoor use with the Autocall 4100ES control panel for mass notification applications. The LOC shall contain an A100-9814 Info Alarm Command Center with 320 X 240 LCD display, In addition to the switches and controls provided inherently with the Command Center, provide an additional sixteen black push on/push off illuminated push buttons for speaker circuit selection, 16 illuminated push buttons for message selection, and a microphone for live messages. The speaker circuits shall be fully user defined and not be contingent on circuit wiring. Circuits shall be defined through system software. Controls shall be installed in a platinum colored cabinet with glass door and magnetic lock. Panel shall be labeled "Emergency Communications". The controls shall be fully replicated at the main FACP in the event that office personnel are unable to initiate emergency messages.
  2. Standard features:
    - a. 24I/O Module
    - b. 16 illuminated push buttons
    - c. Magnetic latch
    - d. 16.5 in. w x 12.63 in. h x 4 in. d 16 ga CRS enclosure
    - e. Indoor, surface or semi-flush mount
    - f. Platinum powder coat finish with white silk screened lettering
  3. Remote Microphone Assembly
    - a. The remote microphone assembly uses power from the panel of the LED. All other interfaces do not draw any additional power other than what is already accounted for on the host interface, which is used for supervising the key switch, push-to-talk (PTT), and microphone wiring.
- W. Mass Notification High Power Speaker Array
1. HyperSpike 5 channel model MA-1, providing alarm tone, pre-recorded or live voice announcements at 80 dB. Measured at 200 meters from the source. The emitter shall be a: 5 sided unit with one (1) 2" outside diameter (OD) pipe and pedestal, wall mounting hardware.
  2. 143 dB SPL peak acoustic output. 125 Hz – 8 kHz Frequency Response
  3. 1.13-mile radius
  4. STI 0.91 out of 1.0
  5. The emitter shall be able to transmit an 80 dB (LAeq) audible signal up to 1,969 feet and operate at a power 1600 W. Equipment shall be suitable for indoor or outdoor wet locations and approvals shall include UL1480A listing with Class I Division 2, Groups A, B, C, and D Hazardous Location Certification; or Non-Hazardous locations only.
  6. Provide wall and pipe mounting kits for exterior installation
  7. Provide a dedicated FACU channel with isolation and disconnects per unit.
- X. Mass Notification High Power Speaker Array Amplifier
1. Provide Encompass Amplifier for Exterior High Power Speaker Array. Amplifier shall consist of the following:
    - a. Electronic Cabinet Dimensions 36" T x 36" W x 12" D
    - b. Electronic Cabinet Weight 155 lbs (not including batteries)
    - c. Audio Enable Input 24VDC nominal relay closure
    - d. Audio Enable Enable Input Active AND Line-in Signal above Detect Threshold
    - e. Audio Input Differential, 1 VRMS (25/70/100 VRMS adapter accessory available)
    - f. Trouble Outputs Trouble Signals: Master, AC, DC, Temperature, Tamper, Amp, Speaker

- g. Output Channels 10
  - h. Primary Input Voltage 120 VAC; 60 Hz Single-phase
  - i. Output Power 320W (avg), 640W (peak)/channel
  - j. Standby Time 60hrs Provide battery size accordingly
- Y. Transmitter/Receiver Beam Smoke Detector with Reflector and Remote Test Station
- 1. The projected beam type smoke detector shall be a 4-wire 24 VDC device to be used with a UL Listed separately supplied 4-wire control panel. Unit shall be listed to UL 268 and shall consist of an integrated transmitter and receiver. The detector shall operate between a range of 15 ft to 330 ft (5 m to 100 m). The temperature range of the beam shall be -4° F to 131° F (-20° C to +55° C) [UL 268 listed temperature range is 32° F to 100° F (0° C to 38° C)]. The beam detector shall feature automatic gain control which will compensate for gradual signal deterioration from dirt accumulation on the lenses. The unit shall include a wall mounting bracket. Testing shall be carried out by using a calibrated obscuration test filter. The reflective beam type smoke detector shall be an Autocall 100RU (330 ft/100 m).
- Z. Fire Alarm/Life Safety System Installation
- 1. Provide and install the system in accordance with the plans and Specifications, all applicable Codes, and manufacturer's' recommendations. All wiring shall be installed in strict compliance with all the provisions of the National Electrical Code, Power Limited Fire Protective Signaling Circuits or if required may be reclassified as non-power limited and wired in accordance with National Electrical Code. Upon completion, the Electrical Subcontractor shall so certify in writing to the Owner.
  - 2. Removal of a smoke detector will not interfere with the transmission of signal from manual stations, waterflow switches, and other initiating devices.
  - 3. All Equipment shall be attached to a non load-bearing wall, and shall be held firmly in place. Fastening and supports shall be adequate to support the required load, and provide a safety factor of five.
  - 4. As indicated on the Riser/Connection Diagram Drawings, each system alarm point or zone in the system shall be uniquely labeled within the Fire Alarm Control Panel. Names of the system point(s)/zone(s) shall be as defined by the Engineer.
  - 5. Fire Sprinkler Activation detecting System(s) shall each be indicated on a separate zone in the Fire Alarm Control Panel.
  - 6. Fire Alarm Control Panel will be mounted with the center of panel 60 inches above floor level.
  - 7. All junction boxes shall be sprayed red, locked, and labeled "Fire Alarm". Wiring color codes shall be maintained throughout the installation in accordance with Massachusetts Fire Alarm Code.
  - 8. Cable and Wiring.
    - a. Conduit and Conductors: Provide complete wiring and conduit between all equipment. Unless otherwise specified within the Installation Manual of the specific equipment being used, all field wiring shall be minimum #14 Type in separate conduit, maximum 40% full, and shall be approved for use as Fire Alarm cable. Conduits of proper size shall be installed from the Control Panel; Equipment to field devices. All field devices shall be mounted upon U.L. Listed Electrical junction boxes. All splices in field wiring shall be made in U.L. Listed Electrical junction boxes. No wire nuts shall be allowed. All Electrical junction boxes shall be labeled as "Fire Alarm System" with decal or other approved markings. The Fire Alarm/Life Safety Installation shall comply fully with all Local, State and National Codes, and the Local Authority Having Jurisdiction (AHJ).
    - b. The Fire Alarm Control Panel 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 Control Panel Cabinet shall be grounded securely to either a cold water pipe or grounding rod. Conduit shall enter into the Fire Alarm Control Panel backbox only at those areas of the backbox, which have factory conduit knockouts.
- c. All field wiring shall be completely supervised. In the event of a primary power failure, disconnected standby battery, removal of any internal modules, or any open circuits in the field wiring; an audible and visual trouble signal will be activated until the system and its associated field wiring are restored to normal condition.
  - d. Fire alarm MC cable shall be allowed above ceilings, in attics and in other areas allowing surface wiring if so approved by the Local Authority Having Jurisdiction.
  - e. Cable shall be the type listed for Fire Alarm/Life Safety use and shall be installed per National Electrical Code.
  - f. Cable for Addressable/Intelligent Alarm Initiating Appliances (Manual Stations, Heat Detectors, and Smoke Detectors) shall be connected as shown on the riser diagram. Cable shall be installed from the Fire Alarm Control Panel to all devices in that Signaling Line Circuit (SLC) loop. The connection and continuity of the wires, which make up that SLC loop will be continuously supervised for shorts, opens, and ground circuit conditions.
  - g. Cable for Alarm Initiating Devices and Appliances (Manual Stations, Heat Detectors, and Smoke Detectors) shall be connected to the Fire Alarm Control Panel, and labeled as shown on the riser diagram. Cable shall be installed from the Fire Alarm Control Panel to all devices in that Initiating Device Circuit (IDC) loop. The connection of the cable to that loop will be continuously supervised for shorts, opens, and ground circuit conditions.
  - h. Cable for Alarm Indicating Appliances (Audible or Visual or combination signal(s)) shall be connected on a per zone basis. Cable shall be installed from the Fire Alarm Control Panel to all devices in that Indicating Appliance Circuit (IAC) loop. The connection of the cable to that loop will be continuously supervised for shorts, opens, and ground circuit conditions.
  - i. 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, as per National Electrical Code.
  - j. All exposed cable below 84 inches from the surface of the finished floor, or other locations where the cable may become exposed and/or damaged, must be within a steel conduit.
  - k. Conduits must also be provided in elevator shafts and hoist ways. Cables within ducts or plenums must conform with the Specifications of the National Electrical Code.
  - l. Conduit shall not enter the Fire Alarm Control Panel, or any other remotely mounted Control Panel equipment or back boxes, except where conduit entry knockouts have been provided by the factory.
  - m. Cable shall meet all the manufacturer's requirements including shielding, twists, capacitance, resistance and gauge. The cable shall not be installed without approval of the manufacturer in writing.
- AA. Final System Acceptance.
- 1. The system will be accepted only after a Factory-Trained Distributor in the presence of the Electrical Subcontractor, the owner's representative and the Local Fire Marshal have accomplished a satisfactory test of the entire system, in

accordance with NFPA 72. Upon completion of a successful test, the Electrical Subcontractor shall so certify in writing to the Owner. The Electrical Subcontractor shall pay all back charges assessed by the Fire Department for all fire alarm system tests.

2. The Electrical Subcontractor shall submit, in the Shop Drawings, a letter confirming that they will provide a U.L. listed testing company to provide the acceptance test.
3. The Electrical Subcontractor will present a complete set of "As- Built" Fire Alarm/Life Safety system Drawings, and the factory supplied Operator's Manual to the Building Owner's Representative and the local AHJ.
4. The Electrical Subcontractor shall provide the on-site services of an Authorized, Factory Trained technical representative to supervise all connections and fully test all devices and components of the system during installation phase.
5. The Electrical Subcontractor shall provide comprehensive Training on the operation, proper use, and testing of the installed Fire Alarm System to the Building Owner's Representative, and the local AHJ

BB. Warranty

1. The Electrical Subcontractor shall warrant the completed fire alarm system, wiring and equipment, to be free from inherent mechanical and electrical defects for a period of one (1) year from the date of the completed and certified test or from the date of the first beneficial use.

2.16 FLOOR BOXES

- A. Recessed floor boxes shall be by Hubbell, Wiremold, or equal and shall have the following features:
  - a. Large Capacity Multi Service Floor Boxes
    - i. Multi-Service Floor Box: Hubbell CFB6G30R Series with CFBS1R8CVR series cover and FBMP series internal device bracket(s) and appropriate HBL Series communication brackets to be coordinated with appropriate communications terminations. For on grade applications use CFB6G30RCR corrosion resistant series boxes.
- B. Installation
  1. Disconnect power before installation. For installation in accordance with National Electric Code and any applicable local codes and standards.
  2. Do not interchange exposed metallic parts with exposed non-metallic parts.
  3. Exposed conductors at any wiring junction may cause short circuits, electrical shock or fire. Proper wiring practices must be followed.
  4. Provide adequate concrete thickness under the floor box to preserve the fire rating of the floor in accordance with national and/or local codes.
  5. Power and communications wiring not separated by a physical barrier is a code violation.
- C. Field Quality Control Testing and Inspection
  - a. Verify layout and installation of system to contract drawing.
  - b. Verify that all wiring junctions or connections have no exposed conductors prior to energizing circuits.
  - c. Verify that all bonding locations are code and standard compliant.
  - d. Verify that a physical barrier separates power and communication wiring.
- D. Verify type of communications jacks required with Owner and Telecommunications system installer.

- E. Verify type of audio/visual jacks required with Owner and Audio/Visual consultant's drawings and Audio/Visual system installer.
- F. Provide receptacles and technology outlets as indicated in floor box on Electrical and Technology drawings and provide conduit to above accessible ceiling from each individual technology outlet as indicated.
- G. Coordinate cover color and finish with Architect in field.

## 2.17 FUSES

- A. General
  - 1. Furnish and install a complete set of fuses for all fusible equipment on the project as specified by the Electrical Drawings. Final tests and inspection shall be made prior to energizing the equipment. This shall include tightening all electrical connections and inspecting all ground conductors. Fuses shall be as manufactured by Mersen, Cooper Bussman, and Littelfuse, or equal.
- B. Mains, Feeders and Branch Circuits
  - 1. Fused circuits rated 601 amperes and above shall be protected by current-limiting Class L A4BQ fuses. Fuses shall be time delay and shall hold 500% of rated current for a minimum of 4 seconds, clear 20 times rated current in .01 seconds or less and be UL listed and CSA certified with an interrupting rating of 200,000 RMS symmetrical amperes.
  - 2. Fused circuits rated 600 amperes or less shall be protected by current-limiting Class RK1 time delay A2D (250V) or A6D (600V) or Class J time delay AJT fuses. Fuses rated 8 amperes and above shall have the Smart Spot blown fuse indicator. This indicator shall provide guidance for ascertaining if the opening was caused by an overload or a short circuit. No holes are permitted in the fuse body for the indicator function. Fuses shall hold 500% of rated current for a minimum of 10 seconds (30A, 250V Class RK1 case size shall be a minimum of 8 seconds) and shall be UL listed and CSA certified with an interrupting rating of 200,000 RMS symmetrical amperes.
  - 3. Metal end caps of fuses rated 61 through 600 amperes shall be electrically connected to the fuse blades to facilitate safe voltage testing during OSHA required LOTO (lock out/tag out) procedures.
- C. Motors and Motor Controllers
  - 1. Motor Protection
    - a. All individual motor circuits shall be protected by Class RK1, Class J, or Class L time delay fuses.
  - 2. Motors under 10 H.P.
    - a. ATDR fuses (Class CC) may be used on motors rated less than 10 H.P. at 480VAC and rated less than 5 H.P. at 240VAC. Fuse holders for Class CC fuses shall incorporate blown fuse indication.
    - b. Fuse sizes for motor protection shall be chosen from tables published for the appropriate fuse. Heavy load and maximum fuse ratings are also shown for applications where typical ratings are not sufficient for the starting current of the motor.

APPLICATION INFORMATION

# LOW VOLTAGE FUSES FOR MOTOR PROTECTION

Three Phase Motor Fuse Selection UL Classes RK5, RK1, J, CC and L

MOTOR HP	FULL LOAD AMPERES	RECOMMENDED FUSE AMPERE RATING								
		MINIMUM 2 SECS.			TYPICAL 5 SECS.			HEAVY LOAD OVER 5 SECS.		
460V		RK5-TRS (Tri-onic®)/RK1-A6D			J-AJT			UL CLASS CC ATDR		
1/2	1.1	1-4/10	1-6/10	2	1-1/2	1-6/10	2	3	3-1/2	4-1/2
3/4	1.6	2	2-1/4	2-8/10	2	2-1/4	2-8/10	3-1/2	5	6-1/4
1	2.1	2-1/2	3-2/10	4	2-1/2	3-2/10	4	5	6-1/4	9
1-1/2	3	3-1/2	4-1/2	5-6/10	3-1/2	4-1/2	5-6/10	6	9	12
2	3.4	4	5	6	4	5	6	8	10	12
3	4.8	5-6/10	7	9	6	8	9	12	15	17-1/2
5	7.6	10	12	15	10	12	15	15	25	30
7-1/2	11	15	17-1/2	20	15	17-1/2	20	25	30	-
10	14	17-1/2	20	25	17-1/2	20	25	30	-	-
15	21	25	30	40	25	30	40	-	-	-
20	27	35	40	50	35	40	50	-	-	-
25	34	40	50	60	40	50	60	-	-	-
30	40	50	60	70	50	60	70	-	-	-
40	52	70	80	100	70	80	100	-	-	-
50	65	80	100	125	80	100	125	-	-	-
60	77	100	125	150	100	125	150	-	-	-
75	96	125	150	175	125	150	175	-	-	-
100	124	175	200	225	175	200	225	-	-	-
125	156	200	225	300	200	225	300	-	-	-
150	180	225	250	350	225	250	350	-	-	-
200	240	300	350	450	300	350	450	-	-	-
250	302	400	450	600	400	450	600	-	-	-
300	361	450	600	-	450	600	-	-	-	-
		CLASS L-A4BT								
300	360	-	601	650						
400	477	-	800	900						
500	590	-	1000	1100						

**Minimum** - This sizing is recommended if motor acceleration times do not exceed 2 seconds. Minimum sizing with RK1, RK5, and Class J fuses will provide overload relay back up protection but may not coordinate with some NEMA Class 20 overload relays. Minimum sizing is generally not heavy enough for motors with code letter G or higher.

**Typical** - Suggested for most applications. Will coordinate with NEMA Class 20 overload relays. Suitable for motor acceleration times up to 5 seconds.

**Heavy Load** - Maximum fuse size in accordance with Table 2. If this fuse size is not sufficient to start the load, RK1, RK5, and J time delay fuse size may be increased to a maximum of 225% of full load amperes. Class CC fuses may be increased to 400% of full load amperes. The Heavy Load column should be used for Design E and high efficiency Design B motor fuse sizing.

3. Motor Controllers
    - a. IEC style and NEMA style motor controllers shall be protected from short circuits by time delay fuses. Controllers and fuses shall be coordinated for Type 2 protection of the motor controllers based upon the motor controller manufacturer's published recommendations. The fuses shall be Class RK1 A2D (250V) or A6D (600V) or Class J AJT, Class CC ATDR or Class L A4BQ.
  4. AC and DC Variable Speed Drives
    - a. AC and DC drives not internally protected by high speed fuses shall be provided branch circuit protection by High Speed Class J (HSJ) fuses. Class J time delay AJT fuses are an acceptable alternative to the HSJ in by-pass applications.
- D. Other Equipment
1. Lighting and control circuits rated 600VAC and less shall be protected by Class

- CC time delay ATDR or ATQR fuses, sized according to the Drawings.
2. Switchboards, panelboards, and load centers shall utilize fully rated and listed components. Series rated overcurrent protective devices are not acceptable.
- E. Labeling
1. Industrial control panel labels shall include a SCCR (short circuit current rating) and shall specify the overcurrent protection device upon which this rating is based as per the National Electrical Code.
  2. Switchboards, panelboards, industrial control panels, and motor control centers shall include a label warning qualified personal of the potential arc flash hazard. The label shall be visible with equipment door closed.
- F. Spares
1. Spare fuses amounting to 10% (minimum three) of each type and rating shall be supplied. These shall be turned over to the Owner upon project completion. Fuses shall be contained and cataloged within the appropriate number of spare fuse cabinets (no less than one), located per Drawings. Spare fuse cabinets shall be equipped with a key lock handle, be dedicated for storage of spare fuses and shall be ATFC.
- G. Execution
1. To prevent mechanical damage to fuses; main, feeder, and branch circuit fuses are to be removed from equipment during transit and re-installed when equipment is to be energized.
  2. As installed Drawings, showing actual fuses installed, shall be submitted to the Engineer after completion of the project.
  3. Fuseholders capable of accepting Class H fuses are not acceptable.
- H. Substitution
1. Fuse sizes indicated on Drawings are based on fuse performance and selectivity ratios. Alternative submittals to furnish materials other than those specified shall be submitted to the Engineer along with short circuit, selective coordination, and arc flash hazard studies.
  2. Performance of any fuses submitted for substitution shall have:
    - a. Indication integral with the fuse so that it indicates the voltage transient when the fuse is opened. This is a relative measure of how severe the fault was and gives information to the maintenance people to make them more efficient. No holes are permitted in the fuse body for the installation of indicators.
    - b. Only the listed UL categories must be used, in order to reduce the possibility of arc flash injuries. Class RK5 and Class H are prohibited and could cause major liability should an arc flash occur.
    - c. All end-caps of fuses must be electrically connected to the fuse blades to prevent misreading of electrical testers during the required OSHA LOTO (Lock-Out Tag-Out) procedures. Misreading on the LOTO final voltage check could cause hazardous shock.

## 2.18 LIGHTING FIXTURES

- A. Furnish all labor, materials and equipment required for a complete installation of lighting equipment specified on the lighting fixture schedule. This shall include plaster frames for all recessed fixtures whether or not itemized or specified on lighting fixture schedule which appears on Drawings.



- B. Electrical Subcontractor shall assume all responsibility for the safe handling of all lighting fixtures which are furnished under this Section and other accessories and lamps until the final inspection has been made by the Architect.
- C. Special fittings and materials that may be required to support fixtures shall be supplied as well as supports or grounds required to secure surface or pendant mounted fixtures on suspended ceilings unless otherwise noted. Fixtures shall be supported from the Building structure, and shall be independent of ducts, pipes, ceilings and their supporting members. This support shall be in addition to regular fixture support bars, and saddles. Fixtures mounted in association with suspended or integrated ceiling systems shall be supported above ceiling by threaded 1/4" diameter continuous galvanized steel hanger rods or #12 jack chain. Each such fixture shall have two supports per fixtures. Where duct work, pipes, type of Building construction materials and structural framing members provide obstructions or difficult support means, hanger rods shall be used in association with horizontal sections of steel support channels in an approved manner. Steel support channels shall be Unistrut, Kindorf, Huskey Products, or equal. Rigid steel conduit may be used instead of steel support channels for size and method of support. Exact mounting height of all stem supported lighting fixtures shall be determined on the job by Architect.
- D. Fixtures, part or parts thereof (including lamps) determined defective upon completion of electrical installation shall be replaced by Electrical Subcontractor, at no cost to Owner.
- E. Consult with General Contractor regarding arrangement of framing members to permit centering of recessed fixtures.
- F. Consult with Ceiling Subcontractor and coordinate fixture locations and supports with suspended ceiling system.
- G. Electrical Subcontractor shall be responsible for furnishing the specified recessed fixtures with proper mounting arrangement to be compatible with the type of ceiling construction in which fixture is to be mounted. If necessary, the type mounting arrangement shall be changed from that specified or indicated on fixtures schedule to conform to this requirement, at no additional cost to Owner. Submission of Shop Drawings of such recessed fixtures shall be interpreted to indicate that Electrical Subcontractor has verified ceiling construction, type and material with the Architect for the various areas of the project in which these fixtures shall be mounted. Shop Drawings of such fixtures shall be accompanied by a written statement indicating Electrical Subcontractor has verified such mounting arrangements with Architect and the date verified.
- H. All suspended lighting fixtures shall be hung in association with improved aligner type hangers, except where noted.
- I. In addition to fixture supports, surface mounted lighting fixtures shall be secured to surface which they mount at a minimum of two points on fixture housing to prevent rotation or movement of fixture out of its normal position of alignment.
- J. After installation and lamping of permanent lighting fixtures and with approval of the Architect, these fixtures may be used for lighting, and will not require re-lamping prior to completion of project, except where lamps are faulty or burnt out.
- K. Lamping color temperature shall be as indicated on Drawings.
- L. Lighting fixtures with multi wattage ballasts and drivers shall be labeled from the factory for the wattage specified to ensure compliance with Energy Code calculations.

- M. All lighting fixtures that utilize LED (light emitting diodes) lamp sources shall be Energy Star rated or DLC (Designlights Consortium) qualified product listed, a kelvin temperature as scheduled having a color rendering index of 80 minimum and minimum L70 lifetime rating of 50,000 at 25°C ambient. LED array and driver packages shall have published IESNA LM-79 and LM-80 testing data as a standard manufactured offering. Individual component testing will not be accepted. LM-79 must be conducted at a laboratory listed in the U.S. Department of Energy's LED Lighting Facts approved testing laboratories list. Testing must be conducted within the accreditation effective and expiration dates detailed for a given laboratory. In-house LM-80 reporting of LED array from LED manufacturer will be accepted.
- N. Where lighting fixtures other than the specified products are provided, the Electrical Subcontractor shall provide light level calculations in accordance with IESNA standards to justify that substituted fixtures are of equal performance to the specified products (applies to all lighting fixtures in all spaces).

## 2.19 LIGHTNING PROTECTION

- A. General
  - 1. Scope
    - a. The work covered by this Section of the Specifications consists of providing services of a qualified lightning protection engineer, labor and materials required for the design and installation of a functional and unobtrusive lightning protection system. System shall comply with the latest issue of Underwriters' Laboratories, Incorporated Master Label Code 96A and NFPA Code No. 780 Lightning Protection Systems. At the completion of the installation an Underwriters' Laboratories, Incorporated Master Label shall be furnished to the Owner.
    - b. If any departure from the Drawings or Shop Drawings covered below are deemed necessary by the Electrical Subcontractor, details of such departures and reasons therefore shall be submitted as soon as practicable to the Architect for approval. No such departures shall be made without prior written approval of the Architect.
  - 2. Quality Assurance
    - a. The system to be furnished under this Specification shall be the standard product of the manufacturer regularly engaged in the production of lightning protection systems and shall be the manufacturer's latest approved design. The equipment manufacturer shall also be an approved manufacturer. All material specified in this Section is manufactured by Heary Bros. Lightning Protection Company, Inc., 11291 Moore Road, Springfield, New York 14141. Lightning protection shall be as manufactured by Heary Brothers Lightning Protection Company Inc., Boston Lightning Rod Inc., East Coast Lightning Equipment, Inc., or approved equal.
  - 3. Submittals
    - a. Complete Shop Drawings showing the type, size, and locations for all equipment, grounds and cable routings, shall be submitted to the Architect for approval prior to start of work.
    - b. Samples and pertinent catalog data shall be submitted to the Architect for approval upon request.
- B. Products
  - 1. Standard

- a. All equipment shall be new, the product of a single manufacturer as outlined above, and of a design and construction to suit the application where it is used in accordance with accepted industry standards.
- b. Equipment
  - 1) All materials shall be copper or bronze and of the size, weight and construction to suit the application where used in accordance with requirements for Class I structures and as per manufacturer recommendations.
  - 2) Conductors shall be copper, 29 strands, 17 gauge minimum, Heary Bros. Cat. No. HB-29-17C.
  - 3) Air terminals shall be solid, round copper bar of 3/8" minimum diameter. Heary Bros. Cat. No. HB308C, and shall project 10" minimum above the object to be protected. Locate and space according to requirements.
  - 4) Air terminal bases shall be of cast bronze with bolt pressure cable connections and shall be securely mounted with stainless steel screws or bolts. Crimp type connectors are not acceptable.
  - 5) Heary Bros. Cat. No. HB16C, 32C, 38C. and 25C. Bases on built-up tar and gravel roofs shall be secured with a proper adhesive and shall have a minimum surface contact area of 18.5 sq. inches, Cat. No. HB23C.
  - 6) Ground rods shall be a minimum 5/8" in diameter and 10'-0" long. Heary Bros. Cat. No. HB106GR. They shall be connected to the system with a two-bolt cast bronze clamp. Heary Bros. Cat. No. HB111X, having a minimum length of 1- 1/2" and employing stainless steel cap screws.
  - 7) Cable fasteners shall be substantial in construction, electrolytically compatible with the conductor and mounting surface and shall be spaced according to requirements. Heary Bros. Cat. No. HB66C, 72C, 64C.
  - 8) Bonding devices, cable splicers and miscellaneous connectors shall be of cast bronze with bolt pressure connections to cable. Cast or stamped crimp fittings are not acceptable. Splicers similar to Heary Bros. Cat. No. HB57C, 26C, 501C bonding devices similar to Heary Bros. Cat. No. HB54C, 97C, 178B, 57XXC, 42C.
  - 9) Equipment on stacks and chimneys shall be protected from corrosion and sized in accordance with requirements.
  - 10) All miscellaneous bolts, nuts and screws shall be brass, bronze or stainless steel.

C. Execution

1. Installation

- a. The installation shall be accomplished by an experienced installer. The installer shall work under the direct supervision of a manufacturer as listed above or his authorized representative.
- b. All equipment shall be installed in a neat workmanlike manner in the most inconspicuous manner as possible. The system shall consist of a complete cable network on the roof involving all air terminals, splices and bonds with cable downloads routed concealed in the Building construction in conduit to ground rod.
- c. Downlead cables shall not be brought directly through the roof. Conduit through proper roof flashings shall be utilized for this purpose.
- d. The Electrical Subcontractor shall furnish and install all necessary PVC conduit for concealed down conductors.

- e. Copper equipment shall not be connected to aluminum surfaces except by means of a bi-metal transition fittings. Lead coating is not to be accepted as a bi-metal transition.
- 2. Coordination
  - a. The lightning protection installer will work with other trades to insure a correct, neat and unobtrusive installation.
  - b. It shall be the responsibility of the lightning protection installer to assure a sound bond to the main water service and to assure interconnection with other Building ground systems, including both telephone and electrical. Proper arresters shall be installed on the power and telephone service by either the utility or the Electrical Subcontractor as applicable.
- 3. Completion
  - a. The lightning protection installer shall secure and deliver the As-Built Shop Drawings to the Architect for the Owner upon completion of the installation.

## 2.20 MINERAL INSULATED METAL SHEATHED CABLE (MI CABLE)

- A. Section Includes
  - 1. Type MI mineral-insulated seamless metal sheathed cable.
  - 2. Cable connectors and connections.
- B. References
  - 1. ANSI/NFPA 70 - National Electrical Code; UL 2196.
- C. Submittals
  - 1. Product Data: Provide for each cable assembly type.
  - 2. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.
- D. Qualifications
  - 1. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum ten years documented experience and manufactured in North America.
  - 2. Cable shall not off gas or propagate smoke.
- E. Regulatory Requirements
  - 1. Conform to requirements of ANSI/NFPA 70.
  - 2. Furnish products listed and classified by Underwriters Laboratories, Inc. As suitable for purpose specified and shown.
- F. Project Conditions
  - 1. Verify that field measurements and conditions are as shown on Drawings.
  - 2. Cable routing shown on Drawings is approximate unless fully dimensioned. Route cable to meet project conditions.
  - 3. Where cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.
- G. Coordination
  - 1. Coordinate work specified in this Section with work provided under other electrical work and the work of other trades.
  - 2. Determine required separation between cable and other work.
  - 3. Determine cable routing to avoid interference with other work.

- H. Manufacturer's – Mineral-Insulated Metal-Sheathed Cable
  - 1. Tyco Thermal Controls/Pyrotenax System 1850 2-hour fire rated, or equal.
  
- I. Mineral-Insulated Metal-Sheathed Cable
  - 1. Description: ANSI/NFPA 70, Type MI
  - 2. Conductor: Copper
  - 3. Insulation Voltage Rating: 600 volts.
  - 4. Cable Temperature Rating: 75 degrees C.
  - 5. Termination Temp. Rating: 90 degrees C.
  - 6. Insulation Material: Magnesium oxide refractory mineral.
  - 7. Metal-sheath Material: Seamless soft drawn copper.
  - 8. Fire Rating: Cable assembly including supports shall have a 2-hour fire rating as listed and classified by Underwriters Laboratories, Inc.
  - 9. Over jacket is available.
  
- J. Wiring Connectors and Terminations
  - 1. Cable Termination:
    - a. Tyco Thermal Controls/Pyrotenax Model Quick-Term Installation Sheet 638. (Solid M.I. conductor to approved solid rated lug is also available as a slight variation to the Quick-Term Termination.)
  
- K. Examination
  - 1. Verify that cable end factory temporary seals have remained intact, that the insulation has not been exposed to air, and that no moisture has entered cable insulation.
  - 2. Verify that work of other trades likely to damage cable has been completed
  
- L. Storage
  - 1. Cables shall be shipped from the manufacturer with ends temporarily sealed against moisture ingress.
  - 2. When cables are cut in the field, the end shall be sealed using standard sealing compound and PVC tape
  - 3. Cable shall be stored in a clean dry location.
  
- M. Handling
  - 1. Cable shall be uncoiled by rolling or rotating supply reel. Do not pull from coil periphery or center
  - 2. Take precautions necessary to prevent damage to cable from contact with sharp objects, including pulling over foreign material or sheaves.
  
- N. Wiring Methods
  - 1. Fire Rated Locations: Use only fire rated cable.
  - 2. Use wiring methods indicated on Drawings and as specified herein.
  
- O. Installation
  - 1. Install products in accordance with manufacturer's instructions.
  - 2. Bending:
    - a. Not less than five (5) times the cable diameter for cable not more than  $\frac{3}{4}$  inch (250 kcmil).
    - b. Not less than ten (10) times the cable diameter for cable more than  $\frac{3}{4}$  inches (350 and 500 kcmil).
  - 3. Pulling:
    - a. For all cables up to and including #1 AWG use 24 inch (250mm) or larger sheaves.

- b. For #1/0 through 250 kcmil inclusive, use 18 inch (460mm) or larger sheaves.
  - c. For 350 kcmil and larger cables, use 24 inch (610mm) or larger sheaves.
  - d. On pulls of over 360 degrees, contact manufacturer for assistance.
  - e. 350 and 500 kcmil cables shall not be pulled more than 360 degrees in total.
4. Splicing: All fire rated splices shall be made in the factory.
- a. In the event a field splice is necessary, it must be approved by the engineer and made in field by personnel trained by cable manufacturer using manufacturer's components.
5. Terminations:
- a. Field made terminations shall be made with cable manufacturer's termination kits only. Stripping tools, crimping and compression tools available from the manufacturer shall be used for proper cable termination.
  - b. Terminations must be completed immediately once started to avoid moisture ingress from surrounding air. Prior to completing each termination, test insulation resistance and follow manufacturer's drying procedures until insulation resistance reaches an acceptable level.
  - c. Connections to ferrous cabinets for single conductor cables shall incorporate brass plates ¼ inch (6mm) thick by 4 inch (100mm) wide by proper length with ½ inch (12mm), ¾ inch (19mm), 1 inch (25mm) or 1-1/4 inch (32mm) drilled and tapped holes. Install per manufacturer's Drawing.
  - d. For applications using 90 degree C rating of cable, lugs shall be rated 90 degrees C.
6. Sheath Induction Reduction:
- a. When multi-phase circuits have paralleled single conductors, cables shall be run in groups having one of each phase in each group.
  - b. Each set of paralleled conductors shall be separated by at least 2.15 single cable diameters.
  - c. On balanced three-phase wye circuits neutral conductors may be located within the 2.15 cable diameter space between groups of phase conductors.
  - d. Each group of cables shall be fastened tightly together, at least once between each cable support on horizontal runs and twice on vertical runs, using ½ inch (13mm) wide by 0.030 inch (0.75mm) thick stainless steel straps.
7. Exposed of Surface Installations:
- a. Cable may be secured directly to fire rated Building structure using an approved method such as one, or any combination, of the following:
    - 1) Straps: ½ inch (13mm) wide x 3-1/2 inch (90mm) long by 0.030 (0.75mm) thick stainless steel or copper straps. Each strap shall contain two ¼ inch (6mm) holes for securing with 3/16 inch (5mm) by minimum 1-3/4 inch (44mm) long steel anchors.
    - 2) Steel struts and cable tray: Use only the steel strut framing system and support recommended by Pyrotenax. Aluminum or other materials are not acceptable.
    - 3) Other approved method.
  - b. Supports shall not exceed six (6) feet on center horizontally, or six (6) feet vertically.
  - c. Cables shall be installed parallel to Building lines.
8. Embedded Installations:
- a. Cables will be run in the same trifoil configuration as exposed installations.
  - b. Protect against damage during pulling, and during concrete pouring or backfill and tamping.

- c. Where cables emerge from grade, provide PVC conduit, metal plate or angle iron. This protection shall minimally extend from 18 inches (460mm) below grade to 8 ft. (2.5m) above grade.
  - 9. Wall or Floor Penetrations:
    - a. Provide sleeve to protect cable and penetration opening during pulling.
    - b. Provide approved fire stopping of all penetrations.
  - 10. Neatly train and lace cable inside boxes, equipment, and panelboards.
- P. Field Quality Control
- 1. Inspect cable for physical damage and proper connection.
  - 2. Measure tightness of bolted connections and compare torque measurements with manufacturer's recommended values.
  - 3. Verify continuity of each conductor.
  - 4. Prior to energizing cables, measure insulation resistance of each cable. Tabulate and submit for approval.

## 2.21 NAMEPLATES

- A. Nameplates shall be furnished and installed on the switchboard and switchboard circuit breakers, panelboards, dry-type transformers, junction boxes, cabinets for all special purpose switches, disconnect switches, starters, zero sequence harmonic filters, and other controls furnished under this Contract, to designate the equipment controlled and function.
- B. Nameplates shall be laminated white bakelite with 1/4" high black recessed letters. Nameplates shall be securely attached to the equipment with galvanized screws or rivets. Adhesives or cements will not be permitted.
- C. Power branch circuit junction boxes shall be identified with circuit's panel(s) origin and circuit number(s) by means of black fibre pen.
- D. All pull boxes and junction boxes shall be identified as to system and function by means of black fiber pen.
- E. Disconnecting means (disconnect switches and enclosed circuit breakers) nameplates shall indicate purpose and identification of the circuit source that supplies the disconnecting means.

## 2.22 OUTLET BOXES AND ACCESSORIES

- A. Outlet boxes and accessories shall be as manufactured by Steel City, Appleton, Raco, or equal.
- B. Lighting outlets in concrete ceilings, walls and columns shall be 4" octagonal rings, 4" deep with round bottom plate. Where concrete slab is less than 5" thick, boxes shall be 2-1/2" deep.
- C. For wood framing and furred ceilings use 4" octagonal outlet boxes, bar hangers and covers. 4-11/16" boxes and covers shall be used where 1" conduit is involved.
- D. Where outlets occur in beams or ribs of pan type concrete construction, a 4" shallow pan outlet, 3/4" deep, shall be used with conduit entering the back of the box.
- E. All fixture outlet boxes shall have 3/8" solid make fixture studs and all auxiliary fixture stems shall be supported from 3/8" male fixture studs.

- F. All outlets in walls other than lighting outlets in concrete shall be Series 52171, 4" square boxes with single of 2- gang raised covers, Series 52C50, of the proper depth required for the particular wall construction and finish. Where the wall construction or finish will not permit a neat cut around the raised cover, Series GW235 boxes shall be used.
- G. Outlets in 2" partitions shall be 4" square, 1-1/4" deep, with raised cover.
- H. Outlet boxes for weatherproof concealed work and exposed rigid conduit work shall be suitable cast or malleable iron conduit fittings, Crouse-Hinds Company, Appleton, Killark, or equal, and shall have threaded conduit hubs.
- I. Outlet boxes recessed in exterior walls will be required to be sealed internally at the openings and seams and sealed to air/vapor barrier.

## 2.23 PANELBOARDS

- A. At each location indicated on the plans, furnish and install an appropriate panel of the ampacity and voltage rating shown on the Drawings.
- B. All panels shall be of the safety dead front circuit breaker type for service on three phase, four wire mains unless otherwise specified. All panels shall be of code gauge steel.
- C. Panels shall be surface or flush mounted, as indicated on the plans, and installed so that the top circuit breaker is no more than 6'-0" above the finished floor.
- D. The panelboards shall bear the Underwriters' Laboratories Label.
- E. All buses shall be copper. All panelboards shall have a circuit directory card mounted in a frame with plastic cover installed on the inside of the door. All directory cards shall be properly filled in, using a typewriter, and indicating areas and devices served by each circuit.
- F. All circuit breakers shall be of quick-make and quick-break type on manual operation, trip-free, and with inverse time characteristics and shall have bolted bus connections; plug-in circuit breakers will not be allowed.
- G. Panelboard trims shall have single doors. Trims and doors shall be made of code gauge, full finish sheet steel. The trim and doors shall be factory finished on both sides. All panelboards shall be keyed alike.
- H. Panelboards shall contain circuit breakers indicated on panelboard schedule on the Drawings. Two and three pole breakers shall be common trip type.
- I. All panelboards shall be equipped with a neutral bar having one solderless connector for each circuit as indicated and with all required knockouts.
- J. Panelboards requiring 200% neutrals and isolated ground shall be as indicated on the Drawings.
- K. Panelboards shall be Square D, Type NQOB for 120/208 volt, Type NEHB for volt, and I-Line for main distribution panelboards, Eaton/Cutler-Hammer, Siemens, or equal.
- L. Provide panelboards with Nema 4X enclosure in Kitchen, Served, and other wash down



areas.

- M. Circuit breakers which are rated at 1200 amps or more shall have Arc Energy Reduction complying with National Electrical Code 240.87.
- N. Fully Rated equipment shall be provided; Series Rated equipment is not acceptable.

#### 2.24 POKE-THRUS

- A. Poke-thru device shall have been examined and tested by Underwriters Laboratories, Inc. to comply with UL514A and/or UL514C, as applicable and tested to Canadian Standard C22.2 and bear the "UL" mark. The poke-thru shall conform to the standards set in the National Electrical Code, Section 300.21.
- B. Poke-thru device shall be for use in 2-hour rated, unprotected reinforced concrete floors and 2-hour rated floors employing unprotected steel floor units and concrete toppings (D900 series designs) or concrete floors with suspended ceilings. Fire resistive designs with suspended ceilings shall have provisions for accessibility in the ceiling below the poke-thru device fittings.
- C. Poke-thru device 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.
- D. Poke-thru device shall be suitable for use in air handling spaces in accordance with Section 300.22C of the National Electrical Code.
- E. Floor-mounted service fittings shall be assembled units suitable for carpet and tile floors and include scrub water finish flange.
- F. Fire-rated poke-through assemblies with recessed devices shall be with up two (2) 20A duplex receptacles and capacity for up to 8 keystone data openings, (1) 3/4" power conduit/junction box and (1) 2" communications conduit stem for voice, data and or A/V wiring in 6" hole; Hubbell System One S1R6 Series, Legrand "Evolution 6AT" Series, or equal.
- G. Fire-rated poke-through assemblies with recessed devices shall be with up two (2) 20A duplex receptacles and multiple center compartment ports capable of accepting voice, data and/or A/V outlets, (1) 3/4" power conduit/junction box, (1) 1-1/4" communications conduit stem, and (1) 2" communications conduit stem for voice, data and or A/V wiring in 8" hole; Hubbell System One S1R8 Series, Legrand "Evolution 8AT" Series, or equal.
- H. Verify type of communications jacks required with Owner and Telecommunications system installer.
- I. Verify type of audio/visual jacks required with Owner and Audio/Visual consultant's drawings and Audio/Visual system installer.
- J. Provide receptacles and technology outlets as indicated in poke thru on Electrical and Technology drawings and provide conduit to above accessible ceiling from each individual technology outlet as indicated.
- K. Coordinate cover color and finish with Architect in field.

## 2.25 PUBLIC SAFETY SIGNAL BOOSTER SYSTEM

- A. Provide a signal booster system complete with all components and wiring required for compliance with all applicable Codes and Regulations. The system shall include but not be limited to the following:
1. One donor antenna to be located on the roof. Run a ½" plenum rated non-radiating coaxial cable from the directional antenna to the Bidirectional Amplifier (BDA). Cable shall be equal to ICA12-50JPLW (1/2" plenum coax).
  2. This Specification is based upon an NFPA Compliant Bird Technologies TX/RX Rescue Line Signal Booster II system. The BDA shall be a Bird Technologies TX/RX Rescue Line Signal Booster II, RFS Cell Wave, or Radio Solutions Inc., or equal. Frequencies shall be coordinated with the Fire and Police departments and the amplifier shall meet all Fire and Police department communications requirements.
  3. Provide a ½" plenum rated radiating cable from the BDA to above the corridor ceilings on each floor. Provide radiating plenum rated cable above ceilings where shown on the Drawings. Radiating cable shall be supported every 5'-0". Provide antennas at a minimum of one every 200' along the radiating cable routing. Provide any additional cabling in strict accordance with manufacturer's Specifications as well as current National Electrical Code to provide complete coverage for the system. A pre and a post signal strength test shall be provided at the job site. Signal strengths shall be noted on a set of plans both pre and post test.
- B. Vertical riser backbone cabling and associated splitters, couplers, and taps shall be installed in two hour rated electric rooms and shafts. Splitters, couplers, and taps throughout system shall be accessible for testing, future service, and/or replacement. Provide access panels where required. Where vertical riser backbone cabling exits two hour rated enclosure provide fire stopping around penetrations. Cabling between the BDA and the Alarm Monitoring Panel shall be two hour rated type.
- C. Signal Strength
1. The Fire and Police Department radio test shall check the signal reception in several locations on the floor area. Signal strength shall provide 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.
- D. Required Signal Levels
1. Signal strength shall provide 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).
  2. A minimum signal strength of -95 dBm (DAQ4) shall be available on over 99% of the floor area required to be covered when transmitted from the fire department.
  3. A minimum signal strength of -95 dBm (DAQ4) shall be received at the fire department system from over 99% of the floor area required to be covered.

- E. Primary Power
  - 1. The emergency responder radio coverage system shall be powered by a dedicated independent circuit of sufficient size. The circuit shall be clearly marked. The location of the electrical panel shall be clearly marked at location approved by the fire official. The primary power source shall be supplied from a dedicated twenty (20) ampere branch circuit and comply with NFPA 72.
  
- F. Secondary Power
  - 1. The emergency responder radio coverage system shall be equipped with a secondary source of power. The secondary source of power shall be a backup battery system which is serially connected to the BDA system (no UPS units). The secondary power supply shall supply power automatically when the primary power source is lost. The secondary source of power shall be capable of operating the emergency responder radio coverage system for a period of at least 12 hours at 100% system operation capacity. All components of the battery backup system shall be housed completely in a NEMA 4 or 4X cabinet and mount below the BDA. System shall have front panel display and alarms. Monitoring the integrity of power supplies shall be in accordance with NFPA 72. Unit shall be TX/RX 6160 Battery Option.
  
- G. Alarm Monitoring Panel
  - 1. A dedicated monitoring panel shall be provided adjacent to the fire alarm control panel to annunciate the status of the signal booster. The monitoring panel shall provide visual and labeled indication of the following for the booster:
    - a. Normal AC power
    - b. Signal booster trouble
    - c. Loss of normal AC power
    - d. Failure of battery charger
    - e. Low battery capacity
    - f. Antenna malfunction
  - 2. The above mentioned alarm points shall be outputs from the BDA system as dedicated relay points. These shall also be monitored via addressable monitor modules to the fire alarm system.
  
- H. All equipment shall have a current FCC Certification.
  
- I. Equipment integrator shall be a certified service center with factory certified technician(s).
  
- J. Warranty: The BDA shall include a 5 year equipment warranty. Include any necessary costs for equipment to contain this warranty level.
  
- K. Submittals
  - 1. Submit manufacturer's data on system and components including Shop Drawings, floor plans with layout of all equipment, cabling, riser diagram for project (typical riser diagram is not acceptable), and mounting equipment and details.
  - 2. Provide copies of personnel certifications in submittal.

## 2.26 PULL BOXES, JUNCTION BOXES AND WIREWAYS

- A. Pull boxes shall be of code gauge galvanized steel with screw covers to match. Pull boxes and wireways shall be as shown on Drawings and/or comply with the National Electrical Code and/or job conditions, with steel barriers separating systems.

- B. Wireways shall be of code gauge steel, baked enamel manufactured standard sections and fittings, with combination hinged and screw covers, as manufactured by Square D “Square-Duct,” Bee Line, Cope or equal.
- C. Conductors passing through pull boxes and wireways shall be identified to indicate their origin and termination. Provide nameplates for all pull boxes.
- D. Refer to Drawings for Handhole specifications.

2.27 SHORT CIRCUIT COORDINATION SELECTIVE COORDINATION STUDY

- A. The Study shall be conducted by the switchgear manufacturer.
- B. The Study work shall be conducted under the applicable Standards of the American National Standards Institute (ANSI) and the National Electrical Code (NEC). Specifically, the following standards shall apply:
  - ANSI-C37.010-1972 Standard Application Guide for AC High Voltage Circuit Breakers.
  - ANSI-C37.5-1969 Calculation of Fault Currents for Application of Power Circuit Breaker Rated on a Total of Current Basis.
  - ANSI-C37.13-1963 Low Voltage AC Power Circuit Breakers (600 Volt Insulation Class).
- C. The basic scope of the Study is the power system, from the power supplier’s service point, through the main secondary distribution system. The studies organization shall identify in its proposal the limits of the system that will be studied.
- D. The Study organization shall prepare a single-line diagram of the power system. This diagram shall identify all components considered in the Study and the ratings of all power devices. (This includes, but is not limited to, transformers, circuit breakers, relays, fuses, busses and cables). Reference numbers shall be used on the diagram related to key items in the report. ANSI device function numbers shall be used on protective relays.
- E. Short Circuit Study:
  - 1. A Short Circuit Study shall be performed which shows the momentary and interrupting fault duties on each bus shown on the single line diagram. A computer shall be used to perform calculations on all 3 phase faults. In addition, an impedance listing shall be prepared showing bus-to-bus impedance values reduced to a common MVA base referenced to a single-line diagram for ease in reviewing data.
  - 2. Study each fault interrupting device related to the calculated duty and recommend changes when appropriate.
  - 3. The Study shall start from utility incoming switches and shall extend through to all panelboards.
- F. Coordination and Selective Coordination Study
  - 1. The Study organization shall perform a comprehensive protection device coordination and selective coordination Study covering all devices identified on the single line diagram. Using a practical compromise between protection of electrical equipment and coordination of devices “downstream”, provides settings for all adjustable protective devices shown on the diagram. Selective Coordination Study shall be provided as per National Electrical Code Article 700.
  - 2. Study the application of devices versus system ends and recommend new or

- additional devices that are needed for adequate protection.
3. Prepare time/current coordination curves to illustrate the protection and coordination achieved with the recommended settings of protective devices. These curves shall reflect the following (where applicable):
    - Appropriate NEC protection points
    - Appropriate ANSI protection points
    - Magnetizing in-rush points of transformers
    - One-line diagram of the system identifying the device plotted
    - Short circuit current levels used for construction
- G. Arc Flash Study
1. The Study organization shall perform an Arc Flash Study as per OSHA. The Electrical Subcontractor shall provide all labeling as per the Arc Flash Study.
- H. The Study organization shall submit three (3) bound copies of a report which shall contain the following information:
1. An executive summary which identifies all significant problems and all recommendations for significant equipment changes.
  2. A tabulation of all protective devices identified on the one-line diagram which their ratings compares with respective fault duty as calculated in the Study.
  3. A tabulation of the settings recommended on all adjustable protective devices with references to the single-line diagram and to coordination curves.
  4. Copies of all time/current coordination curves developed in the Study.
  5. The analysis of problems that lead to specific recommendations included in the executive summary.
  6. The single-line diagram of the system studies, including all ratings, identifications described.
  7. Copies of all computer results referenced to the single-line diagram and the impedance listings.
  8. A ground fault Study for all breakers specified with ground fault, including the associated zero sequence impedance diagrams.
- I. Short circuit and ground fault Study shall be submitted with panelboard Shop Drawings to verify that available fault currents fall within panelboard/ breaker ratings. Coordination Study may follow, but shall be submitted with the switchboard Shop Drawing.
- J. Necessary field studies shall be accomplished at no additional expense to the contract.

## 2.28 STARTERS

- A. Motor starters shall be furnished and installed by the Electrical Subcontractor except as noted otherwise in other Sections of this Specification.
- B. All motor starters shall be of the maintained contact type and have individual running overload protection in each phase and shall be provided with two sets of auxiliary contacts (one normally open and one normally closed).
- C. Starters shall be of size and type required for the particular motor horsepower and voltage.
- D. Locate starters adjacent to panel feeding same unless otherwise indicated on the Drawings.
- E. Manual starters shall be of the toggle mechanism type for full voltage starting.

- F. Magnetic starters shall be across-the-line type, with means for remote control, except maintained contact type starters shall be used only where noted for specific items of equipment.
- G. All starters shall have overload reset button, pilot light to indicate on or off and hand-off-auto switch in cover unless otherwise indicated.
- H. Starters shall be furnished in the enclosures called for on the Drawings and shall be grouped whenever possible.
- I. Motor starters, where grouped, shall be mounted on a new 3/4" thick exterior grade plywood mounting board finished to match starter enclosures.
- J. All starters and remote control stations furnished under this Section shall have laminated plastic engraved nameplates designating the equipment controlled. Letters shall be 1/4" high.
- K. Motor starters and controls shall be Square D, General Electric, Siemens, or equal.
- L. All magnetic starters furnished under this Section which are connected to circuits operating at more than 120V shall have built-in control transformers with 120V secondary control supply.
- M. Thermal trips for all motor starters supplied under this Section shall be ambient temperature compensated.

## 2.29 SURGE PROTECTIVE DEVICES (SPD's)

- A. Scope
  - 1. The Electrical Subcontractor shall furnish and install the Surge Protective Device (SPD) equipment having the electrical characteristics, ratings, and modifications as specified herein and as shown on the Drawings. To maximize performance and reliability and to obtain the lowest possible let-through voltages, the ac surge protection shall be integrated into electrical distribution equipment; switchboard, emergency panelboards, optional standby emergency panelboards, and the computer panelboards.
- B. References
  - 1. SPD units and all components shall be designed, manufactured, and tested in accordance with the latest applicable UL standard (ANSI/UL 1449 3<sup>rd</sup> Edition).
- C. Submittals – For Review/Approval
  - 1. The following information shall be submitted to the Engineer:
    - a. Provide verification that the SPD complies with the required ANSI/UL 1449 3<sup>rd</sup> Edition listing by Underwriters Laboratories (UL) or other Nationally Recognized Testing Laboratory (NRTL). Compliance may be in the form of a file number that can be verified on UL's website or on any other NRTL's website, as long as the website contains the following information at a minimum: model number, SPD Type, system voltage, phases, modes of protection, Voltage Protection Rating (VPR), and Nominal Discharge Current (I<sub>n</sub>).
  - 2. Where applicable the following additional information shall be submitted to the engineer:
    - a. Descriptive bulletins

b. Product sheets

D. Submittals – for Construction

1. The following information shall be submitted for record purposes:
  - a. Final As-Built Drawings and information for items listed shall incorporate all changes made during the manufacturing process.

E. Qualifications

1. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.
2. For the equipment specified herein, the 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 five (5) 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.

F. Manufacturer's

1. Eaton / Cutler-Hammer products, Current Technologies, Liebert, or equal.
2. The listing of specific manufacturer above does not imply acceptance of their products that do not meet the specified ratings, features, and functions. Manufacturer listed above is not relieved from meeting these Specifications in their entirety.

G. Voltage Surge Suppression - General

1. Electrical Requirements
  - a. Unit Operating Voltage – Refer to Drawings for operating voltage and unit configuration.
  - b. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 115% of the nominal system operating voltage.
  - c. The suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression component. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.
  - d. Protection Modes – The SPD must protect all modes of the electrical system being utilized. The required protection modes are indicated by bullets in the following table:

Configuration	Protection Modes			
	L-N	L-G	L-L	N-G
Wye	●	●	●	●
Delta	N/A	●	●	N/A
Single Split Phase	●	●	●	●
High Leg Delta	●	●	●	●

- e. Nominal Discharge Current ( $I_n$ ) – All SPDs applied to the distribution system shall have a 20kA  $I_n$  rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an  $I_n$  less than 20kA shall be rejected.
- f. ANSI/UL 1449 3rd Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 3rd Edition VPR for the device shall not exceed

the

following:

MODES	208Y/120	480Y/277	600Y/347
L-N; L-G; N-G	700	1200	1500
L-L	1200	2000	3000

2. SPD Design

- a. Maintenance Free Design – The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs containing items such as replaceable modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
- b. Balanced Suppression Platform – The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating replaceable SPD modules shall not be accepted.
- c. Electrical Noise Filter – Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method. Products unable able to meet this Specification shall not be accepted.
- d. Internal Connections – No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.
- e. Monitoring Diagnostics – Each SPD shall provide the following integral monitoring options:
  - 1) Protection Status Indicators - Each unit shall have a green / red solid-state indicator light that reports the status of the protection on each phase.
    - a) For wye configured units, the indicator lights must report the status of all protection elements and circuitry in the L-N and L-G modes. Wye configured units shall also contain an additional green / red solid-state indicator light that reports the status of the protection elements and circuitry in the N-G mode. SPDs that indicate only the status of the L-N and L-G modes shall not be accepted.
    - b) For delta configured units, the indicator lights must report the status of all protection elements and circuitry in the L-G and L-L modes.
    - c) The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode. All protection status indicators must indicate the actual status of the protection on each phase or mode. If power is removed from any one phase, the indicator lights must continue to indicate the status of the protection on all other phases and protection modes. Diagnostics packages that simply indicate whether power is present on a particular phase shall not be accepted.
  - 2) Remote Status Monitor – The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its



- status. Both the NO and NC contacts shall change state under any fault condition.
- 3) Audible Alarm and Silence Button – The SPD shall contain an audible alarm that will be activated under any fault condition. There shall also be an audible alarm silence button used to silence the audible alarm after it has been activated.
  - 4) Surge Counter – The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of  $50 \pm 20A$  occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. In order to prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total.
    - a) The ongoing surge count shall be stored in non-volatile memory. If power to the SPD is completely interrupted, the ongoing count indicated on the surge counter's display prior to the interruption shall be stored in non-volatile memory and displayed after power is restored. The surge counter's memory shall not require a backup battery in order to achieve this functionality.
- f. Overcurrent Protection
- 1) The unit shall contain thermally protected MOVs. These thermally protected MOVs shall have a thermal protection element packaged together with the MOV in order to achieve overcurrent protection of the MOV. The thermal protection element shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur that would cause them to enter a thermal runaway condition.
- g. Fully Integrated Component Design – All of the SPD's components and diagnostics shall be contained within one discrete assembly. SPDs or individual SPD modules that must be ganged together in order to achieve higher surge current ratings or other functionality shall not be accepted.
- h. Safety Requirements
- 1) The SPD shall minimize potential arc flash hazards by containing no user serviceable / replaceable parts and shall be maintenance free. SPDs containing items such as replaceable modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
- H. System Application
1. The SPD applications covered under this Section include the switchboard, emergency panelboard, optional standby emergency panelboard, and the computer panelboard assemblies. All SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C, B, and A environments.
  2. Surge Current Capacity – The minimum surge current capacity the device is capable of withstanding shall be as shown in the following table:

Minimum surge current capacity based on ANSI / IEEE C62.41 location category			
CATEGORY	Application	Per Phase	Per Mode
C	Switchboard	250 kA	125 kA
A	Computer Panelboards	120 kA	60 kA
A	Emergency Panelboards and Optional Standby Emergency Panelboards	120 kA	60 kA

3. SPD Type – All SPDs installed on the line side of the service entrance disconnect shall be Type 1 SPDs. All SPDs installed on the load side of the service entrance disconnect shall be Type 1 or Type 2 SPDs.
  
- I. Switchboard, Emergency Panelboard, Optional Standby Emergency Panelboard, and the Computer Panelboard Requirements:
  1. The SPD application covered under this Section includes computer panelboards. The SPD units shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category B environments.
    - a. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.
    - b. SPDs shall be installed immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.
    - c. The panelboard shall be capable of re-energizing upon removal of the SPD.
    - d. The SPD shall be interfaced to the panelboard via a direct bus bar connection.
    - e. The SPD shall be included and mounted within the panelboard by the manufacturer of the panelboard.
    - f. The SPD shall be of the same manufacturer as the panelboard.
    - g. The complete panelboard including the SPD shall be UL67 listed.
  2. Switchboard Requirements:
    - a. The SPD application covered under this Section is for the switchboard location. Service entrance located SPDs shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category C environments.
    - b. The SPD shall be of the same manufacturer as the switchboard.
    - c. The SPD shall be factory installed inside the switchboard at the assembly point by the original equipment manufacturer.
    - d. Locate the SPD on the load side of the main disconnect device, as close as possible to the phase conductors and the ground/neutral bar.
    - e. The SPD shall be integral to switchboard as a factory standardized design.
    - f. All monitoring and diagnostic features shall be visible from the front of the equipment.
  
- J. Factory Testing
  1. Standard factory tests shall be performed on the equipment under this Section. All tests shall be in accordance with the latest version of NEMA and UL standards.
  
- K. Installation
  1. The Electrical Subcontractor shall install all equipment per the manufacturer's recommendations and the Drawings.
  
- L. Warranty

1. The manufacturer shall provide a full ten (10) year warranty from the date of shipment against any SPD part failure when installed in compliance with manufacturer's written instructions and any applicable National or Local Code.

#### 2.29 TELEPHONE, DATA, VIDEO OUTLET AND CONDUIT SYSTEM

- A. Furnish and install back boxes and conduits as called for on the Drawings.
- B. Refer to Drawings for back box requirements and locations.
- C. Where back boxes are located in environmental air plenum ceiling areas, the conduits shall be run to the nearest corridor located outside the environmental air plenum area.
- D. Actual back box locations and equipment shall be confirmed in the field with Architect and Owner before installation.
- E. Provide blank cover plate for each back box location.

#### 2.30 THERMAL SWITCHES

- A. Thermal switches shall be NEMA Type 1 toggle switch for normal duty with thermal overload relay. Switch enclosures shall be of a type approved for the location and atmosphere in which it is mounted. Thermal switches shall be installed where called for or where required by Code. Thermal switches shall be provided with pilot where called for on the Drawings.
- B. Thermal switches shall be as manufactured by Square D, Eaton, Siemens, or equal.

#### 2.31 TIME CLOCKS

- A. Provide time clocks where shown on the Drawings for the control of lighting.
- B. Time clocks shall be shall be Tork DLC400BP, Intermatic, Paragon, or equal.
  1. Provide a 4 zone lighting controller with photosensor input (Tork model EPC2 photosensor to be supplied with controller).
  2. Memory Module shall be capable of being programmed at any one location and inserted into DLC400BP (with memory module socket) in any other remote location.
  3. Optional programmer shall be available (Model MMP), capable of accomplishing Windows based settings on a PC for easy duplication of Memory Modules or individualized programs for multiple locations.
  4. Each zone shall be capable of independent, user settable turn On and Off light level set points ranging from 1 to 100 footcandles.
  5. Three position slide switches shall be provided for each of the 4 zones allowing for user settings based on
    - a. time of day or
    - b. combination time of day and light level or
    - c. light level.
  6. Controller shall provide 30 Amp general purpose isolated contacts (unpowered) for each zone as well as a 500 ma, 24VDC output.
  7. Controller shall have 1 digital input per channel for:
    - a. remote contact closure which can be used to turn corresponding outputs On/Off outside of the normal control time or
    - b. remote timed override which can be accomplished for the corresponding

- outputs with the use of Tork model SSA200R-24.
8. Enclosure shall provide separate wiring compartments for power connections and auxiliary connections.
  9. Controller shall be capable of local override On or Off to the next scheduled event using the keypad for each zone.
  10. Each zone shall be capable of astronomic function, adjustable from 10-60 degrees Northern or Southern latitude. Each zone can additionally be offset +/- 1-299 minutes for both sunset and sunrise.
  11. Controller shall provide automatic daylight saving time (which can be omitted). Leap year adjustment shall be compensated for automatically.
  12. Controller shall have 365 day holiday capability with 24 single dates and 4 seasons of unlimited duration.
  13. Controller shall be capable of 99 set points with separate scheduling for each day of the week.
  14. Controller shall have back-up capability:
    - a. Schedule shall be retained for 40 years without power,
    - b. real time shall be retained for 6 months using a field replaceable 9V lithium battery.
  15. Unit shall have a NEMA type 3, metal indoor/outdoor enclosure.

#### 2.32 WIRE AND CABLE

- A. Wiring shall be a minimum of #12 AWG solid, except motor control circuit wiring and fire alarm system wiring may be #14 AWG. Wiring for 120V branch circuits which exceed a distance of 100' from the panel to the last outlet shall be #10 AWG, 190 ft. from the panel to the last outlet shall be #8 AWG and 280 ft. from the panel to the last outlet shall be #6 AWG minimum, wiring for 277V branch circuits which exceed a distance of 200' from the panel to the last outlet or light fixture shall be #10 AWG, and 300 ft. from the panel to the last outlet or light fixture shall be #8 AWG minimum. The Electrical Subcontractor shall be required to perform voltage drop calculations on all branch circuits in which the actual proposed routing of the circuit exceeds 100 ft. to insure a maximum voltage drop of 3% is not exceeded. Wire sizes shall be increased to maintain the maximum 3% voltage drop.
- B. Wires and cables shall be single conductor, except as otherwise specified or indicated on Drawings. Wires of sizes #8 AWG and larger shall be stranded, while wires of sizes smaller than #8 AWG shall be solid. In general, conductors shall be of soft drawn copper and shall have a conductivity of not less than 98% of the ANSI Standard for annealed copper, except as otherwise specified or indicated on Drawings. Aluminum conductors shall only be used where specifically indicated on the Drawings. Pressure type connectors shall be used at all terminals.
- C. Wire shall be Type THWN-2, XHHW or approved equal, rated 90 degrees C. minimum and suitable for wet and dry locations.
- D. MC cable may be used for branch circuit wiring only, where run concealed, where allowed by Code and approved by the Authority Having Jurisdiction. Type MC cable shall be supported and secured at intervals not exceeding six feet.
- E. Wire and cable shall be by one of the following: Phelps Dodge Copper Products Corp., General Cable Co., AFC Cable Systems, Triangle Conduit and Cable Co., or equal.
- F. Terminal lugs and splice connectors shall be of an ampacity equal to the circuit on which they are utilized.

- G. Emergency feeders that cannot be run in conduit below grade shall be Mineral Insulated Metal – Sheathed Cable (MI Cable), refer to Specification Section.
- H. All wiring where run in environmental air plenums shall conform to Article 300-22 of the National Electrical Code.
- I. Wiring shall be supported from the Building structure, and shall be independent of ducts, pipes, ceilings and their supporting members.

#### 2.33 WIRING DEVICE PLATES

- A. All device plates shall be Specification Grade, .032” thick, Type 430, stainless steel, brushed finish. Plates shall be of appropriate type and size for all wiring and control devices.
- B. Plates shall be set so that all edges are in contact with the mounting surface. Plaster fillings will not be allowed. Multi-device locations shall have one common device plate.
- C. Nameplate designation for device plates shall be engraved directly on plates and filled in black.
- D. Device plates shall be by the same manufacturer as devices.
- E. All receptacle device plates for circuits other than 120V, 2 wire, shall be engraved with 1/4” high letters, filled black, indicating voltage characteristics of the outlet.
- F. Plates for surface type boxes shall not overlap boxes and shall be designed for use with surface boxes.
- G. Device plates for circuits connected to the emergency distribution system shall have engraved nameplates marked “Emergency Circuit,” 1/4” high letters, filled in black.
- H. Device plates for weatherproof receptacles shall be clear Polycarbonate “In-Use” type, pad lockable.

#### 2.34 WIRING DEVICES

- A. Light Switches
  - 1. All local wall switches shall be of the flush quiet toggle type, as follows, or as manufactured by Pass and Seymour, Inc., Leviton Manufacturing Co., or equal.
  - 2. All switches shall be suitable for the control of tungsten filament lamps, and shall carry the proper marking of the Underwriters' Laboratories.
  - 3. Local switches shall be installed in such a position that they shall bear evenly and truly, and be secured on the axis of the supporting members.
  - 4. Under no circumstances are wooden wedges, shims or blocks to be used in truing up local switches. Should the outlet box in any case come too far back of the finished surface, recess boxes and screws of the proper length to reach the box shall be used of such a size as to form a shoulder at exactly the proper point to retain the switch in position.
  - 5. Switches shall be rated 20 amperes, 120 - 277 volts, equal to the following:
    - Single Pole Switches - Hubbell HBL1221
    - Double Pole Switches - Hubbell HBL1222
    - Three-Way Switches - Hubbell HBL1223
    - Four-Way Switches - Hubbell HBL1224

Switch with Pilot Light - Hubbell HBL1221PL

Key switches shall be equal to corresponding switches above.

6. Refer to Drawings for Specification of Dimmer Switches.
7. Color of switches shall be white, unless otherwise noted.

B. Receptacles

1. Duplex receptacles shall be grounding type, rated 20 amperes, 125 volts. Receptacles shall be back and side wired with screw type terminals or pressure type, screwless terminals having suitable conductor release arrangement.
2. Special receptacles for single equipment, where required, shall have additional grounding leg and shall be of capacity for the equipment to be connected.
3. In general, convenience receptacle circuits shall be independent of lighting circuits and shall not be controlled by lighting circuit breaker switches or lighting switches, unless specifically indicated on the Drawings.
4. Receptacles shall be as follows, or as manufactured by Pass and Seymour, Inc., Leviton Manufacturing Co., or equal:
  - a. All 15 and 20 ampere, 125 and 250 volt non-locking type receptacles shall be tamper resistant type. (*Dwelling Units, including attached and detached garages and accessory buildings to dwelling units, and common areas of multifamily dwellings/ Guest rooms and guest suites of hotels, motels, and their common areas/ Child care facilities/ Preschools and education facilities/ Business offices, corridors, waiting rooms and the like in clinics, medical, and dental offices, and outpatient facilities/ Assembly occupancies including places of awaiting transportation, gymnasiums, skating rinks, and auditoriums/ Dormitory units, Assisted living facilities*). Tamper resistant normal circuit receptacles duplex receptacles – Hubbell HBL5362TR.
  - b. Tamper resistant computer circuit duplex receptacles – Hubbell HBL5362TR – Color of receptacles shall be gray. All receptacles circuited to “C” panelboards shall be gray.
  - c. Tamper resistant emergency circuit duplex receptacles – Hubbell HBL5362TR – Color of receptacles shall be red.
  - d. GFCI duplex receptacles installed on the exterior of the Building shall be “Weather Resistant” type.
  - e. Tamper resistant duplex receptacles controlled by Digital Plug Load Room Controllers – Hubbell BR20C2TR.
5. USB Charger Devices shall be as follows, or as manufactured by Pass and Seymour, Inc., Leviton Manufacturing Co., or equal:
  - a. 20 amp, 2 USB chargers and duplex tamper resistant receptacle (5.0 amp) – Hubbell USB20A5W.
  - b. 20 amp, 4 USB charger receptacle (5.0 amp) – USB4W.
6. GFCI Receptacles
  - a. General Description: Straight blade, non-feed-through-type. Comply with NEMA WD 1, NEMA WD 6, UL 498, Federal Specification W-C-596, and UL943, Class A. Include indicator light that is lighted when device is tripped. Must have self-test feature (conducts an automatic test every three seconds, ensuring ground fault protection. If ground fault protection is compromised, power to the receptacle must be discontinued.
  - b. Tamper resistant duplex GFCI receptacles, rated 20 amperes, 125 volts. Receptacles shall be as follows, or as manufactured by Pass and Seymour, Inc., Leviton Manufacturing Co., or equal:
    - 1) Hubbell – GFTRST20.
7. Color of receptacles shall be white, unless otherwise noted.

## 2.35 ZERO SEQUENCE HARMONIC FILTERS

- A. Quality Assurance
  - 1. Manufacturer shall be ISO 9001 certified.
  - 2. Transformers shall be CSA certified and UL listed.
  - 3. Transformers shall be EPA Energy Star listed.
  - 4. Transformers shall be factory tested to CSA C9.
  - 5. Transformers shall meet all relevant CSA, EPA, IEEE, NEMA, NFPA, and UL standards.
  
- B. Submittals
  - 1. Shop Drawings shall include:
    - a. Enclosure dimensions.
    - b. Mounting devices.
    - c. Terminals.
    - d. Taps.
    - e. Internal and external component layout.
    - f. Amperage (neutral).
    - g. kVA rating.
    - h. Voltage.
    - i. Frequency.
    - j. BIL level.
    - k. Insulation class.
  
- C. Operations and Maintenance Manuals
  - 1. Operations and Maintenance Manuals shall include:
    - a. Recommended environmental conditions.
  
    - b. Recommended periodic inspections and maintenance.
  
- D. Materials
  - 1. Type 'IoFilter™', Zero Sequence Harmonic Filter (Dry Type) to CSA C9.
  
- E. Product Description – The design of the zero sequence harmonic filter, described in this Specification, shall be optimized for harmonic rich environments that are characterized by high neutral currents. These filters shall:
  - 1. Provide an ultra-low zero sequence impedance path for all third order, load-generated zero sequence harmonic currents, including I<sub>3</sub>, I<sub>9</sub>, I<sub>15</sub>, I<sub>21</sub>.
  - 2. Reduce neutral current between the point of filter application and the power source.
  - 3. Reduce voltage and current distortion.
  - 4. Reduce voltage and current imbalance.
  - 5. Reduce CMN (neutral-ground voltage) at the point of application.
  - 6. Reduce current crest factor.
  - 7. Reduce average and peak phase.
  - 8. Increase voltage stability during single-phase disturbance.
  - 9. Reduce system losses.
  - 10. Improve system power factor.
  - 11. Harmonic cancellation shall be by electromagnetic means only. No capacitors or electronics shall be used.
  
- F. Device Configuration
  - 1. Type: ANN.

2. Insulation Class: 220<sup>0</sup>C.
  3. Temperature Rise: 150 Deg. C.
  4. System Frequency: 60 Hertz.
  5. System Voltage: 208 Volts.
  7. BIL: 10,000 Volts (windings 1000V or less).
  8. Rating: As indicated on Drawings.
- G. Filter Characteristics
1. Key Requirements
    - a. Zero sequence reactance at 60Hz: <0.3.
    - b. Zero sequence impedance at 60Hz: <0.9.
    - c. Neutral connection shall be rated at three times the ampacity of the phase current.
  2. Basic Requirements:
    - a. Built to the following Standards: CSA C9-M1981, CSA22.2 No.47-1977, UL-506, ANSI C75.110, and NEMA ST-20.
    - b. Three-phase, common core construction.
    - c. Convection air-cooled.
    - d. Copper Windings.
    - e. Type: ANN.
    - f. Insulation Class: R.
    - g. Temperature rise: 150<sup>0</sup>.
    - h. Voltage Class: 1.2kV.
    - i. BIL Rating: 10kV.
    - j. Magnetic field at 1.5 feet: max. 0.1 Gauss.
    - k. Full load Efficiency at 170°C: EPA Energy Star requirements.
    - l. Sound level: per C57.12.91.
    - m. Enclosure: ventilated, drip-proof NEMA-1.
    - n. Finish: PQI super white power coat.
    - o. Anti-vibration pads shall be used between the core and the enclosure.
  3. Options:
    - a. Over-temperature alarm - wired to internal terminal strip:
      - 1) Contact (one per set point): normally closed.
      - 2) Set point: 180°C.
      - 3) Epoxy vacuum impregnation.
- H. Vendor Information:
1. Evidence of significant relevant application experience.
  2. Quantitative performance data including before/after effect on voltage distortion at load panels that demonstrates the capability to achieve the harmonic mitigation called for in this Specification.
  3. Product technical Specification.
  4. Pertinent product application information.
- I. Certification:
1. Manufacturer shall be ISO 9001 certified.
  2. Device shall be CSA certified and UL listed.
  3. EPA Energy Star listed.
- J. Warranty:
1. Manufacturer shall guarantee that the product will perform as described in Section E of this Specification Section.
  2. Manufacturer shall warranty the product against defective materials and workmanship.
  3. Minimum terms and conditions: 15 year, with standard limited liability clauses.



- K. Acceptable Mfr and Product:
  - 1. Power Quality International, Inc. – I.Filter™, Powersmiths, Square D, or equal.

### PART 3 - EXECUTION

#### 3.1 CLEANING, ADJUSTING AND TESTING

- A. At the completion of the work, all parts of the installation shall be thoroughly cleaned. All devices, equipment, conduits, and fittings shall be completely cleaned of grease, metal cuttings, dirt which may have accumulated during construction, and protection covers. Any discoloration or damage to parts of the Building, its finish or furnishings due to failing to properly clean the electrical system shall be repaired by the Electrical Subcontractor without cost to the Owner.
- B. The Electrical Subcontractor shall test all work and equipment as directed by the Architect and by Authorities Having Jurisdiction, furnish all equipment, necessary personnel and the electrical power.
- C. The entire installation shall be tested for shorts, grounds and open circuits and all defects shall be corrected before acceptance of his work. All work shall be demonstrated to be in proper operating condition to the complete satisfaction of the Architect and Owner.

#### 3.2 CONCRETE WORK

- A. The General Contractor shall provide concrete work for site lighting pole bases.
- B. The General Contractor shall provide duct and conduit envelopes and pads for electrical equipment. The General Contractor shall provide 4" concrete pads for all floor mounted electrical distribution equipment.
- C. The Electrical Subcontractor shall furnish all equipment anchor bolts and shall be responsible for their proper installation and accurate location.

#### 3.3 CONDUIT WORK

- A. All wiring shall be installed in heavy wall rigid steel unless otherwise noted below and run concealed except as indicated on the Drawings. Branch circuit wiring in hung ceilings, furred spaces or exposed may be installed in electrical metallic tubing. Panelboard feeders may be run in electrical metallic tubing except panelboard feeders run underground or in concrete slabs shall be in heavy wall rigid steel conduit as specified above or PVC. All exposed conduit in spaces indicated as mechanical rooms and where installed exposed below the 8' level elsewhere on the project shall be rigid steel conduit. Conduit extensions in metal partitions may be made with flexible metal conduit, with grounding conductor.
- B. Connections to portable and permanently mounted motorized equipment and motors, as well as the equipment housing, shall be made with approved liquid tight flexible metal conduit. Flexible connections shall be a maximum of 18" long and with grounding conductor. Flexible connections shall be used prior to attachment to equipment housings.
- C. Conduit ends shall be cut square, threaded and reamed to remove burrs and sharp edges. Field threads shall be of the same type and have the same effective length as factory cut threads. Excessive exposed threads will not be allowed. Turns, wherever required in exposed conduit runs shall be made by the use of factory-made bends, or field made

bends. Condulets, or in the event of a multiplicity of conduits making the same turn, a steel junction box with a removable steel cover may be used. Offsets and bends for changes in elevation of exposed conduit runs shall be made at walls or beams and not in open spaces between walls or beams. Conduits shall be routed so as not to interfere with the operation of maintenance of any equipment. The entire job shall be done in a neat and workmanlike manner. Steel supports or racks shall be galvanized steel channel and fittings, Unistrut, Kindorf, Husky Products Company, or equal.

- D. All conduit work shall be carefully cleaned and dried inside before the installation of conductors. Wire shall not be pulled into conduit system until Building is completed. Plug conduit ends to exclude dust, moisture, plaster or mortar while Building is under construction. No lubricants or cleaning agents which might have a deleterious effects on conductor coverings shall be used for Drawing conductors into raceways.
- E. Drawings, in relation to routing of conduits, are diagrammatic. The number and size of conduits and wire shall be furnished and installed as indicated by the Drawings. Conduits shall be routed in the field so as to be coordinated with the Building structure. Concealed conduit shall be as short and direct as possible. Exposed conduit shall be run in straight lines parallel to walls, beams and columns and with right angle bends and threaded conduit fittings. All conduit in concrete slabs shall be run above bottom steel reinforcing, below top reinforcing and column ties. Conduits passing through floors, walls and beams shall be of such size, number and in such locations so as not to impair the strength of the construction. At time of roughing conduits in concrete slab area, prior to pouring of slab, the Electrical Subcontractor shall consult the Structural Engineer for coordination and approval of size, spacing and method of conduit installation in slabs and walls, as well as penetration of such. Particular attention shall be given to the installation of conduits at grouped areas, such as panelboard, cabinet and pull box entrances.
- F. All metal conduit buried in the earth or fill shall be coated with two coats of heavy asphalt paint over its entire length, including couplings.
- G. Raceways in ceiling spaces shall be routed in such an approved manner as to eliminate or minimize the number of junction boxes required, but also shall be routed in an orderly and organized manner. Support rods and clamps shall be furnished and installed as directed by the Architect. Support of conduits by use of wire is strictly prohibited. Conduits shall be supported and secured by conduit support devices.
- H. Where rigid metal conduit is threaded in the field, a standard conduit cutting die providing 3/4" taper per foot shall be employed. Threadless coupling shall not be used on rigid metal conduit except where specifically allowed by the Architect. Running threads shall not be used on rigid metal conduit.
- I. Conduit work shall be installed in such a manner to keep exposed threads to an absolute minimum, and in no case shall more than three threads be left exposed after the conduit work is made up tight. This requirement applies to all conduit work, including conduit buried in earth or fill or in concrete.
- J. Minimum size conduit shall be 1/2" nominal trade size.
- K. A minimum 3/16" diameter twisted nylon plastic type fish cord shall be furnished and installed in all empty raceways. Provide a tag on each end of fish cord indicating the location of the other end.

### 3.4 ELECTRIC SERVICE

- A. Consult with National Grid/Eversource, hereinafter called the Utility Company, with respect to providing service and metering to the Building.
- B. Primary Service:
  - 1. The project shall be served from a utility company pole and shall run underground to a new pad mounted transformer.
  - 2. Transformer shall be installed on a concrete pad where shown on the Drawings. The exact location for terminating primary and secondary conduit at the transformer shall be coordinated with the Utility Company. All 90° risers into transformer pad shall be rigid galvanized steel conduit.
  - 3. The Utility Company shall furnish and install primary cable.
  - 4. Transformer shall be furnished and installed by the Utility Company. Primary connections at the transformer shall be by the Utility Company.
  - 5. The Electrical Subcontractor shall coordinate all work related to installing the primary services with the Utility Company. The Owner will pay for all backcharges incurred by the Utility Company.
  - 6. The Electrical Subcontractor shall furnish and install an extra Schedule 40 PVC duct from the utility co. pole to the transformer pad as shown on the Drawings.
- C. Secondary Service:
  - 1. The Electrical Subcontractor shall furnish and install secondary conduit and cable from the pad mounted transformer to the main disconnecting device. Secondary connections at the transformer shall be by the Electrical Subcontractor. Terminal connectors at the transformers secondary service shall be furnished and installed by the Electrical Subcontractor. Secondary service characteristics shall be 120/208 volt, three phase, four wire.
  - 2. The Electrical Subcontractor shall coordinate with the Utility Company to ensure the installation of the secondary service shall conform with the Utility Company's requirements.
  - 3. Metering shall be provided as indicated on Drawings, by the Utility Company.
- D. Division of responsibility with respect to the underground service extension shall be as follows:
  - 1. The General Contractor shall be responsible for the work and materials required for the following:
    - a. Excavation.
    - b. Backfill.
    - c. Transformer pad.
    - d. Concrete encasement of conduit.
    - e. Resurfacing of grades.
  - 2. All other materials, equipment and labor required for the complete ductbank shall be furnished and installed by the Electrical Subcontractor under this Section, including the following:
    - a. Primary and secondary raceways, including handholes.
    - b. Grounding system.
    - c. Pull strings.

### 3.5 EQUIPMENT CONNECTIONS

- A. The Electrical Subcontractor shall provide all connections to all equipment requiring electrical service, including power cables, branch circuit extensions, fire alarm cables, motors, controllers, lighting fixtures and all other equipment and systems specified or

shown on the Drawings.

### 3.6 EXTERNAL CABLE TV SERVICE

- A. Furnish and install from utility pole to the Building, as shown on the Drawings, Schedule 40 PVC duct with pull wire for Cable TV service. Consult with the Cable TV Company regarding this service and do all work according to their requirements.
- B. The Electrical Subcontractor will be responsible for providing complete Cable TV service to the Building.
- C. The Cable TV Company will install the Cable TV cable to the Building. The Owner will pay for all backcharges incurred by the Cable TV Company.
- D. Provide pull strings for entire run of conduit for service cabling from Cable TV service origination to point of demarcation. Provide pull string for spare conduit.

### 3.7 EXTERNAL TELEPHONE SERVICE

- A. Furnish and install from utility pole to the Building, as shown on the Drawings, Schedule 40 PVC duct with pull wire for Telephone cable installation. Consult with the Telephone Company regarding this service and do all work according to their requirements.
- B. The Electrical Subcontractor will be responsible for providing complete telephone service to the Building. Coordinate number of lines required with the Owner prior to installation.
- C. The Telephone Company will install the telephone cable to the Building. The Owner will pay for all backcharges incurred by the telephone company.
- D. Provide pull strings for entire run of conduit for service cabling from telephone service origination to point of demarcation. Provide pull string for spare conduit.

### 3.8 FIRE STOPPING

- A. Electrical installations in hollow spaces, vertical shafts and ventilation or air handling ducts shall be so made that the possible spread of fire or products of combustion will not be substantially increased. Openings around electrical penetrations through fire-resistance rated walls, partitions, floors or ceilings shall be firestopped using approved methods to maintain the fire-resistance rating. Refer to Section 07 84 10 for Firestopping. All fire stopping material and installation will be by the Electrical Subcontractor.

### 3.9 GROUNDING

- A. Grounding methods shall be in accordance with the Massachusetts Electrical Code Article 250 and Local Utility Company Regulations.
- B. Furnish and install from the main service switch to the street side of the water meter a stranded copper grounding conductor in rigid steel conduit. If the water service pipe is of material which is not electrically conductive, furnish and install approved copper plates or rods buried and grounded below grade, to which the main service grounding conductor shall be connected.
- C. Connections to the water pipe shall be made by a suitable ground fitting or lug connection to a plugged tee.

- D. The required equipment grounding conductors and straps shall be sized in compliance with National Electrical Code and shall be provided with green insulation equivalent to the insulation on the associated phase conductors.
- E. Flexible metallic conduit equipment connections utilized in conjunction with branch circuits shall be provided with suitable green insulated grounding conductors connected to approved grounding terminals at each end of the flexible conduit.
- F. The neutral conductor of all circuits shall have an identifying marking preferable a covering of white, readily distinguishable from the other conductors. This wire shall be unbroken from the distribution switch to the outlet.
- G. Each Electrical expansion fitting shall be provided with a bonding jumper.
- H. Ground metal frame of Building. Where metal of frame of Building cannot be grounded, provide concrete encased electrode as per National Electrical Code.

### 3.10 HVAC WIRING

- A. Wiring for low voltage temperature control equipment is included under Section 23 00 00.

### 3.11 INSTALLATION OF OUTLETS

- A. If any discrepancy is found to exist between the electrical plans and any other Drawings associated with the project, notify the Architect at once and have location verified before outlets are installed. Any reasonable change in location of outlets and equipment prior to roughing shall not involve additional expense to the Owner.
- B. Consult with the Ceiling Subcontractor regarding the centering of outlets in ceiling tile.
- C. Whenever outlets of any system are installed in brick, masonry or concrete construction, furnish and install the necessary boxes and conduit in connection therewith so that the General Contractor may build them in as the work progresses. Box offsets shall be made at all outlets to provide for proper adjustment to finished surfaces.
- D. Through-wall boxes will not be permitted. Outlet boxes shall not be mounted back to back, but shall be staggered a minimum of 12" on center.
- E. Knockouts in any boxes shall not be left open and all boxes not having equipment mounted on them shall be provided with blank covers.
- F. Bar hanger type outlets shall be used in hollow framed partitions other than those of the masonry or construction block type, with bar hanger supported from two partition studs. Bar hangers shall be secured to metal type partition studs with self- threading metal screws, or drill through hangers with caddy (or equal) clips shall be used.

### 3.12 INSTALLATION REQUIREMENTS

- A. All equipment mentioned in these Specifications or those on the Drawings shall be furnished new except where noted and completely installed and adjusted and left in a clean, safe and satisfactory condition, ready for operation and all supplies, appliances, and connections of every sort and description necessary to the operation of the equipment shall be furnished and installed to the satisfaction of the Architect and Owner.

- B. The Owner will not be responsible for materials and equipment until they have been tested and accepted.

### 3.13 MOTOR AND CONTROL WIRING

- A. The Electrical Subcontractor shall provide all wiring, including conduit, wire, junction boxes, disconnecting switches, and overcurrent protection, to and between all motors, starters, control devices and related electrical equipment whether specified or shown under Section 26 00 00 or other Sections, except where such items are factory wired as well as factory mounted on the driven equipment.
- B. Unless otherwise specified, the Electrical Subcontractor shall mount and align all starters, control devices, safety switches, power factor correction capacitors and other related electrical equipment whether specified in this or other Divisions of this Specification, except where such items are factory mounted on the driven equipment. The Electrical Subcontractor shall determine the correct rotation of any equipment connected to a polyphase motor and connect motor for this rotation before equipment is started.
- C. Unless otherwise specified, all wiring to motors, control equipment and related electrical equipment shall run in rigid conduit or EMT, with flexible metal conduit connections or liquid-tight flexible connections where specified elsewhere. Conduits shall be large enough to accommodate motor branch circuits and grounding conductors whether or not so indicated on Drawings. Wire sizes shall be as shown or to comply with the National Electrical Code.

### 3.14 PROJECT CLOSEOUT

- A. A certificate of completion shall be issued by the Electrical Subcontractor indicating that the installation is in conformance with the Construction Documents and all applicable Local, State and Federal Statutes and Codes. Final inspection by the Engineer shall be conducted after receipt of the Certificate of Completion. At minimum, life safety items shall be 100% complete including emergency lighting systems, the fire alarm system, and the emergency standby system before the Electrical Subcontractor request for final inspection. If final inspection by the Engineer proves that the emergency lighting systems, the fire alarm system, and the emergency standby system are not 100% complete, the Engineer will backcharge the Electrical Subcontractor at his hourly rate for re-inspection.

### 3.15 SLEEVES, INSERTS AND SUPPORTS

- A. The Electrical Subcontractor shall lay out and install his work in advance of the pouring of concrete floors and walls.
- B. Furnish and install all inserts, conduit hangers, anchors and steel supports necessary for the support and installation of all electrical equipment.
- C. Where openings are required in walls and floors for the passing of raceways, ducts or busways, the Electrical Subcontractor shall furnish the General Contractor with the necessary information regarding dimensions and locations so that he may install suitable concrete stops to provide these openings. Such openings shall be by the General Contractor in such a manner so as not to interfere with the fireproof integrity of the Building.
- D. The Electrical Subcontractor will be held responsible for the location of and maintaining in proper position, sleeves, inserts and anchor bolts supplied and/or set in place by him. In

the event that failure to do so requires cutting and patching of finished work, such work shall be done at the Electrical Subcontractor's expense by the General Contractor.

### 3.16 SPECIAL COORDINATION INSTRUCTIONS

- A. Coordination with the work of other trades is referred to within various parts of this Section. The following special instructions shall also be carefully noted:
1. The Electrical Subcontractor shall obtain from the HVAC Engineer copies of all Shop Drawing prints showing the ductwork installation as it will be put in place on the project. These Drawings shall be thoroughly checked by the Electrical Subcontractor and the routing of all conduits and installation of all outlets and electrical equipment shall be coordinated with the ductwork so as to prevent any installation conflict. Such coordination shall be done prior to roughing-in conduits, outlets and electrical equipment.
  2. Locations of all wall outlets shall be verified with the Architect prior to roughing in conduits. Refer to details and wall elevations on the Architectural Drawings; mounting heights indicated on these Architectural Drawings and/or specific dimensional information given to the Electrical Subcontractor by the Architect shall take precedence over such information indicated on the Electrical Drawings.
  3. Refer to all other Drawings associated with this project. Any equipment which requires an electrical supply circuit, switch, controls and connections, even though not indicated on the Electrical Drawings, shall be furnished and installed as directed by the Architect. Locations of lighting fixtures shall conform to the architectural reflected ceiling plans.
  4. Refer to Architectural Drawings for areas in which the concrete slab is poured on grade. In these areas a moisture proofing membrane will be installed on the grade fill or earth prior to pouring of slab. Electrical conduits shall be so installed, where possible, to avoid the necessity of penetrating this moisture proofing membrane. Such penetration of the membrane shall only be made when specifically allowed by the Architect, and shall be made only at locations directed by the Architect.

### 3.17 UNDERGROUND DUCTBANK

- A. Furnish and install ductbank as herein specified and as shown on the Drawings. The entire length of ductbank must be inspected and approved by the Utility Company prior to being covered.
- B. Materials shall be as follows:
1. Conduit-PVC Schedule 40.
  2. Conduit supports (duct system) shall be molded plastic with interlocking lugs and skeletonized structure. Minimum separation 3-1/2 inches.
- C. Duct System shall be as follows:
1. The size and number of conduit shall be as indicated on the Drawings.
  2. The entire length 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 the top is a minimum of 36 inches below finished grade.
  5. Changes in direction shall be made by long sweep bends. Minimum radius 25 feet except that at the end of a run within 10 feet of termination, manufactured bends may be used having a minimum radius of 36".
  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".
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".
  8. When the required number of conduits have been installed, securely tie the assembly together at distances not exceeding 7 feet. Tie shall consist of three turns of No. 18 iron wire. Separate ties required for low tension and high tension conduit runs.
  9. Where conduit is encased, the duct envelope shall be of monolithic construction.
    - a. Pouring of concrete shall be continuous throughout the length of construction. The end of the pour shall be interlocked or sloped. If the installation is halted, the ends of the conduit shall be plugged.
    - b. Concrete shall not be poured until the conduit installation has been inspected and approved.
  10. After the installation is completed, each conduit shall be cleaned and identified. A standard flexible mandrel and stiff bristle brush shall be pulled through each conduit. The mandrel shall be not less than 12" long and the diameter approximately 1/4" less than the conduit.
  11. Install approximately 12" below the top of the trench above each conduit or direct buried cable a 6-inch wide plastic warning tape. Tape shall be yellow in color with black letters reading "Buried Electric Lines."
  12. Electric handholes shall be precast and shall be installed where indicated. The exact location of each handhole shall be determined after careful consideration has been given to the location of other utilities, grading and paving. The location of each handhole shall be approved by the Architect before installation. Handholes shall be monolithically constructed precast-concrete having the required strength as established by ASTM A 79 Grade 60 and inside dimensions by the Drawings or Specifications. Frames and covers shall be delivered on the job unpainted and, after approval, shall be given two (2) coats of asphalt paint. In unpaved areas, the top of handhole covers shall be approximately 1-2 inch above the finished grade. Where existing grades that are higher than finished grades are encountered, provide a brick collar to elevate temporarily the handhole cover to existing grade level. Where duct lines enter handholes, the sections of duct may be either cast in the concrete or may enter the handhole through a square or rectangular opening of suitable dimensions provided in the handhole walls. Where openings are provided for the entrance of duct lines, the space between ducts and between ducts and handhole walls shall be caulked tight with lead wool installed over the handhole sump. A cable-pulling iron shall be installed in the wall opposite each duct line entrance. All handholes shall be provided with double-lockable type covers.

### 3.18 WIRE AND CABLE

A. Wiring for all branch circuits and feeder circuits shall be color coded as follows:

1. 3-phase, 4-wire, 208Y/120 volts:

<u>Phase</u>	<u>Color</u>
A	Black
B	Red
C	Blue
Neutral	White
Equip. Ground	Green
2. 3-phase, 4 wire, 480Y/277 volts:

<u>Phase</u>	<u>Color</u>
A	Brown



B	Orange
C	Yellow
Neutral	Gray
Equip. Ground	Green

3. Connections to terminal shall be arranged Phase A, B, C from left to right.
  4. Signal system shall be color coded differently from electrical systems described above.
  5. For large size conductors available only in black, use colored plastic tape at all ends and where connections and splices are made for the specified color code identification. Tape shall be wrapped around the conductor three complete turns.
- B. In each case, the phase wires shall be connected to the phase supply mains in proper rotation to assure a balanced condition on the panel. The circuit numbers assigned on the Drawings are used for convenience only and need not designate the circuit on the panel to which that circuit may be connected. However, the circuit numbers and circuit description are required to be typewritten on the panelboard directory at the conclusion of the work, and shall represent the circuits as actually connected to the panelboard.
- C. Joints and splices shall be made in an approved manner and shall be equivalent, electrically and mechanically, to the conductor insulation. Solid conductors shall be spliced with approved wiring connectors. Conductors of Size No. 8 AWG and larger shall be connected by use of solderless pressure connectors; these joints and splices shall be taped with one wrap of varnish cambric tape and then a minimum of three wraps of No. 88 Scotchbranch (3M Company) all-weather vinyl plastic electrical tape, or equal Permacel or Plymouth Company. Each wrap of tape shall be half-lapped. Conductors of Size No. 4 AWG or larger shall have two coats of insulating varnish applied over the tape.
- D. Switch leg wiring shall be the same color as the phase conductor from which it is supplied.

END OF SECTION

**EMERGENCY LIGHTING RELAY PANEL LCE1 SCHEDULE**

RELAY	PANEL	CIRCUIT NUMBER IN LIGHTING PANEL	DESCRIPTION	NOTES	PHOTOSENSOR CONTROL	TIME SWITCH CONTROL	VOLTAGE
1	EP1	15	BUILDING MOUNTED LIGHTING	1/4	X	X	120
2	EP1	16	BUILDING MOUNTED LIGHTING	1/4	X	X	120
3	EP1	17	BUILDING MOUNTED LIGHTING	1/4	X	X	120
4	EP1	18	BUILDING MOUNTED LIGHTING	1/4	X	X	120
5	X	X	X	X	X	X	X

**LIGHTING RELAY PANEL LCN1 SCHEDULE**

RELAY	PANEL	CIRCUIT NUMBER IN LIGHTING PANEL	DESCRIPTION	NOTES	PHOTOSENSOR CONTROL	TIME SWITCH CONTROL	VOLTAGE
1	PPG	18	SITE LIGHTING	1/3	X	X	120
2	PPG	19	SITE LIGHTING	1/3	X	X	120
3	PPG	20	SITE LIGHTING	1/2	X	X	120
4	PPG	21	SITE LIGHTING	1/2	X	X	120
5	PPG	22	SITE LIGHTING	1/2	X	X	120
6	PPG	26	BUILDING MOUNTED LIGHTING	1/2	X	X	120
7	PPG	27	BUILDING MOUNTED LIGHTING	1/2	X	X	120
8	X	X	X	X	X	X	X
9	X	X	X	X	X	X	X
10	X	X	X	X	X	X	X

\*REFER TO SINGLE LINE LIGHTING INTERATOR PANEL COMMUNICATION LEVEL DETAIL FOR PANEL CAPACITY AND RELAY QUANTITY. NOTE NO SPACES ARE ALLOWED. PANEL CAPACITY SHALL BE PROVIDED AS SPARE RELAYS. THIS IS TYPICAL OF ALL LIGHTING RELAY PANELS.

**LIGHTING PANEL RELAY SCHEDULE NOTES**

- LIGHTING RELAY PANEL HAS A MASTER OVERRIDE SWITCHES TO CONTROL ALL RELAYS IN PANEL IN CUSTODIANS OFFICE.
- AS PER ASHRAE 90.1 2010 AND 2018 IECC, LIGHTING FIXTURES SHALL AUTOMATICALLY SHUTOFF FROM MIDNIGHT OR WITHIN ONE HOUR OF THE END OF BUSINESS OPERATIONS, WHICHEVER IS LATER, UNTIL 6AM OR BUSINESS OPENING WHICHEVER IS EARLIER OR:
- AS PER ASHRAE 90.1 2010 AND 2018 IECC, CONNECTED LIGHTING POWER SHALL BE REDUCED BY AT LEAST 30% FROM MIDNIGHT OR WITHIN ONE HOUR OF THE END OF BUSINESS OPERATIONS, WHICHEVER IS LATER, UNTIL 6AM OR BUSINESS OPENING WHICHEVER IS EARLIER OR DURING ANY PERIOD WHEN NO ACTIVITY HAS BEEN DETECTED FOR A TIME OF NO LONGER THAN 15 MINUTES. THE LIGHTING FIXTURES SHALL TURN ON VIA LIGHTING FIXTURE INTEGRAL PHOTOSENSORS, IF NO ACTIVITY HAS BEEN DETECTED FOR A TIME OF NO LONGER THAN 15 MINUTES, THE LIGHTING FIXTURES SHALL AUTOMATICALLY DIM BY 50%. IF ACTIVITY IS DETECTED, THE LIGHTING FIXTURE INTEGRAL MOTION SENSORS SHALL DRIVE THE LIGHTING LEVEL UP TO 100%. THE INTEGRAL MOTION SENSORS/PHOTOSENSOR SHALL NOT HAVE THE CAPABILITY TO SHUTOFF THE LIGHTING FIXTURES COMPLETELY ONLY BE CAPABLE OF DIMMING THE LIGHTING FIXTURES BY 50% AND RAMPING UP TO 100%. IN ADDITION, THE LIGHTING CIRCUIT CAN BE TIME SWITCH CONTROLLED VIA THE LIGHTING RELAY PANEL.
- AS PER ASHRAE 90.1 2010 AND 2018 IECC, LIGHTING FIXTURES ARE EXEMPT FROM AUTOMATICALLY REDUCING THE LIGHTING CONNECTED POWER BY AT LEAST 30% SINCE THESE LIGHTING FIXTURES ARE LIGHTING EXITS FROM THE BUILDING AS REQUIRED FOR SAFETY AND SECURITY. IF NORMAL ELECTRIC UTILITY CO. POWER IS LOST, LIGHTING FIXTURES WILL AUTOMATICALLY TURN ON AS POWERED BY THE EMERGENCY GENERATOR.

1	LIGHTING RELAY PANEL SCHEDULES	SCALE: N.T.S.
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**LED SITE LIGHTING FIXTURE SCHEDULE**

NOTES:  
 1. LIGHTING FIXTURES SHALL BE FURNISHED COMPLETE WITH ALL HARDWARE, LAMPS, HANGERS, ACCESSORIES, ETC. FOR A COMPLETE AND PROPER INSTALLATION.  
 2. THE MANUFACTURERS AND CATALOG NUMBERS IDENTIFIED IN THIS LIGHTING FIXTURE SCHEDULE ARE INTENDED TO ESTABLISH A GENERAL LEVEL OF QUALITY, CONFIGURATION, MATERIALS, AND APPEARANCE REQUIRED. THIS IS NOT A PROPRIETARY SPECIFICATION AND IT SHOULD BE NOTED THAT "OR EQUAL" APPLIES TO ALL LIGHTING FIXTURES DENOTED HEREIN. IT IS UNDERSTOOD THAT ALL MANUFACTURERS WILL HAVE MINOR VARIATIONS IN CONFIGURATION, APPEARANCE, AND PRODUCT SPECIFICATIONS AND SUCH MINOR VARIATIONS SHALL NOT ELIMINATE SUCH MANUFACTURERS AS AN APPROVED EQUAL.  
 3. LIGHTING FIXTURES SHALL CONFORM TO THE REQUIREMENTS OF THE ELECTRIC UTILITY CO. REBATE PROGRAM, WHERE APPLICABLE.  
 4. MOUNTING ABBREVIATIONS: "RW" = RECESSED IN WALL, "SW" = SURFACEWALL, "P" = POLE, "G" = GROUND, "PT" = POST TOP.  
 5. REFER TO TECHNOLOGY DRAWINGS, COORDINATE EXACT MOUNTING LOCATION AND ORIENTATION OF ALL CAMERAS AND ASSOCIATED MOUNTING ARMS WITH ARCHITECT/ENGINEER PRIOR TO INSTALLATION.  
 6. POLE LENGTH SHALL BE AS REQUIRED SO THAT BOTTOM OF LIGHTING FIXTURE IS AT 15' ABOVE FINISHED GRADE, TAKING INTO ACCOUNT LIGHTING FIXTURE, ARM, POLE, POLE BASE, AND CONCRETE POLE BASE. PROVIDE ELEVATION INCLUDING ALL DIMENSIONS DURING SUBMITTAL PHASE FOR REVIEW.  
 7. POLE LENGTH SHALL BE AS REQUIRED SO THAT BOTTOM OF LIGHTING FIXTURE IS AT 12' ABOVE FINISHED GRADE, TAKING INTO ACCOUNT LIGHTING FIXTURE, ARM, POLE, POLE BASE, AND CONCRETE POLE BASE. PROVIDE ELEVATION INCLUDING ALL DIMENSIONS DURING SUBMITTAL PHASE FOR REVIEW.  
 8. LIGHTING FIXTURE WILL DIM TO 50% POWER, 50% LIGHT OUTPUT, PER DIMMING PROFILE. IF MOTION IS DETECTED DURING THE TIME THAT THE LIGHTING FIXTURE IS OPERATING AT 50%, THE LIGHTING FIXTURE GOES TO 100% POWER AND LIGHT OUTPUT. THE LIGHTING FIXTURE REMAINS ON HIGH UNTIL NO MOTION IS DETECTED FOR THE DURATION PERIOD, AFTER WHICH THE LIGHTING FIXTURE RETURNS TO LOW. DURATION PERIOD IS SET AT FACTORY TO 15 MINUTES.

TYPE	MANUFACTURER	CATALOG NUMBER	VOLTAGE	MOUNTING	WATTAGE	TOTAL LUMENS	COLOR TEMP.	DIMMING (%)	BUG	DISTRIBUTION TYPE	DESCRIPTION/REMARKS	COLOR/FINISH	APPROVED ALTERNATE MANUFACTURERS
SL1	NLS LIGHTING	CAL-S-TP2-S6-T5-32L-1-30K-UNV-AM-CBA-MGF-PC-FSP-20	UNV	P	106	10000	3000K	0-10V	B3 U0 G2	V	SINGLE HEAD, DARK-SKY FRIENDLY PARKING/ROAD SITE LIGHTING FIXTURE, WITH PHOTOCELL, ON 15'-0" (SEE NOTE 6) 6" ROUND STEEL POLE WITH DECORATIVE ARM 6-1/4" X 4" ACCESS DOOR, PROVIDE INTEGRAL MOTION SENSOR (SEE NOTE 8). MARINE GRADE FINISH POLE, ARM, AND FIXTURE.	CBA	CYCLONE PHILIPS ACUTY BRANDS
SL2	NLS LIGHTING	SSF-S-6R-COG45-16L-7-30K-UNV-1B-CBA-VRB-MGF	UNV	G	35	2030	3000K	0-10V	B1 U0 G2	-	36" SITE BOLLARD LIGHTING FIXTURE, DARK-SKY FRIENDLY, FLAT TOP, WITH STACKED LOUVER LENS, MARINE GRADE FINISH.	CBA	MCGRAW-HEDISON WAC LIGHTING ACUTY BRANDS
SLW	NLS LIGHTING	CAL-S-TP2-S6-T4-32L-53-30K-UNV-WM-CBA-MGF	UNV	W	54	5616	3000K	0-10V	B2 U0 G3	IV	WALL MOUNTED SITE LIGHTING FIXTURE, ON DECORATIVE ARM, MARINE GRADE FINISH. DARK-SKY FRIENDLY.	CBA	CYCLONE PHILIPS ACUTY BRANDS



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ELECTRICAL  
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