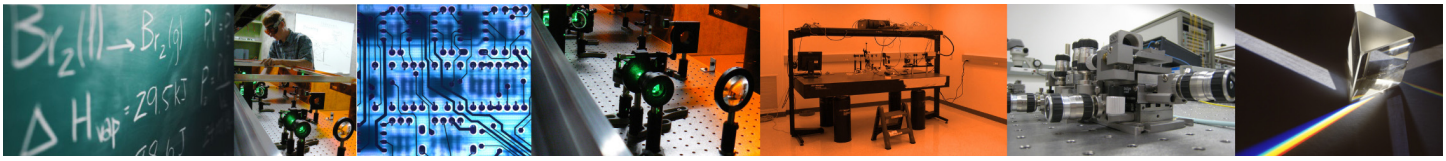
dsu delaware state university : optical science center for applied research



Construction Documents - Volume 2

Divisions 15 through 17

Geotechnical Report

Supplemental Geotechnical Evaluation

Prliminary Vibration Analysis of Floor Framing

Supplemental Pile Analysis

04 October 2013

richärd + bauer

in association with

becker morgan group

and ballinger

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APPENDICES

APPENDIX 1

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware

Prepared by:
Duffield Associates, Inc.
Consultants in the Geosciences
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Wilmington, Delaware 19808

Project No. 2484.GQ, Dated: April 30, 2012

APPENDIX 2

Supplemental Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
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Project No. 2484.GQ, Dated: October 17, 2012

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SECTION TITLE

APPENDIX 3

Preliminary Vibration Analysis of Floor Framing

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Project No. 2484.GQ, Dated: February 22, 2013

+ + END OF SECTION + +

SECTION 15000 - GENERAL REQUIREMENTS MECHANICAL

PART 1 - GENERAL

1.1 INTENT OF DOCUMENTS

A. Consider drawings and specifications as supplementing each other. Perform or furnish work specified but not shown, or shown but not specified, as though mentioned in both specifications and drawings.

B. Consider flow diagrams and details as part of Contract Documents. Provide equipment, valves, piping and other accessories shown on flow diagrams and details as if they were shown on drawings.

C. Provide minor items, accessories or devices as necessary for completion and proper operation of systems whether or not they are specifically called for by specifications or drawings.

D. Work includes providing all labor, material, equipment and service necessary and reasonably incidental to proper completion of all systems as shown on drawings and as specified.

1. "Provide" means to furnish and install complete and in place.

2. "Furnish" means to furnish at site of work unless otherwise stated.

E. Coordinate work and equipment of mechanical trades with work and equipment specified elsewhere to assure complete and satisfactory installation.

1. Perform work such as excavation, backfill, concrete, flashing, etc., required under Division 15 in compliance with requirements of applicable Division of specifications.

1.2 REPAIR WORK INCLUDED

A. Repair damage to work installed under Division 15 or to work of others, caused by neglect on the part of the Division 15 Contractor at own expense and to satisfaction of Architect.

1.3 UNFINISHED OR FINISHED AREA, GENERAL DEFINITION

1. Finished area shall be defined as a space with walls either tiled, plastered, covered or painted except certain concrete or concrete block foundation walls below grade.

2. Run vertical piping through finished spaces in chases or concealed in walls or partitions.

3. Conceal all piping and conduit above ceilings, where there are ceilings in finished areas. Where indicated "at ceiling", piping shall be exposed below the ceiling.

4. Areas where bottoms of floor or roof slabs serve as finished ceilings shall also be considered as finished areas.

B. Unfinished areas shall be defined as spaces without wall finish (with or without ceilings).

C. Where in doubt as to classification of any space(s), obtain written clarification from Architect before roughing-in.

1.4 CONTRACT DRAWINGS

A. Drawings indicate arrangements, approximate sizes and relative locations of principle apparatus, equipment, devices and services to be provided.

B. Layout of equipment indicated on drawings shall be checked and compared against all drawings and specifications of all trades and exact locations determined using approved shop drawings of such equipment.

1. Where physical interference occurs, consult with Architect and prepare dated, dimensioned drawings correcting such interferences. Submit to Architect for review of such drawings, and distribute same as required.

C. Measurement of drawing by scale shall not be used as a working dimension. Such measurements shall be taken from figured dimensions.

1.5 LOCATIONS OF FIXTURES

A. Fixtures, equipment, sleeves outlets, registers, grilles, piping and ductwork and connections thereto shall be located as directed by Architect and to avoid conflicts with work of others.

B. When so directed, by Architect, prepare 1/4-inch scale drawings to indicate and dimension, size, and locations of all sleeves in slabs, partitions, foundation wall, beams and/or columns.

C. Obtain approval of Architect of above drawings before continuing with work.

1.6 EQUIPMENT DEVIATIONS FROM DESIGN

A. Dimensions and ratings of equipment specified or indicated on drawings establish desired outlines and characteristics of such equipment. Minor deviations will be permitted to allow manufacturers specified to bid on their nearest stock equipment, providing that equipment equals or exceed basic performance conditions indicated.

B. Manufacturer's catalog or model numbers and types mentioned in specifications or indicated on drawings are intended to be used as guides and shall not be interpreted as taking precedence over specific ratings or duty called for or shown, which modify stipulations in such catalog. Verify duty specified with particular characteristics of equipment to be submitted for approval, and submit only items which comply with specification requirements.

C. Where equipment furnished differs in physical character from that specified or indicated or where equipment substituted at request of Division 15 Contractor, which is acceptable to Owner and Architect, requires increased services or facilities to be provided, pay costs for such services and other modifications that may be required to accommodate substituted equipment.

1.7 SUBSTITUTIONS

A. Comply with "Conditions of Contract."

B. Substituted equipment or equipment options, where permitted and approved, must fit within the allowable physical space and satisfy all manufacturer-required service clearances.

C. Whether approved or not, the Contractor shall replace substituted equipment that cannot fit into the allowable space, at his own expense.

D. Contractor shall make any modifications to related systems, required as a result of substitutions, at his own expense.

1.8 GUARANTEE AND CERTIFICATION

A. All work, equipment and materials shall be guaranteed and certified to be free from defects and leaks for not less than one year following date of beneficial use, unless specified for a longer period elsewhere.

B. Defective work, equipment and/or materials, and any resulting damage to work of other divisions, shall be repaired or replaced, as directed, for duration of stipulated guarantee period.

PART 2 - PRODUCTS

2.1 STANDARD OF QUALITY

A. Materials shall strictly comply with quality, style and sizes specified and shown on contract drawings.

1. Manufacturer's names and model numbers may be stated in contract documents for the purpose of establishing standards of quality, style, size and type, and shall not be construed to exclude equipment or materials of other acceptable manufacturers, subject to compliance with contract requirements.

2. Wherever a manufacturer is specified, any other acceptable manufacturer’s item shall conform in all respects to the specified item.

3. Consideration will not be given to claims that another manufacturer’s item meets performance requirements with lesser construction.

4. Performance as delineated on contract drawings and in specifications shall be interpreted as minimum performance.

PART 3 - EXECUTION

3.1 INTENT OF DOCUMENTS

A. General arrangement of ductwork, piping and equipment shall be as shown on contract drawings.

1. Deviations: Submit detailed drawings of proposed deviations, due to actual field conditions or other causes, to Architect for review and approval

2. Such changes shall be made at no additional cost to the Owner.

B. Carefully investigate structural and finish conditions affecting work under Division 15 and arrange such work accordingly, furnishing such fittings, valves, transitions and accessories as required to meet such conditions.

1. Diagrammatic Nature of Contract Drawings: Inasmuch as drawings are generally diagrammatic, and because of small scale of drawings, it is not possible to indicate all off-sets, fittings, and accessories which may be required. Provide these off-sets, fittings and accessories at no additional cost to the Owner.

3.2 COORDINATION WITH OTHER DIVISIONS

A. Coordinate work with other divisions in order to best arrange equipment, ducts, piping, fixtures, finish work, and conduits.

B. Reconcile points of conflict between work of this division and work of other divisions.

C. Carefully study contract drawings and specifications pertaining to work of project, examine building site during construction and compare drawings with existing conditions.

3.3 WORK PRACTICE AND PROTECTION OF EQUIPMENT

A. Protect surfaces, either finished, in preparation for finishing or finish material application, against

damage from welding, cutting, burning, soldering or similar construction activities.

1. Division responsible for installation of item damaged shall make good damage as directed by Architect at expense of division causing damage, and at no cost to Owner.

2. Maintain protective coverings and coatings, and replace when so directed by Architect until work is ready for acceptance.

B. Exposed polished metal fittings, parts and devices, shall have protective coating applied and maintained during course of construction, and shall not be installed until adjoining tile or masonry work has been finally acid-cleaned.

3.4 INSTALLATION PROVISIONS

A. Install equipment, piping and ducts to preserve access to fittings, valves and accessories. In general, piping and ducts shall be concealed unless otherwise indicated on plans, but when exposed they shall be run so as to allow maximum head room consistent with proper pitch.

B. No waterproofing shall be cut, except on written approval of Architect.

C. Install sewers and water service piping below recorded frost penetration for area involved except that water service lines shall have not less than 36 inches cover over pipe, and sewers and drainage lines shall have covering of not less than 30 inches. Pipes installed under roadways or points requiring special conditions shall be installed as outlined in specifications.

3.5 LINES AND GRADES

A. Lay out work, establish heights and grades for exterior and interior piping and ductwork included in specifications in accordance with intent of drawings, physical conditions of building and finished site grades. Assume responsibility for accuracy of such heights and grades meeting physical conditions of building and specification requirements.

3.6 LEAKS

A. Assume responsibility for leaks in Division 15 work during construction and guarantee period, and rectify, at no cost to Owner, such leaks that occur immediately upon notification by Owner. Repair damage to other work resulting from such leaks which may occur during construction and guarantee period at once, at no cost to Owner.

3.7 COORDINATION DRAWINGS

A. To coordinate fit and installation of mechanical and electrical work prepare fully-dimensioned 3/8-inch scale reproducible coordination drawings, delineating proposed sheet metal installation. Then add those remaining items which are under Division 15 and distribute prints to contractors for other divisions.

1. Each mechanical subcontractor shall subsequently, in succession, delineate his respective work, including piping, ducts, equipment and conduit to scale, with necessary vertical and horizontal dimensions on reproducible copy. Monitor progress of coordination drawing development and act promptly to resolve conflicts or encroachments that become apparent, whether they affect structure, finishes or mechanical or electrical work.

2. In event of conflict or dispute among contractors regarding location or configuration of work, which subcontractors cannot resolve, Architect shall intercede and his decision shall be binding on contractors, without recourse, except as provided in contract documents.

3. When work has been properly shown on coordination drawings and Division 15 contractor, and all subcontractors agree that their respective work can be installed and will properly fit

together, they shall so acknowledge by endorsing drawings.

3.8 COMMISSIONING

A. Execute commissioning of equipment and systems as specified in SECTION 01770 - CLOSEOUT REQUIREMENTS, SECTION 15950 - TESTING, ADJUSTING AND BALANCING (TAB) FOR HVAC. Commissioning requirements specified in these documents apply throughout Division 15 and shall be provided/met by the Division 15 Contractor whether specifically listed in the applicable context or not.

3.9 CUTTING, REPAIRING AND PATCHING

A. Assume responsibility for cutting and patching required for work of Division 15.

B. Except as otherwise indicated or approved by Architect, provide materials for cutting and patching which will result in equal-or-better work than work being cut-and-patched, in terms of performance characteristics and including visual effect where applicable.

1. Comply with requirements, and use materials identical with original materials where feasible and where recognized that satisfactory results can be produced thereby.

C. Provide adequate temporary support for work to be cut, to prevent failure. Do not endanger other work. Provide adequate protection for other work during cutting and patching, to prevent damage; and provide protection of work from adverse weather exposure. Assume responsibility for correction and repair of damages incurred.

3.10 PLUMBING VENTS THROUGH ROOF

A. Except when otherwise shown on the contract drawings or specified, terminate vents passing through roof 24 inches above roof.

B. Provide lead flashing.

C. Provide curb and counter-flashing.

3.11 ACCESS PANELS

A. In general, arrange mechanical work so that access panels will not be required.

B. Where air volume control units, valves, dampers, steam traps, drain traps, junction boxes, etc., must be concealed in finished solid construction, and where access panels have not been shown on drawings, provide access panels of adequate size to permit servicing, adjustment or removal of such concealed items.

1. Wherever possible, provide access panels not smaller than 16" x 16".

C. Provide panel types in accordance with Division 8 of the specifications.

D. Deliver access panels, with screwdriver locking device for installation by applicable Contractor.

3.12 CONCRETE

A. Provide concrete required for work under Division 15, unless otherwise noted. Concrete shall be 3000 psi in accordance with provisions of Division 3.

1. Housekeeping Pads: Set all floor-mounted equipment on 4” high concrete housekeeping pads, unless otherwise shown or specified. Engage the services of the Structural or General Contractor, and pay for them, to provide the concrete housekeeping pads.

a. Pads shall be 4” wider and longer than vibration isolation base or structural base of equipment being set on pad.

a. Boilers and Chillers: Comply with equipment manufacturer’s installation requirements for extent of pad. A full width and length pad is not always required or desired.

3.13 PAINTING

A. Where indicated in contract documents, prime and finish paint mechanical equipment, ductwork, piping and their supports in equipment rooms, machine rooms, equipment and machine areas, outdoors and in occupied spaces. Comply with materials and methods specified in Division 9.

+ + END OF SECTION + +

SECTION 15055 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section describes electrical equipment and wiring provided under Divisions 15.

1.2 SUBMITTALS

A. Submit for review for motors and variable frequency drives:

1. Product Data:

a. For Motors, include the following:

1) Manufacturer.
2) Type.
3) Model.
4) Service factor.
5) Frame size.
6) Electrical Characteristics: Include rpm, hp, voltage, phase, frequency, and power factor.
7) Physical Characteristics: Weights and dimensions.
8) Enclosure types.
9) Standard Efficiency Ratings: Include:

a) Part-load efficiency.
b) Power-factor curves.
c) UL listing, where applicable.
d) Current at full-load, no-load, and locked rotor current.
e) Bearing identification.
f) Guaranteed efficiency and NEMA spread of efficiency.

b. For Variable Frequency Drives (VFD), include the following:

1) Published catalog data.
2) Heat rejection to surroundings, Btuh.
3) Typical efficiency vs. speed graph for variable torque load.

2. Shop Drawings: For variable frequency drives, include unit dimensions, electrical sizing data, wiring diagrams, control diagrams, and sequences of operations.

3. Calculations: For variable frequency drives, submit calculations customized for this installation, showing total harmonic voltage distortion is less than 5 percent.

a. Provide input line filters sized as required by the VFD manufacturer to ensure compliance with IEEE standard 519.
b. The acceptance of this calculation must be completed prior to drive installation.
c. Prior to installation, provide the estimated total harmonic distortion (THD) caused by the VFD.
d. The results shall be based on a computer aided circuit simulation of the total actual system, with information obtained from the power provider and the user.
e. If the voltage THD exceeds 5 percent, the VFD manufacturer shall recommend the additional equipment required to reduce the voltage THD to an acceptable level.

4. Quality Control Submittals:

a. Source Quality Control Reports:

1) Variable frequency drive factory test reports.

b. Field Test Reports.

1) Variable frequency drive field test report.

B. Submit for record for motors:

1. Motor Schedule: Schedule of all motors and the size of their thermal overload elements.

1.3 QUALITY ASSURANCE

A. All products and composite packages shall meet all applicable paragraphs of IEEE, NEC and NEMA Standards, shall be designed for installation in accordance with the NEC, and shall be UL or ETL labeled.

B. The variable frequency drive manufacturer shall customize the variable-speed motor drive output signal to compensate for the actual distance (greater than 50 feet) between the variable frequency motor drive and the motor.

1.4 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.

2. Torque, speed, and horsepower requirements of the load.

3. Ratings and characteristics of supply circuit and required control sequence.

4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 MOTOR DESIGN CRITERIA

A. Unless otherwise indicated, design motors for starting torque and current in accordance with NEMA Standards using a service factor of 1.15 at constant speeds. Motors shall be U.L. listed and labeled.

B. For motors outdoor weather-exposed, provide totally enclosed fan-cooled (TEFC) or totally enclosed air over (TEAO) motors, unless indicated otherwise.

C. For all other motor locations, provide open drip-proof (ODP) motors, unless indicated otherwise.

D. Motors and drives shall not produce sound levels exceeding 90 dBA in accordance with Subpart G (Occupational Noise Exposure) of OSHA Standards. Sound measurement data shall be obtained in accordance with IEEE Standard 85.

E. Select motors to operate within their horsepower rating, and not on the basis of service factor.

F. Provide a grounding lug in the motor terminal box.

G. Vibration amplitudes shall be in accordance with requirements of the referenced NEMA Standard

MG 1-12.06.

H. Motors shall have ball bearings with externally accessible grease inlet/outlet fittings. Where motors are enclosed within equipment, provide grease extension tubing to exterior of equipment.

I. The motor frame, end bells, and conduit box shall be cast iron; stator windings shall be copper.

1. Open drip-proof motors, 5.0 hp and smaller, may be rolled steel.

J. Motors supplied with equipment shall be selected by the equipment manufacturer for the intended service.

K. Motors for variable frequency drive service shall be "Inverter Ready, Premium-Efficiency", and shall be selected by the variable frequency drive manufacturer.

1. Design motors used with variable frequency drives with a cast iron motor housing, and 1.15 service factor when operated across-the-line and 1.0 on inverter.

2. Motors shall be provided with "Inverter Grade"
wiring and insulation complying with the requirements of NEMA MG1 Part 30 and 31, including Section IV Part 30.02.2.9.

3. Motors shall have a 10:1 speed range on variable torque loads and 4:1 speed range for constant torque loads.

L. Provide a stainless steel nameplate for each motor, indicating model number, HP, voltage, phase, frequency, frame, full load current requirement, locked rotor current requirement, full load efficiency, full load power factor, and weight.

M. Use NEMA Procedure IEEE 112, Test Method B (with separation of losses), to determine motor efficiencies. The spread between the specified nominal efficiency and the guaranteed minimum efficiency shall not exceed the values listed in NEMA MG 1-12, Table 12-10 (extrapolated as necessary).

N. Design motors to operate continuously at full load at 40 degrees C ambient with Class "B" temperature rise.

O. Motor Efficiency: Motors, 1.0 horsepower and larger, shall be Premium Efficiency, constant speed, squirrel cage induction type motors, 1800 RPM unless otherwise indicated. Efficiency shall meet the requirements of NEMA MGM, Table 12-12.

P. All single-speed motors 1/2 horsepower and larger shall be "T" frame size conforming to the referenced NEMA standards.

2.2 MOTORS, DRIVES AND BASES

A. Provide motors with V-belt drives (use only Type A, B, C or D matched sets) or direct drives as indicated.

1. Design drives for 150 percent of the specified motor nameplate horsepower rating.

2. Provide V-belts of endless cord impregnated rubber of trapezoidal cross-section.

3. Provide adjustable screw device for belt tensioning, unless specified otherwise.

4. Drives shall have a minimum of two belts.

B. Bearings for 480-volt motors shall be shielded, regreasable, vacuum degassed steel ball bearings

sized for an average life of 100,000 hours. Bearing housings shall hold sufficient lubricant to minimize lubrication frequency.

C. Provide cast iron or steel slide rail type vibration bases in accordance with Division 15.

2.3 MOTOR STARTERS

A. Motor controllers, including those for auxiliary equipment, shall conform to requirements of Division 16.

B. Outdoor Installation of Starters: Protect motor starters on equipment installed outdoors with weather-proof NEMA 4 enclosures.

C. Outdoor Installation of Disconnects: Disconnect switches installed outdoors shall be weather-proof type, NEMA 3R or 4.

2.4 BELT AND COUPLING GUARDS

A. Provide removable guards to completely enclose all V-belt drives, shafts, sheaves and couplings.

B. Guard construction and design shall comply with requirements of OSHA (1910.219) and ANSI Standard B15.1, Section 8.

C. Belt guards shall be solid metal with perforations.

D. Tachometers shall be readable with guards in place.

E. Where grease fittings are enclosed by guards, provide grease fitting extensions to an accessible location outside of the guard.

2.5 MOTOR ELECTRICAL CHARACTERISTICS

A. Motors Smaller than 3/4 hp: 115 volts, 1 phase, 60 Hz, unless indicated otherwise.

B. Motors 3/4 hp and Larger: 460 volts, 3 phase, 60 Hz, unless indicated otherwise.

2.6 FACTORY TESTING OF MOTORS

A. Perform factory tests on all motors, 150.0 hp and larger, in accordance with NEMA MG1, including tests for winding resistance, high potential, vibration check, and running and locked rotor amperage.

2.7 VARIABLE FREQUENCY DRIVES (VFD's)

A. Acceptable Manufacturers subject to compliance with requirements:

1. ABB ACH 550 Series.

2. Allen-Bradley (Rockwell Automation) 1336 Plus II.

3. Danfoss Graham VLT 6000 Series.

4. Mitsubishi Electric Automation.

5. Saftronics (Emerson Industrial Automation) GP-10.

6. Yaskawa Commercial HVAC Drives.

7. York Air-Modulator.

B. General Requirements

1. Drives shall be installed and wired under Division 16.

2. Mount the drive controller section and the bypass section in a common enclosure, in separate barrier compartments, each with its' own disconnect interlocked with the compartment door.

C. Drive Controller Section

1. Each variable frequency drive shall convert 460 volt, plus or minus 10 percent, 3-phase, 60 Hz, plus or minus 2 percent, input power into an adjustable frequency/voltage output.

   a. The drive shall continue to operate normally on loss of input power for up to 5 cycles.
   b. Design the controller to operate in an ambient temperature of 0 deg C to 40 deg C continuously.
   c. For NEMA 1 enclosures and for drives 20.0 HP and less, operation at ambient temperatures up xto 55 deg C shall be permitted if the drive is derated by 10 percent for each 5 deg C over 40 deg C.
   d. The drive manufacturer shall warrant the drive for storage temperature limits of at least minus 20 deg C to plus 65 deg C.
   e. Minimum efficiency at full load: 97 percent.

2. Output power shall provide step-less speed control of the motors throughout a continuous speed range of 6 to 60 Hz under variable torque loads not exceeding the motor's full-load rating, and with starting capability down to 6 Hz.

3. The VFD shall be of the variable voltage DC bus type. The power circuit shall consist of an AC to DC power rectifier containing power diodes, a DC power filter and a fixed voltage input DC to AC power inverter.

   a. The rectifier shall utilize IGBT technology and shall be insensitive to the phase rotation of the AC line and shall not cause a displacement power factor of less than 0.95 lagging under any speed and load condition.
   b. The drive shall employ a pulse width modulation (PWM) inverter system using third generation IGBT's or intelligent power modules (IPM) rated as required by the current rating of the motor.

4. Control techniques, other than Pulse Width Modulated (PWM) technology, are not acceptable.

5. The output carrier frequency shall be user selectable for any value between 3 and 12 kHz.

6. The output power frequency shall be variable from 2.4 Hz to 120 Hz for all power drive ratings.

   a. The VFD’s shall be able to start into a spinning motor and shall be able to determine the motor speed in any direction and resume operation without tripping.
   b. If the motor is spinning in the reverse direction, the VFDs shall start into the motor in the reverse direction, bring the motor to a controlled stop, and then accelerate the motor in the preset method of starting.

7. Drives shall be 6-pulse with a 5% line reactor. Where motors are 20 HP or greater a passive harmonic filter shall be provided with each drive to limit harmonic distortion to less than 5%. Passive filter to be equal to TCI Model HG-7.

8. The enclosure shall be NEMA Type 1, gasketed, with a lockable handle interlocked to prevent opening or closing the VFD door with the disconnect handle in the "ON" position.

    a. Provide a fusible input power disconnect switch with current limit fuses with a minimum interrupting capacity of 100,000 amperes rms symmetrical or a motor circuit protector.
    b. Provide 3 spare fuses if the disconnect switch is fused.

9. Operating and monitoring devices shall include:

    a. Modification of drive adjustments via a touch keypad. All electrical values, configuration parameters, I/O assignments, parameter adjustments, application and activity function access, faults, local control, adjustment storage, self-test and diagnostics will be in plain English.
    b. The display shall be a high resolution, LCD backlighted screen capable of displaying two lines of 16 characters each.
    c. List the drive model number, torque type, software revision number, horsepower, output current, motor frequency and motor voltage on the LCD display.
    d. Display output frequency, output current, output power, output voltage, line voltage, elapsed time, motor speed, trip cause and load.
    e. A single keystroke scrolling function shall allow dynamic switching between display variables.
    f. The terminal keypad shall consist of programmable function keys to allow both operating commands and programming options to be preset by the operator. A hardware selector switch shall allow the terminal keypad to be locked out from unauthorized personnel.
    g. The operator terminal shall offer a general menu consisting of parameter setting, I/O map, fault history, and drive configuration.

        1) A software lock will limit access to the main menu.
        2) The main menu shall consist of keypad configuration, drive configuration, general configuration, diagnostic mode and drive initialization screens.

    h. Provide arrow keys to scroll through menus and screens, select or activate functions or increase the value of a selected parameter.
    i. Provide a data entry key to confirm a selected menu, numeric value or allow selection between multiple choices.
    j. A RUN key and a STOP key shall command a normal starting and stopping as programmed when the AC drive is in keypad control mode.
    k. Each VFD shall include diagnostic LED's.
    l. Provide a user interface that is a Windows 3.1 based personal computer, serial communication link or detachable operator interface.

D. Factory-mount the following accessories:

1. Provide a terminal strip for connection of external start lockout and reset contacts.

2. Clearly number and mark all terminals.

E. Input/Output (I/O), Reference Signals

1. Inputs:

    a. Process control speed reference interface to receive either a 0-10 Vdc, 4-20 mA or speed potentiometer signal.

        1) This input signal shall be optionally connected via a software configuration to an internal PI loop controller, which shall calculate an

error signal by comparing the process follower input to the drive speed setpoint.

2) This PI controller shall have individually programmable values for proportional gain and integral reset values and shall be configurable for either direct (larger speed error increases drive speed) or reverse (larger speed error reduces drive speed).

b. Remote start and stop contacts.
c. Remote forward/reverse contacts.
d. Remote preset speed contacts.
e. Remote external trip contact.
f. Remote reset contact.
g. Remote jog contact.

2. Outputs:

a. Programmable digital relays (2) N.O. contacts.
b. Form C contact to indicate drive fault.
c. Two programmable analog output signals.

F. Protection:

1. Upon power-up, the drive shall automatically, test for operation of memory, option module, loss of analog reference input, loss of communication, DC to DC power supply, control power, and the pre-charge circuit.

2. Protect the drive against short circuits between output phases; between output phases and ground; on the outputs; on the internal supplies; and on the logic and analog outputs.

3. The drive shall have a minimum power loss ride-through of 200 milliseconds, and shall have the user defined option of frequency fold-back to increase the duration of the powerloss ride-through.

4. The drive shall have a selectable ride-through function to allow the logic to maintain control for a minimum of one second without faulting.

5. For a fault condition other than a ground fault, short circuit or internal fault, an auto restart function shall provide up to 5 programmable restart attempts. The programmable time delay before restart attempts shall range from 1 second to 30 seconds.

6. The deceleration mode of the drive shall be programmable for normal and fault conditions.

7. Upon loss of the analog process follower reference signal, the drive shall fault or operate at a user defined speed set between software programmed low speed and high speed settings.

8. The drive shall have solid state I^2t protection that is UL listed, and shall meet UL 508 C as a Class 10 or Class 20 overload protection and shall meet IEC 947. The adjustment shall be from 0.45 to 1.05 percent of the current output of the Drive.

9. The drive shall have a thermal switch with a user selectable pre-alarm to provide a minimum of 60 seconds delay before over-temperature fault, and shall use bonded fin heatsink construction.

10. The drive shall have a programmable fold-back function that will anticipate controller over-temperature or overload condition and fold back the frequency to avoid a fault condition. The output frequency shall be software enabled to fold back when the motor is overloaded.

11. There shall be 3 skip frequency ranges that can each be programmed with selectable bandwidth of 2 or 5 Hz. The skip frequencies shall be programmed independently, back to back or overlapping.

G. Adjustment and Configurations

1. The drive shall self-configure to the main operating supply voltage and frequency. No operator adjustments shall be required.

2. Factory pre-set the drive to operate most common applications.

3. Linear and S-curve acceleration and deceleration ramps shall be available. The acceleration and deceleration ramp times shall be adjustable from 0.1 to 999.9 seconds.

4. The volts per frequency ratios shall be user selectable to meet quadratic torque loads, normal and high torque machine applications.

5. The memory shall retain and record run status and fault type of the past 4 faults.

6. Slip compensation shall be a software enabled function.

7. The software shall have a NOLD (no load) function that will reduce the voltage to the motor when selected for variable torque loads. The output voltage will then automatically adjust to meet the torque requirement of the load.

8. Sequencing logic shall coordinate the engage and release thresholds and time delays for the sequencing of the drive output and mechanical actuation.

2.8 FACTORY TESTING OF VARIABLE FREQUENCY DRIVES

A. Factory test motor, drive and controls as a single unit before shipment.

B. Factory testing shall include:

1. Demonstration of full-load running operation for 24 hours (continuous).

2. Operation of a load at 110 percent of full load for 60 seconds.

3. Operation of a 100 percent load during a power outage of 3 cycles.

4. Operation of a 100 percent load during an input power condition of 80 percent of rated voltage for 20 cycles.

5. Automatic restart of the load after a power outage of longer than the unit’s ride through capability and after a simulated safety circuit shutdown.

6. Printed circuit boards shall be subjected to a "burn-in" cycle test at 104 degrees F, for 15 hours at 32 to 149 degrees F cycle range.

7. Test each VFD at full load with application of line-to-line and line-to-ground bolted faults.

PART 3 - EXECUTION

3.1 OVERALL MECHANICAL/ELECTRICAL/CONTROLS COORDINATION TABLE.

ITEM	FURNISHED BY	INSTALLED BY	POWER BY	CONTROL BY	MONITOR BY	OTHER/COMMENTS
Smoke damper integral to air handler	15	15	17	17	15	Smoke damper to be supplied with integral actuator
Fire damper	15	15	N/A	N/A	N/A	
Variable frequency drive	15	16	16	17	15	
Smoke detectors/fan shutdown for fire/smoke alarm	13	15	13	13	13	FAS to provide addressable relay for fan shutdown. BAS to monitor spare contacts on FAS relay or direct from smoke detector (as indicated on contract drawings). Wiring from addressable relay to fan motor starter or variable frequency drive by Division 13, Fire Alarm.
VAV/CV boxes for temperature control (not for lab airflow control)	15	15	17	17	15	

3.2 COORDINATING ELECTRICALLY OPERATED EQUIPMENT AND CONTROLS

A. Unless otherwise noted, all power wiring shall be provided by Division 16, and all control wiring shall be provided by Division 17.

B. Power wiring, for the purpose of this specification, shall be defined as follows: Wiring from the power source panelboard, or switchboard, to the disconnect switch or disconnect switch and starter including wiring from these switches to the equipment.

C. Other wiring and conduit required, whether line (120V) voltage or low voltage to provide for the operation of the equipment, Building Automatic Control System control devices (except smoke detectors) shall be considered as control wiring. Power sources for all control wiring shall be from Building Automatic Control System spares in electrical panels provided by Division 16.

D. Install electrical wiring in accordance with requirements of Division 16.

E. Power wiring under Division 16 shall include power feeders to major pieces of apparatus. From the source of building power, extend feeder to wiring terminals on the equipment and separately mounted disconnect switches and separately mounted motor starters.

1. At individual motors, extend power wiring to the wiring chamber on the motor.

2. At factory assemblies of components, such as duplex pumps, extend power wiring to the assembly.

a. Where control panels include motor starters, terminate power wiring under Division 16 at the control panel terminal strip and extend to each motor as work of Division 16.
b. Where control panels do not include motor starters, extend power wiring as work of Division 16 through motor starters and terminate at the wiring chamber on each motor.

3. At factory manufactured apparatus with control panels, terminate power wiring at the control panel terminal strip as work of Division 16, and extend to each motor by the manufacturer.

F. Unless indicated otherwise, control wiring under Division 15 shall include all connections to control devices, interlock wiring, control relays, alarm wiring, and minor power wiring to auxiliary components for major pieces of apparatus.

1. Minor power wiring, 120 volts and lower, shall include requirements for such equipment as damper motors, solenoid valves, and interconnecting control wiring on apparatus that has not been factory installed.

2. Provide control wiring that is not indicated on Electrical Drawings as work of Division 15.

G. All internal wiring in apparatus shall be completely factory installed.

1. Where internal wiring cannot be factory installed, it shall be field installed under Division 15.

H. Internal wiring in apparatus shall be brought to terminal strips at one location, for connection of field wiring.

1. For individual motors, provide larger wiring chamber of conduit entry. For apparatus with a control panel, provide barrier type terminal strips in an enclosure arranged for conduit entry.

I. Control panels provided as a part of apparatus shall include circuit protection for each motor, electric heater, control circuit and other circuits requiring protection.

1. Where remote manual controls are required, they shall operate at 120 volts maximum and a control power transformer shall be provided for that purpose.

J. Panels, relays, terminal and junction boxes, contactors, circuit breakers, safety switches, motor starters and similar items, shall be identified by name, function and/or control.

1. Name plates shall be at least 1 x 3 inches, with characters not less than 1/4 inch. Name plates shall be made of two laminated black plastic sheets bonded with a middle sheet of white plastic, and characters engraved in one black sheet to the depth of the white plastic. (See specification Division 16.)

K. Unless indicated otherwise,, provide controls and control devices, mountings for controls and other electrical devices as specified and necessary for the complete installation and satisfactory operation of electrically operated controls furnished as work of Division 17.

L. Furnish wiring diagrams to contractor performing work of Division 17 for incorporation into the elementary wiring diagrams for all pieces of control equipment to be installed under the contract.

M. Verify that the voltage and current characteristics of the electrical equipment furnished are suitable for the electrical services as specified or indicated.

N. Outdoor equipment shall be wired weather-proof with flexible seal-tight conduit, cast boxes and rigid steel conduit.

3.3 DESIGN MODIFICATIONS

A. The drawings show electrical systems which supply, control, or monitor systems specified elsewhere. The electrical system shown has been based on specific manufacturers' data, or information conveyed to the electrical designer.

1. Equipment Deviations from Design: Where the Contractor provides equipment of larger capacity or different electrical characteristics, from design, he shall provide all required electrical system changes at no additional cost to the Owner.

3.4 MOTOR INSTALLATION

A. Provide all maintenance and lubrication of motors and drives until final acceptance by the Owner.

3.5 START-UP OF VARIABLE FREQUENCY DRIVES

A. The drive equipment manufacturer shall provide a factory-trained engineer to supervise initial start-up, ensure proper operation of the system, and to instruct operating personnel in the operation and maintenance of the system.

3.6 TRAINING (VARIABLE FREQUENCY DRIVES)

A. An on-site training course of (2) working days shall be provided by a representative of the variable frequency drive manufacturer, and shall be quoted as a separate line item.

3.7 MOTOR SPEED TURNDOWN

A. The minimum speed, under turndown conditions, for all fans and pumps controlled by variable frequency drives, shall be as follows:

FANS AND PUMPS WITH SPECIFIED VIBRATION STATIC DEFLECTION (IN.)	MINIMUM MOTOR SPEED (RPM)
0.75	434
1.5	307
2.5	238
3.5	200

+ + END OF SECTION + +

SECTION 15060 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section describes hangers and supports for piping, ductwork and equipment in HVAC systems.

1.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.3 SUBMITTALS

A. Submit for review:

1. Product data, including installation instructions for each type of support and anchor, materials of construction, finish and rated load capacities.

2. Shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances and assembly methods of components.

3. Submit the guide or anchor manufacturer's identification of each guide or anchor type, its designated location and line size.

4. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

5. Maintenance data on items requiring maintenance.

1.4 QUALITY ASSURANCE

A. Materials, design and manufacturer of pipe hangers and supports shall conform to MSS SP-58.

1. Selection and application of pipe hangers and supports shall conform to MSS SP-69, except where more stringent requirements are specified in this section.

2. Fabrication and installation practices of pipe hangers and supports shall conform to MSS SP-89, except where more stringent requirements are specified in this section.

3. All work shall conform to the ANSI/ASME Codes for Pressure Piping specified above.

B. Stamp the manufacturer's name, part number and size on each support.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Pipe Hangers, Pipe Clamps and Wall Brackets: Anvil Intl. Inc., Carpenter & Patterson, National Pipe Hanger, B-Line, Pipe Shields, Inc.

2. Roller Hangers: Anvil Intl. Inc., Power Pipe Supports, Carpenter and Patterson, National Pipe Hanger, B-Line.

3. Pipe Insulation Protection Shields: Anvil Intl. Inc., Carpenter and Patterson, National Pipe Hanger, B-Line, Value Engineered Products.

4. Hanger Inserts: Anvil Intl. Inc., National Pipe Hanger, B-Line.

5. Spring Hangers: Anvil Intl. Inc., Power Piping Company, Carpenter & Patterson, National Pipe Hanger, B-Line.

6. Pipe Supports for Rooftop Piping and Piping Located at Grade: Anvil Intl. Inc., Carpenter & Patterson, National Pipe Hanger, B-Line.

7. Trapeze Hangers: Unistrut, Anvil Intl. Inc., (Power-Struct), National Pipe Hanger, B-Line.

8. U-Bolts: Anvil Intl. Inc., B-Line, Carpenter & Patterson, National Pipe Hanger.

9. Guides: Power Pipe Supports, Anvil Intl. Inc., Flexonics, Metraflex, NPS Industries, Inc., Hyspan, Keflex, National Pipe Hanger, B-Line.

10. Anchors: National Pipe Hanger, B-Line.

2.2 GENERAL

A. Hot-dip galvanize hangers and strut located outdoors after fabrication in accordance with ASTM A123.

B. Pre-galvanize strut channels in accordance with ASTM A653 G90.

C. Paint hangers and clamps for support of bare copper piping with copper colored epoxy.

D. Zinc-plate hangers not in direct contact with copper pipe in accordance with ASTM B633.SC3.

2.3 HANGER RODS

A. Hanger rods shall be threaded at both ends or continuously threaded rods of circular cross-section. Provide adjusting locknuts at upper attachments and hangers.

B. Provide hanger rods for the following pipe sizes as tabulated as a minimum for single rigid rod hangers, subject to the load ratings of MSS-SP-58. Hanger rods may be reduced one (1) size for double rod hangers with 3/8-inch minimum diameter.

Pipe Size - Inches	Minimum Rod Diameter - Inches
1/2 to 2	3/8

Pipe Size - Inches	Minimum Rod Diameter - Inches
2-1/2 to 3	1/2
4 to 5	5/8

2.4 UNINSULATED COPPER TUBING SUPPORTS

A. Size hangers to fit copper tubing outside diameters.

1. Adjustable steel swivel ring, band type hanger, B-Line B3170 CT.

2. Malleable iron ring hanger, B-Line B3198RCT or hinged ring hanger B3198HCT.

3. Malleable iron split-ring hanger with eye socket, B-Line B3173CT with B3222.

4. Adjustable steel clevis hanger, B-Line B3104CT.

B. For supporting vertical runs provide epoxy painted or plastic coated riser clamps, B-Line B3373CT or B3373CTC.

2.5 INSULATED HORIZONTAL PIPING HANGERS

A. Heating Hot Water, Boiler Feedwater, Boiler Blowdown, Safety Valve Vents.

1. 2-inch and smaller pipe: Provide adjustable steel clevis, B-Line B3100 with pipe covering protection saddle B-line 3160-3165 series or pipe insulation protection shield as indicated.

2. 2-1/2-inch and larger pipes:

a. Adjustable steel yoke pipe roll B-line 3110 with pipe covering protection saddle or

b. Pipe roll with sockets, B-line 3114 with pipe covering protection saddle or with pipe insulation protection shield as indicated.

B. Glycol Chilled Water, Chilled Beam Chilled Water, Cooling Coil Condensate:

1. 5-inch and smaller pipes: Adjustable steel clevis, B-Line B3100 with pipe insulation protection shield as indicated.

2.6 PIPE INSULATION PROTECTION SHIELDS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. B-Line B-3151

2. Carpenter & Paterson

3. Anvil Intl., Inc.

4. National Pipe Hanger 300

B. Provide pipe insulation protection shields on all insulated piping and tubing.

1. Shields shall be of galvanized steel construction, 16 gauge minimum thickness, and with a saddle arc of 120 degrees minimum.

2. Shield length shall increase with increase in support spacing, and shall be based on the insulation manufacturer's recommendations.

C. Provide calcium silicate insulation inserts at each pipe insulation protection shield for pipe sizes 4 in. and larger, and for all applications on piping systems operating above 350 F. Do not use wood inserts.

1. Calcium silicate insulation inserts shall be at least the same length as the protection shield.

D. Pipe support spacing shall be as stated in ASHRAE and Mark's Mechanical Engineer's Handbook. See pipe support spacing tables, this specification section.

2.7 VERTICAL SUPPORTS

A. Riser clamp sized to fit outside diameter of pipe, B-Line B3373.

B. Riser clamp sized to fit outside diameter of copper tubing, B-Line B3373CT.

2.8 PLASTIC PIPE SUPPORT OR HOSE HANGER

A. V-Bottom clevis hanger with galvanized 18 gauge continuous support channel, B-Line B3106 and B3106V.

2.9 BEAM CLAMPS

A. For Piping 1-inch in diameter and smaller: C-Clamps shall have lock nuts and cup point set screws, B-Line B351L, or B3036L. Provide top flange C-clamps when attaching a hanger rod to the top flange of structural shapes, B-Line B3034 or B3033. Refer to manufacturers' recommendation for set screw torque. Provide retaining straps to maintain the position on the beam where required.

B. For Piping Larger than 1-inch in diameter: Steel clamps shall be B-Line B3050, or B3055. Malleable iron or forged steel beam clamps with cross bolt shall be B-Line B3054 or B3291-B3297 Series as required to fit beams.

2.10 CONCRETE INSERTS

A. Provide cast in place spot concrete inserts where applicable, either steel or malleable iron body, B-Line B2500 or B3014. Spot inserts shall allow for lateral adjustments and have means for attachment to forms. Select inserts to suit threaded hanger rod sizes, B-Line N2500 or B3014N series.

B. Provide continuous concrete inserts where applicable. Channels shall be 12 gauge, ASTM A 570 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 load rating of 2,000 lbs/ft. in concrete, B-Line B221, 321, or 521. Select channel nuts suitable for strut and rod sizes.

2.11 BRACKETS

A. Welded strut bracket and pipe straps, B-Line B3064 and B2000 series.

B. Welded steel brackets, B-Line B3066 or B3067, with roller chair or adjustable steel yoke pipe roll. B-Line B3120 or B3110.

2.12 PIPE REST

A. Carbon steel adjustable pipe saddle and nipple attached to steel base stand sized for pipe

elevation. B-Line B3093 and B3088T or B3090 and B3088. Pipe saddle shall be screwed or welded to appropriate base stand.

2.13 TRAPEZE HANGERS - DIRECT MOUNTING HANGERS

A. Trapeze hangers shall be constructed from 12 gauge roll formed ASTM A570 Gr. 33 structural steel channel, 1-5/8 x 1-5/8 minimum, B-Line B22 strut.

2.14 SPRING HANGERS

A. Light loads, movement less than 1/4-inch, B-Line B3262 or B3264.

B. Medium loads, movement 1/4-inch through 3/4-inch, Anvil Intl. Inc., Figure No. B-268.

C. Heavy loads, movement exceeding 3/4-inch, Anvil Intl. Inc., Figure No. 98.

D. Sway bracing, Anvil Intl. Inc., Figure No. 301.

2.15 PIPE ROLL STANDS

A. Adjustable roller stand with base plate, B-Line B3117SL, or B3118SL.

B. Adjustable roller support and steel support sized for elevation. B-Line B3124.

2.16 PIPE SUPPORTS FOR ROOFTOP PIPING

A. For Piping 1-1/2-inches and Larger:

1. Supports shall consist of a cast iron adjustable type pipe roller stand, Anvil Intl. Inc., No. 274, mounted on a base plate. Spring isolators shall be in accordance with Section 230548.

2. Base plates shall be steel welded to a minimum 3-inch pipe column. For rooftop piping, a minimum 3-inch pipe column shall extend down through a curbed pitch pocket and shall be welded completely to a steel base plate; the base plate, 6-inches by 6-inches, shall be securely bolted to steel beams using 1/2-inch high-strength bolts at corner lines. Seal weld pipe column watertight where it penetrates the metal roof deck.

B. For Piping 1-1/4-inches and Smaller:

1. Supports shall be placed on 12-inch by 12-inch by 2-inch thick precast concrete blocks placed atop the roof. Piping shall be secured to blocks with pipe clamps on 6-foot centers.

2.17 GUIDES AND ANCHORS - GENERAL

A. Laminations, linings and insulation of guides shall have a Flame Spread rating of 25 and Smoke Developed rating of 50 when tested in accordance with ASTM E 84.

B. Design anchors, guides and restraints for imposed loadings.

C. Design guides to accommodate pipe insulation thicknesses specified in Section 230700 with a minimum 1/8-inch clearance between inside diameter of guiding cylinder and outside diameter of insulation.

2.18 GUIDES

A. Spider Guides: Furnish guides of steel consisting of a bolted two-section outer cylinder and base

with a two-section four-lug guiding spider arranged for bolting to pipe. Finish with one shop coat of paint. Unit shall permit axial movement of the pipe and shall be sized for insulated piping, as required. For guiding uninsulated copper pipe, the interior surface of the guiding cylinder shall be factory laminated with a layer of DuPont "Nomex" woven fabric, minimum 1/8-inch thick. Approved Model: B-Line B3281 through B3287.

B. Adjustable Roller Guides: Furnish guides of steel consisting of two pipe rollers, each with roller support sockets designed to securely lock the adjusting nuts in place after the proper level or slope has been attained. Approved Model: B-Line B3114.

2.19 ANCHORS

A. Locate anchors where shown on the drawings.

B. Fabricate anchors of steel consisting of integral pipe bolting clamps with T-bar base. Finish with one (1) shop coat of paint. Approved Model: National Pipe Hanger No. 975.

C. For anchoring uninsulated copper pipe, factory-laminate the interior surface of the pipe bolting clamps with a minimum 1/8-inch thick layer of DuPont "Nomex" woven fabric.

2.20 DUCT HANGERS AND SUPPORTS

A. Provide trapeze, strap or angle iron hangers meeting SMACNA, HVAC Duct Construction Standards - Metal and Flexible, and BOCA Mechanical Code.

B. Materials of hangers, supports and fasteners shall conform to the manufacturer's load ratings.

C. Hangers, supports, upper attachments and inserts shall be hot-dip galvanized steel, aluminum, or stainless steel to match the ductwork being supported.

2.21 SUPPLEMENTAL STEEL

A. Attach hangers to the building structural beams. Where hangers do not correspond with the building structural beams, provide supplemental steel members fastened to the building structural steel beams. Provide two (2) coats of primer on the supplemental steel. Submit details of hanger attachments to the building structure to the Architect for approval before drilling or burning holes in the structure.

B. Design and fabricate supports using structural quality steel bolted framing materials. Channels shall be roll formed, 12 gauge ASTM A 570 Grade 33 steel, 1-5/8" x 1-5/8" or greater as required by loading conditions. Provide clamps and fittings designed for use with the strut system.

2.22 U-BOLTS

A. Heavy-Duty Carbon Steel: B-Line Numbers B3188 and B3188N5.

2.23 SHOP PAINTING

A. Shop-paint all carbon steel hangers and supports in exposed areas as indicated on Architectural drawings.

2.24 DIELECTRIC CONTROL

A. For copper tubing in contact with metallic pipe clamps, brackets or supports, provide an insulating pipe clamp assembly with plastic cushion. Pipe clamp assembly shall eliminate metal-to-metal contact and form an insulating liner to prevent galvanic action between copper tubing and metallic clamps, brackets and supports.

2.25 PIPE SUPPORT STANCHIONS

A. Stanchions shall be pipe mounted, B-Line Numbers B3090, B3093, and B3095.

2.26 PREFABRICATED ROOF CURBS AND EQUIPMENT SUPPORTS

A. Acceptable Manufacturers, subject to compliance with requirements: Custom Curb, Pate, ThyCurb, Vent Products, Curbs Plus, RPS.

B. General: Size curbs and equipment supports as required to suit roof opening and equipment base. Curbs shall be a minimum of 12-inches high, unless indicated otherwise. Refer to Architectural and Structural drawings for roof slope at curb/support location and for installation details. Construct to fit single or double roof pitches as required. Construct and certify load carrying capacity to suit equipment weight and wind loads with not less than 100% safety factor.

C. Equipment and Duct Mounting Supports: Where indicated on drawings, provide supports tested and certified for load carrying capacities; minimum 14 gauge galvanized steel; mitered and welded corners; internal reinforcing supports welded; self-flashing and mounting flange; 2 x 2 chemically treated wood nailer and counterflashing cap.

D. Platform Curb: Provide curb to serve as a mounting platform for mechanical equipment.

1. Minimum 14 gauge galvanized steel, four-sided insulated platform roof curb with minimum 3/4-inch thick plywood top.

2. Mitered and welded corners, welded internal angle reinforcing for sides and top for support of platform top and equipment supports.

3. Wide flashing and mounting flange without cant and counter flashing cover.

4. Steel welds primed after fabrication.

5. Fiberglass insulation, minimum 2-inches thick, on inside surfaces.

6. Counter flashing cover of minimum 0.064-inch thick welded aluminums sheet with flared drip edges.

7. Standing seams on covers 43-inches x 105-inches and larger.

8. Curb shall be a minimum of 6-inches wider and longer than footprint of equipment (isolation) base.

PART 3 - EXECUTION

3.1 INSTALLATION - PIPE HANGERS AND SUPPORTS

A. Support horizontal pipe runs using hangers and supports. Space the hangers so that the supported load does not exceed the load recommended by the hanger manufacturer. Space the hangers so they do not exceed the support spacing requirements listed in this Section. The supported load shall not overstress the building structural members.

B. Support vertical pipe at each floor using riser clamps. When run in a shaft, support riser clamps on both sides of the clamp. Support piping less than 1-1/4-inch every 8 feet with pipe clamps.

C. Securely bolt pipe roller hangers to the steel support.

D. For pipe supported on rod hangers, provide roller hangers where thermal movement will cause the

hanger rod to deviate more than 4 degrees from the vertical, or where longitudinal expansion will cause a movement of more than 1/2-inch in the piping.

E. Wall brackets are acceptable where pipes are adjacent to walls or other vertical surfaces which may be used for support.

F. Provide hangers and supports within 12-inches of each horizontal elbow for piping 6-inches in diameter and larger. Provide sway bracing for piping 4-inches in diameter and larger at changes in direction of 45 degrees and greater.

G. Furnish embedded inserts for pipe hangers installed in concrete slabs or masonry walls for installation during concrete forming or masonry erection.

H. For the support of two or more pipes of similar temperatures running adjacent to each other at the same elevation and at the same slope, structural steel trapeze hangers are acceptable. Limit the longitudinal hanger spacing to suit the smaller diameter pipe.

I. Support riser piping independently from the connected horizontal piping.

J. Provide isolation hangers and supports as specified under Section 15070.

K. Do not provide pipe hooks, chains or perforated steel strap for pipe supports.

L. Do not support piping from ceiling supports, ductwork, equipment, cable trays, electrical conduit or other piping.

M. Do not hang piping from metal floor deck, metal roof deck or steel joists.

N. Cut off excess hanger rod lengths. Secure rods by use of locknuts or elastic stop nuts.

O. Support the base of vertical pipe stacks, except copper water pipe risers, with a base leg. Cut the top of the base leg to shape and completely weld to the heel of the base elbow. Weld leg support to a bearing plate and bolt to the floor. Locate base leg on the vertical pipe centerline.

P. Secure pipe hangers attached to concrete structure and slabs with embedded inserts, anchor bolts or concrete fasteners, or, with specific written approval from the Architect, power-driven inserts. Do not drill or shoot without specific written approval of the Architect. Location and types will be reviewed for compatibility with building structure systems only. Apply a safety factor of 5 in selection of inserts and expansion bolts. Select and design inserts and expansion bolts for seismic loadings specified in Section 15070.

Q. Install hanger inserts prior to installation of concrete or masonry. The Contractor shall be responsible for the correct location and position of the inserts for work of this Section.

R. Support vertical drops to plumbing fixtures and equipment.

S. Rooftop supports shall rest on building structural steel, not on roofing material; make arrangements with the General Contractor so that all rooftop supports are in place before roofing is completed.] [for piping on grade, supports shall rest on concrete, not on grade.

T. Provide maximum support spacing as listed below. Locate one support within one foot on both sides of concentrated pipe-mounted loads, including valves, meters, and pumps. Reduce the span, if required, to comply with the load ratings of the supports/hangers, and so as to not overstress the supporting structural members.

1. Support standard-weight steel piping for glycol and water services as follows:

Nominal Pipe Size (Inches)	Maximum Support Spacing (Feet)
1/2	7
3/4	7
1	7
1-1/2	9
2	10
2-1/2	11
3	12
4	14
5 and larger	16

2. Support copper tubing as follows:

Nominal Pipe Size (Inches)	Maximum Horiz. & Vert. Support Spacing (Feet)
1/4 to 1/2	5
5/8 to 3/4	5
1	6
1-1/4	7
1-1/2	8
2	8
2-1/2	9
3	10
4	12
6	14

U. Provide supports for piping under raised-floor areas. Coordinate location of supports with raised-floor pedestals.

3.2 INSTALLATION - DUCT HANGERS AND SUPPORTS

A. Support ductwork using trapeze, strap or angle iron hangers conforming to SMACNA HVAC Duct Construction Standards - Metal and Flexible, and International Mechanical Code. Provide supplemental structural steel to span joists where required. Deflection of supplemental structural steel shall be limited to 1/180 of the span.

B. Do not support ductwork from furring, hung ceilings, metal floor deck, metal roof deck or from another duct or pipe.

C. Do not hang lighting fixtures or piping from ductwork.

D. Where vertical ducts penetrate floor openings, follow the detail identified in the SMACNA HVAC Duct Construction Standards - Metal and Flexible.

E. Where duct connects to or terminates at masonry openings or at floors where concrete curbs are not present, follow the detail identified in the SMACNA HVAC Duct Construction Standards - Metal and Flexible.

F. For insulated ductwork, install hangers on the outside of the insulation. To maintain the insulation value, inset a piece of 1-inch thick, 6 pcf fiberglass board with a foil/scrim/kraft (FSK) jacket at

these supports.

3.3 INSTALLATION OF GUIDES

A. Install guides as shown on the contract drawings. When not shown on the contract drawings, locate the first pipe guide at a maximum distance of 4 pipe diameters from each end of expansion joints or pipe loops. Locate second guide at a distance of 14 pipe diameters from the first guide.

B. Place spider guides on the pipe prior to the application of insulation, if required. After the insulation is applied, bolt or weld the body of the pipe guide to the structure and bolt the upper cap in place.

3.4 INSTALLATION OF ANCHORS

A. Where anchors do not correspond with building structure, provide supplemental steel supports extended and fastened to the building structure.

B. Design supplemental steel supports for the seismic loadings specified in Section 15070.

3.5 SUPPORTS FROM EXISTING CONCRETE

A. Attach with drilled in mechanical anchors, Hilti or equal, or other approved means, lead shield anchors and powder or power fasteners are not acceptable.

+ + END OF SECTION + +

15061 - PIPE AND PIPE FITTINGS - PLUMBING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes pipe and pipe fittings used in plumbing and fire protection systems.

1.02 SUBMITTALS

A. Submit for review:

1. Manufacturer's technical product literature for pipe, fittings and bolting.

2. Field Test Reports (see Part 3 of this Section).

3. Chemical Cleaning Effluent Disposal Plan (see Part 3 of this Section).

1.03 DELIVERY, STORAGE AND HANDLING

A. Protect flange faces with wood, plastic or soft metal to prevent damage.

B. Factory apply plastic end-caps for all piping, except for hub-and-spigot and clay pipes. Maintain end-caps in place until pipe is installed.

C. Store pipe and fittings inside for protection from moisture and dirt, or with weatherproof packaging.

D. Stack pipes to prevent distortion.

E. Follow specific requirements of manufacturers.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

A. Underground Domestic Water Service Piping:

1. General: Pipe and fittings shall be cement-lined to ANSI A21.4/AWWA C104 and externally coated with bitumastic material.

2. Pipe: Ductile iron pressure bell and spigot pipe conforming to ANSI A21.51/AWWA C151, Class 150, Mechanical joints, with rubber gaskets to ANSI A21.11/AWWA C111 and corrosion-resistant low-alloy high-strength steel bolts.

3. Fittings to be ductile iron Class 150 conforming to ANSI A21.10/AWWA C110.

4. Piping shall be copper tubing Type K conforming to ASTM B 88.

5. Fittings shall be wrought copper, soldered joints conforming to ANSI 16.22.

B. Domestic Cold Water, Domestic Hot Water, Treated Rainwater Supply Within Building:

1. Pipe: Copper tubing, Type L, drawn temper, conforming to ASTM B 88.

2. Fittings: Wrought copper, solder joint, conforming to ANSI B16.22.

3. For piping 2-1/2" diameter and over, no-sweat copper fittings conforming to ASTM B 75. With Victaulic Style 606 couplings conforming to ASTM A 536 with Grade "E" EPDM gasket conforming to ASTM, D-2000 may be used.

C. Domestic Cold Water Domestic and Domestic Hot Water Exposed in Finished Areas:

1. Pipe: Chrome-plated, seamless red brass, iron pipe size, regular wall thickness, conforming to ASTM B 43, matching fixture or equipment connection.

2. Fittings: Cast bronze to ASTM B 61, chrome-plated.

D. Sanitary, Storm Water and Vent Piping:

1. Underground, within building and to three feet outside building walls or as shown on plans.

   a. Service weight, externally coated cast iron hub-and-spigot soil pipe and fittings, conforming to ASTM A 74, with caulked oakum and lead joints, or with elastomer push-on joints with "Multi-tite" gasket as manufactured by U.S. Pipe and Foundry Co. or equal.

2. Underground Piping:

   a. Polyvinyl chlorine PVC Schedule 40 unplasticized, gravity sewer pipe with bell-and-spigot conforming to ASTM D 3034-SDR 35, colored green for in ground identification.
   b. Joints to be push-on type with flexible elastomatic seal gasket. Joints to meet F 477 specifications. Joints to be tested in accordance with ASTM D 3212
   c. Underground PVC piping to be installed in accordance with J-M Publication TR 614 B.

3. Above Ground, Interior Building:

   a. Service weight, coated, hubless, cast iron soil pipe and fittings conforming to CISPI 301 and ASTM A-888 with joints made of Neoprene sealing coupling sleeve surrounding by Series 300 stainless steel shield and clamp assembly. Hubless joints for horizontal pipe and fittings five inches and larger shall be suitably braced to prevent horizontal movement. Th9s shall be done at every branch opening or change of direction by the use of braces, blocks, or rodding, to prevent movement.
   b. Copper tube to ASTM B 306, Type DWV, drawn temper for nonpressure application, with cast bronze solder-joint drainage fittings conforming to ANSI B16.23 or wrought copper solder-joint drainage fittings with dimensions to ANSI B16.29.

4. Underground foundation drain piping shall be:

   a. Extra strength perforated clay pipe conforming to ASTM C 200. Perforations to be 1/2" diameter, on three-inch centers and half way around pipe circumference.
   b. Polyvinyl chloride (PVC) perforated sewer pipe and fittings conforming to ASTM 34 D 2729 with gravity rated fittings of same material suitable for solvent cement joints.

F. Sump Pump and Sewage Ejector Discharge Piping:

1. Above ground pumps discharge piping shall be:

   a. Galvanized steel Schedule 40 pipe to ASTM A 53 Grade A, dimensions to ANSI B36.10, with threaded fittings of galvanized cast iron to ASTM A 126, dimensions to ANSI B16.3 Class 125.
   b. For piping over 2" dia. grooved connections with Victaulic Type 77 couplings could be used.

2. Underground pump discharge piping shall be:

   a. General: Pipe and fittings shall be externally coated with bitumastic material.
   b. Pipe: Cast iron or ductile iron pressure pipe conforming to ANSI A21.51/AWWA C151 Class 50, bell and spigot type.

c. Fittings: Cast iron fittings conforming to ANSI A21.10/AWWA C110 with mechanical joints with rubber gaskets conforming to ANSI A21.11/AWWA C111 and corrosion-resistant low-alloy high-strength steel bolts.

or

a. Pipe: PVC pressure pipe to AWWA C900, Class 150 push-on bell-and-spigot ends, with rubber gaskets to ASTM D 1869, pipe OD matching ductile iron pipe sizes, Johns-Manville Blue-Brute with Ring-Tite joints.
b. Fittings: Cast iron fittings to ANSI A21.10/ AWWA C110 with mechanical joints with rubber gaskets conforming to ANSI A21.11/AWWA C111 and corrosion-resistant low-alloy high-strength steel bolts.

2.03 NIPPLES

A. Pipe nipples shall be of the same material as the pipeline in which they are installed and shall conform to ASTM A 733.

B. Unthreaded part shall not be less than 1-1/2".

PART 3 - EXECUTION

3.01 INSTALLATION

A. Unless shown otherwise, route piping in the most direct manner, parallel to building lines.

B. Locate piping to maintain clearance around equipment, and minimum piping headroom of 7 feet, except where otherwise shown.

C. Space piping so that insulation and flanges, if any, have at least 2 inch clearance after maximum movement.

D. Where a well or control instrument is to be installed in piping 2-1/2 inches and smaller, increase the pipe size by at least one pipe size to avoid restricting the flow in the pipe, unless otherwise specified.

E. Close open ends of piping and equipment, when it is not being worked on, with flange covers, caps or plugs.

F. In Domestic Water Systems, connect branch lines to the top of the line. In Fire Protection Water Systems, connect piping to allow for gravity drainage.

G. Connect branch lines in nitrogen, natural gas, laboratory gases, oxygen, and compressed air service to the top or upper half of the line, preferably the top. Follow manufacturer's guidelines and contract drawings for branch take-offs of vacuum lines.

H. Do not use pipes smaller than 1/2 inch, unless otherwise documented.

I. For pressures over 15 psig, use nipples and caps instead of plugs for permanent closures. Plugs in equipment provided by the equipment manufacturer are acceptable.

J. Bending of steel or copper pipe is not permitted.

K. Clean all piping materials before installation to remove grease, loose dirt, mill scale and other foreign matter.

L. Provide valved vents at all high points of water piping, and valved drains at all low points of water piping for draining and flushing. Locations shall be determined by the Contractor.

M. Provide escutcheons at all locations where piping, installed exposed to view, penetrates walls, partitions, floors and ceilings.

N. Provide unions or companion flanges where shown on the contract drawings and in following locations even if not shown:

1. In bypasses around valves and equipment.

2. In connection to equipment between shutoff valves and equipment, on the supply and return piping connections.

O. Maintain the following minimum pitches:

Safety and relief valve discharge	1" in 4'
Stormwater piping 2-1/2" and smaller	1" in 4'
Stormwater piping 3" and larger	1" in 8'
Sanitary piping 2-1/2" and smaller	1" in 4'
Sanitary piping 3" and larger	1" in 8'
Domestic cold water	1" in 50'
Domestic hot water	1" in 50'
Treated rain water supply	1" in 50'
All other	1" in 50'

P. Pipes shall not be installed in transformer vaults, electrical equipment rooms, elevator machine rooms or similar areas containing electrical equipment. Pipes shall not be installed over, around, in front of, in back of, or directly below, electrical controls, panels, switches, terminals, boxes, or similar electrical equipment. Provide drip pans over electrical equipment (at no cost to the Owner) only after approval by the Owner.

Q. Reduce pipe sizes with reducing fittings. Bushings shall not be permitted.

R. Changes in pipe size of soil, waste, and drain lines shall be made with increasers. Changes in direction, where space permits, shall be made with long sweep bends, wye-fittings, and 1/8- or 1/16-bends, or combination wye and 1/8-bends.

3.02 WELDED PIPE JOINTS

A. Weld joints in the following piping:

1. Fire protection black steel piping.

2. Natural gas piping: Underground and above grade piping 2" dia. and over.

3. Stainless steel distilled water piping.

B. Perform welding using qualified welders and procedures following specified reference standards.

C. Mitered welds for elbows are not allowed.

D. Welded branch connections may be used in place of welding tees provided that requirements of the applicable ANSI/ASME Code for Pressure Piping, B31.9 are met.

E. Weldolets or similar code-approved fittings may be used for branch connections. Branch connectors may be a maximum of one pipe size smaller than the main or branch main.

F. Welders, welding procedures, performance of welders and welding operators shall comply with the requirements of ANSI/ASME B31.9 and the ANSI/ASME Boiler and Pressure Vessel Code, Section IX. Keep records and certifications required by code on file and available for inspection.

G. Whenever welding is done close to walls, floors or building structure, thoroughly clean the surfaces of weld splatter. Remove weld splatter from the surface of all welds, pipe and pipe supports.

H. Inspect welded pipe joints as follows:

1. Visually examine all welded pipe joints for imperfections.

2. A record of visual examinations shall be made available to the Owner upon request.

3. Evaluate imperfections revealed by examination in accordance with the criteria in the specified (ANSI/ASME B31.9) code.

4. Remove weld defects by grinding or chipping and repair or replace weld joints.

I. Welding shall be electric arc welded.

J. Welding shall conform to procedure for metallic arc welding of steel pipe, fittings, and flanges under provisions of ANSI Piping Code and ASME Boiler and Pressure Vessel Code. Filler metal shall comply with ASME Specifications SA-233 for iron or steel arc welding electrodes, Classification E-6010, and shall provide physical properties in deposited metal comparable to the base metal. Clean each complete bead or layer with hammer and wire brush. Remove weld splatter from pipe ends, surface or weld before laying down next successive bead or layer.

3.03 THREADED PIPE JOINTS

A. The following piping shall have threaded joints:

1. Galvanized steel piping.

2. Carbon steel pipe 2-1/2" and smaller, as specified elsewhere in this Section.

B. Seal threaded joints with a non-corrosive, non-hardening compound or PTFE tape applied on the male thread. Caulking of threaded joints is not permitted.

C. Thredolets or similar code-approved fittings may be used for branch connections. Branch connectors may be one pipe size smaller than the main or branch main.

D. Ream or file pipe ends to size of bore, remove chips and cuttings. Cut pipe ends square. Completed joints in chromium-plated brass pipe shall have no more than one thread exposed.

3.04 SOLDERED PIPE JOINTS

A. Solder joints in the following piping:

1. Domestic cold and hot water copper tubing.

2. Drainage copper piping D.W.V.

3. Other piping specified in this Section to have soldered joints.

B. Use lead-free, 95/5 (tin/antimony) solder.

C. Solder joints in accordance with the current edition of the Copper Tube Handbook of the Copper Development Association.

D. Tubing and fittings 2 inches and larger shall be tinned prior to soldering.

E. Remove excess solder and flux with a cloth or brush.

3.06 CAULKED PIPE JOINTS

A. Following piping shall have caulked joints:

1. Cast iron soil pipe.

B. Hub-and-spigot, cast iron pipe joints shall be caulked firmly with oakum of hemp and filled with molten lead not less than 1" deep and not to extend more than 1/8" below rim of hub. Joint shall be poured full, at one pouring, with sixteen ounces of soft pig lead for each inch in diameter of cast

iron pipe. No paint, varnish, or other coatings shall be permitted on jointing material until after joint has been tested and approved.

C. To join screwed pipe to cast iron pipe, provide ring on screwed pipe to form spigot end.

3.07 FLANGED CONNECTIONS

A. Flange bolt holes shall straddle the pipe vertical and horizontal center-lines, and shall match the orientation of mating flanges.

B. Except for stainless steel piping] lubricate bolts or studs over the entire thread length with an anti-seize compound consisting of copper flakes and graphite disperse in water resistant grease. Approved Manufacturer: Jet-Lube Koper-Kote.

C. Install piping to equipment without strain.

D. Provide gaskets at all flanged connections as specified elsewhere in this section.

3.08 EQUIPMENT PIPING

A. Provide piping from backflow preventers, pump glands, relief valves or other drainage to spill over open sight drains, floor drains, or other discharge points, and terminate with plain end (unthreaded) pipe.

B. Where suction or discharge of pump is smaller than pipe size noted on drawings, provide reducing elbows or fittings at the pump connection. Strainers, valves, flexible connections, expansion joints, and other pipe-mounted accessories shall be full line size.

3.09 DOMESTIC WATER PIPING

A. Piping risers and stacks shall be supported by metal brackets attached to building construction or by other Architect approved methods.

B. Branch piping shall be as indicated, but shall be a minimum 3/4" with last [ten] feet to each 1/2" outlet fixture a minimum of 1/2".

C. Provide commercial type water hammer absorbers as indicated and as required for quiet operation of domestic water systems. Commercial absorbers shall be sized and placed in accordance with Plumbing and Drainage Institute Standard PDI WH-201.

3.10 ELECTROLYSIS CONTROL

A. See Section 15140, for isolation between piping and pipe supports.

B. Isolate non-ferrous piping passing through openings in structural steel with nonconductive material permanently attached to the pipe.

C. Make connections between non-ferrous metallic piping and ferrous piping, fittings, or equipment with dielectric fittings, nipples or unions specified in Part 2 of this Section.

3.11 PIPING SYSTEM DRAINS

A. Pitch each piping system to low points where entire system can be emptied through drains. Wherever isolation valves are installed, provide a drain plug to ensure that all piping can be drained.

B. Pitch outside water piping so that water can be drained from underground piping through drains installed in building served.

C. Provide drain piping system wherever drain locations are recommended by equipment manufacturers.

3.12 PIPING SYSTEM TESTING

A. Before testing, complete the installation of each pipe line, including final supports, hangers and anchors, insulation and painting. Clean piping and equipment of metal cuttings and foreign matter as they are installed and in accordance with all applicable codes and standards.

B. Provide two days notice of testing to the Owner. Testing may be witnessed by an Owner representative.

C. Pressure test piping in accordance with the applicable ANSI/ASME Code for Pressure Piping (B31), local Plumbing Codes, and applicable NFPA Standards.

D. Pressure vessels, tanks, pumps, rotating and other mechanical equipment shall not be subject to the piping field pressure test.

E. Equipment, instruments and piping specialties which are not be included in the test shall be either disconnected from the piping and the end of the pipe, blanked off by a blind flange, plug or cap, or isolated by insertion of a line blind or spool piece as required. Disconnect instrument air lines and close all openings.

F. Test piping in sections as required.

G. Provide systems to be pressurized with gauges and pressure-relieving devices.

H. Lines containing check valves shall have the source of test pressure located on the high-pressure side of the valves. Line control valves shall be set and maintained in a wide-open position.

I. Maintain a record of all tests, showing line designation, test pressure, ambient temperature, date of test, retests, and signature of Owner.

J. Perform pneumatic testing in accordance with ANSI/ASME B31.9, except for the following:

1. Perform pneumatic test using either oil-free compressed air or dry nitrogen [use nitrogen for nitrogen piping.]

2. Prior to application of full pneumatic test pressure, a preliminary test at 10 psig for 10 minutes before applying final test pressure.

3. Test pressure shall be as indicated elsewhere in this Section.

4. After the preliminary test, apply pressure gradually in stages of not more than 25 psig until test pressure is reached, allowing a minimum of 10 minutes between stages. Maintain test pressure for a minimum of thirty (30) minutes without fluctuation; then reduce pressure to operating pressure and begin checking for leaks.

5. Check all joints, welds, valves, etc. for leaks with a thick soap-water solution or with a special fluid made specifically for this purpose and hold pressure for a minimum of eight (8) hours.

6. Provide protection of persons and property during leak testing.

K. Perform hydrostatic testing in accordance with ANSI/ASME B31.9 except for the following:

1. Test pressure shall be as indicated elsewhere in this Section.

2. Maintain test pressure for a minimum of thirty (30) minutes before examining all joints, welds, valves, etc. and hold test pressure for a minimum of four (4) hours.

L. Test pressures shall be as follows:

SYSTEM	HYDROSTATIC TEST PRESSURE (PSIG)	DURATION (HOURS)	REFERENCE INFORMATION
Domestic Water Systems	165	0.5	K-2
Sanitary and Laboratory Acid Waste Piping	Static Fill - No Leakage	0.5	
Storm Water System	Static Fill - No Leakage	0.5	

M. Drainage System - Exterior

1. Test system before any section of waste or water drainage has been backfilled more than six inches above tip of pipes, exclusive of joint area. Wherever possible, test section of system from manhole to manhole. Plug lower end of each section to be tested with suitable device manufactured for this purpose and satisfactory to Architect. Fill section being tested with water and observe leakage.

2. For sewage and waste piping to be acceptable, water leakage after filling shall not exceed two gallons per 24 hours per lineal foot of pipe joints with joints under constant pressure of not less than 0.10 psig.

3. For storm water to be acceptable, water leakage after filling shall not exceed three gallons per 24 hours per lineal foot of pipe joints with all joints under constant pressure of not less than 0.10 psig.

3.13 FLUSHING OF PIPING SYSTEMS (DOMESTIC WATER)

A. Complete pressure testing before flushing piping systems. Flushing may be witnessed by the Owner, and shall be performed in accordance with the following procedures:

1. Flush clean with new potable water and drained at all lowpoints. Connected equipment (coils, etc.) shall be isolated and flushed individually with a hose.

2. Flushing for piping and equipment shall be complete when water samples taken at all low points indicate clean discharge (i.e., no visible solids). If not clean, continue flushing and sampling until discharge is clear.

3.14 CLEANING OF PIPING SYSTEMS

A. Submit a plan for disposal of the chemical cleaning effluent to the Owner for approval. Obtain written permission from the Owner to drain effluent on the site from cleaning and flushing operations. Otherwise, dispose of effluent offsite in a manner acceptable to all codes and regulations.

B. Complete flushing before cleaning piping systems.

3.15 DISINFECTION OF DOMESTIC WATER SYSTEM

A. Upon completion of tests and necessary repairs or replacements, disinfect hot and cold domestic water piping and other systems that may be connected to same supply source. Disinfect piping after thoroughly flushing with water to remove sediment.

B. Chlorinating materials shall be either liquid sodium hypochlorite solution or granular calcium hypochlorite. Introduce into system as specified in AWWA Standard for Water Mains, C601-68. Provide connections for pumping chlorine solution into system.

C. Following flushing, disinfect piping system in accordance with one of following methods:

1. Disinfect outside mains, to point inside building at main shutoff valve, as described in

AWWA Standard C 601-68 for a minimum contact time of 24 hours.

2. Fill piping system inside building, beginning at point of main shutoff valve, with solution containing 100 ppm of available chlorine. Retain solution in systems for not less than 4 hours, during which time all valves and faucets shall be opened for flushing, until chlorine is no longer detected. Drain system.

D. After sterilization, flush solution from system with clean drinking water until residual chlorine content is not greater than 1.0 ppm at extreme end of system.

E. Spent chlorine is industrial waste. Dechlorination prior to discharge from piping shall be required if final concentration exceeds 1.0 ppm or if municipal system receiving this discharge shall require dechlorination.

F. Obtain representative water sample from system for analysis by recognized bacteriological laboratory. If all samples tested for coliform organisms are negative, submit letter and laboratory reports, certifying successful completion of sterilization. If any sample tested indicate presence of coliform organisms, repeat entire sterilization procedure.

3.16 BALANCING OF DOMESTIC HOT WATER SYSTEM

A. Provide and install valves indicated on plans and, if required, additional balancing valves on domestic hot water recirculating system.

B. Balance hot water system after completion of installation of domestic hot water, hot water recirculating piping, water heaters and recirculating pumps.

C. Balanced system should provide almost instantaneous hot water at any portion of building.

3.17 PIPE WRAPPING

A. Protect steel or copper piping and fittings installed underground, in concrete slabs or in masonry walls with two layers of tightly applied spirally-wrapped tape, 3M Co., Number 50.

3.18 CONTROL VALVE PIPING AND VALVE BYPASS PIPING

A. Valves and strainers at automatic control valves shall be full pipe size indicated on the contract drawings. Reduce pipe size at control valves with reducing fittings at inlet and outlet of control valve. Provide straight lengths of inlet and outlet piping as shown on drawings or as recommended by the control valve manufacturer, whichever is greater.

B. Provide bypass pipe around all automatic control valves where shown on the contract drawings. For stations with one control valve, bypass pipe shall be same size as control valve. For stations with two or more control valves, bypass pipe shall be same size as largest control valve. Bypass piping shall have full line size manual throttling valves.

+ + END OF SECTION + +

SECTION 15070 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. This section describes the vibration control and seismic restraint systems for mechanical equipment, piping and ductwork.

B. This Section describes seismic restraint equipment for mechanical equipment.

1.02 REFERENCE CODES AND STANDARDS

A. Comply with the following in accordance with Division 1.

1. 2009 International Building Code

2. ASCE 7 Minimum Design Loads for Building and Other Structures, Chapter 13.

3. National Fire Protection Association (NFPA)
13 Installation of Sprinkler Systems

4. Sheet Metal and Air-Conditioning Contractors National Association, Inc. (SMACNA)
Seismic Restraint Manual: Guidelines for Mechanical Systems

1.03 PERFORMANCE CRITERIA

A. SEISMIC RESTRAINT DESIGN CRITERIA

1. General: Design seismic restraints for indicated horizontal and vertical forces acting simultaneously. Connections shall be positive anchorage without consideration of frictional resistance.

2. Seismic Criteria: Seismic Design Category B, Component Importance Factor: To be determined by each contractor in accordance with ASCE 7-05. See structural drawings for Occupancy Category.

3. SMACNA Seismic Hazard Level: Provide piping and ductwork with seismic restraints in accordance with Seismic Hazard Level (SHL) indicated in this Section, or the SMACNA Seismic Restraint Manual: Guidelines for Mechanical Systems, and in accordance with applicable building code.

4. Rigid Seismic Restraint Loading

a. Horizontal: Horizontal seismic force equal to the below listed percentage of the weight of the segment of system supported, including contents, fittings, inertia bases and insulation:

1) Life safety systems, including fire protection water and sprinklers - 30 percent, SHL B.
2) All other systems - 10 percent, SHL C.

b. Vertical: Vertical seismic force equal to 0.33 times the horizontal seismic force specified above.

5. Design resilient seismic restraints for twice the horizontal and vertical seismic forces as determined for rigid seismic restraints.

6. Provide seismic restraints on each side of flexible couplings.

7. Spacing of seismic restraints shall not exceed twice the maximum spacing of pipe hangers and supports listed in Sections 230529.

8. Seismic restraints are not required for the following:

   a. Piping less than 1-1/4-inch inside diameter in boiler and mechanical equipment rooms.
   b. Other piping less than 2-1/2-inches.
   c. Rectangular air handling ducts less than 6 square feet in cross-sectional area.
   d. Round air handling ducts less than 28-inches in diameter.
   e. Piping suspended by individual hangers 12-inches or less in length from the top of the pipe to the bottom of the supporting structural member where the hanger is attached.
   f. Ducts suspended by hangers 12 inches or less in length from the top of the duct to the bottom of the supporting structural member.

9. Design, furnish and install sprinkler systems in accordance with NFPA 13 provisions for "Protection of Piping Against Damage Where subject to Earthquake." Where criteria more stringent than NFPA 13 are specified in this Section, design systems to comply with more stringent criteria.

10. Connect hangers and braces to steel beams where possible.

11. Locate hangers and braces connected to steel joists within 5 inches of the joist panel point; otherwise provide stiffeners in accordance with the details shown on the structural contract drawings.

1.04 SUBMITTALS

A. Submit for review:

1. Product data, dimensions, materials of construction, specifications, and installation instructions.

   a. For each vibration isolator:

      1) Equipment identification tag
      2) Isolator type
      3) Actual load
      4) Static deflection expected under actual load
      5) Specified minimum static deflection
      6) Additional deflection to solid under actual load
      7) Ratio of spring height under actual load to spring diameter.

2. Shop Drawings: Layout of piping and ductwork to be isolated including vertical risers showing:

   a. Support points
   b. Weight at support points
   c. Isolator points
   d. Static deflection expected under actual load
   e. Specified static deflection
   f. Additional deflection to solid under actual load
   g. Ratio of spring height under load to spring diameter.
   h. [Steel rails] Steel base frames, and concrete inertia bases showing steel work, reinforcing, vibration isolator mounting attachment method and location of equipment attachment bolts.

B. Submit for record:

1. Shop Drawings: Submit shop drawings showing locations and details of seismic restraints, including connections to structure. Show load reactions at structural connections which equal or exceed 2000 pounds. Submit, for record, load reactions at structural connections which are less than 2000 pounds.

2. Certification: Submit certification signed and sealed by Professional Engineer as indicated in this Section, stating that seismic restraints and connections have been designed, furnished and installed in accordance with design criteria indicated in this Section.

1.05 .QUALITY ASSURANCE

A. Coordinate size, location, and special requirements of vibration isolation equipment and systems with work of other Sections. Coordinate plan dimensions with size of housekeeping pads.

B. Provide vibration isolators of appropriate sizes and proper loading to meet specified deflection requirements.

C. Provide, at no additional cost, incidental materials needed to meet requirements, even if not expressly specified or shown on the contract drawings.

D. Provide seismic restraints on vibration isolation devices as indicated in this Section.

E. Furnish services of Professional Engineer employed by the Contractor to supervise design, procurement and installation of seismic restraints. Include cost of Professional Engineer's services in the bid.

1.06 SPEED AND BALANCE REQUIREMENTS

A. Fans and other rotating mechanical equipment shall not operate at speeds in excess of 80% of their critical speed.

B. Vertical vibration of rotating equipment shall be less than levels indicated elsewhere. Measure vibration on equipment or steel frame equipment base when equipment is mounted on its vibration isolation mounts. If equipment has an inertia base, the allowable vibration level shall be reduced by the ratio of equipment weight alone to equipment weight plus inertia base weight.

Equipment Speed (rpm)	**Vibration Displacement (mils, peak-to-peak)**
Under 600	4
600 to 1000	3
1000 to 2000	2
over 2000	1

1.07 COORDINATION

A. Coordinate the locations of seismic restraints with the requirements of other trades. Coordinate with work of other Sections for the installation of cast-in place anchor bolts, inserts and embedded plates required for seismic restraint connection to structure.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Acceptable Manufacturers, subject to compliance with requirements:

B. Vibration Control Equipment: Each type of vibration control equipment, including mountings, hangers, rails, structural steel bases, and welded concrete pouring forms shall be the product of one of the approved vibration control equipment manufacturers listed below, unless listed otherwise under the product specification.

1. Amber Booth Company - A.B.

2. Korfund Dynamics Corporation - K.D.

3. Mason Industries, Inc. - M.I.

4. Kinetics Noise Control, Inc. - K.N.C.

5. Vibration Mounting and Controls, Inc. - V.M.&C.

6. Vibration Eliminator Company, Inc. - V.E.C.

C. Seismic Control Equipment:

1. B-Line Systems, Inc.

2. Mason.

2.02 VIBRATION ISOLATION MOUNT TYPES

A. General

1. Metal parts of vibration isolation units installed outside shall be hot-dip galvanized in accordance with ASTM Standard A-123 or neoprene-coated after fabrication.

2. Isolator types are scheduled to establish minimum standards. Optionally, labor-saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories shall not degrade vibration isolation system.

3. Static deflection of isolators shall be as specified in this section.

4. The scheduled static deflections are the minimum acceptable deflections for the mounts under actual load. Isolators selected on the basis of rated deflection will not be acceptable.

B. Unit FSN (Floor Spring and Neoprene)

1. Spring isolators shall be free-standing and laterally stable without any housing.

2. Spring diameter shall be a minimum of 80% of the compressed height of spring at design load.

3. Springs shall have minimal additional travel to solid equal to 50% of actual deflection.

4. Mounts shall have leveling bolts.

5. The spring element in the isolator shall either be set in a neoprene with a steel washer or the isolator shall be mounted on a unit DNP isolator. If a DNP isolator is provided, provide a rectangular bearing plate sized to load the pad uniformly in the range of 40 to 50 psi. If spring isolator is supplied with a neoprene friction pad, provide a stainless steel, aluminum or galvanized steel plate between the friction pad and the DNP isolator. The

DNP isolator, separator plate and friction pad shall be permanently adhered to one another and to the bottom of the bearing plate.

6. If the isolator is to be fastened to the building structure and a Unit DNP isolator is provided under the bearing plate, provide neoprene grommets for each bolt hole in the base plate. Size bolt holes to allow for grommet installation. Hold-down bolt hole assembly shall include washers to distribute the load evenly to grommet. Bolts and washers shall be galvanized steel.

7. Acceptable Models (Unit FSN isolators), neoprene pad, if provided, selected from Unit DNP:

Type SW ..... A.B.
Type WSL. ..... K.D.
Type SLF. ..... M.I.
Type FDS. ..... K.N.C.
Series A. ..... V.M.& C.
Type OST ..... V.E.C.

C. Unit FSNTL (Floor Spring and Neoprene, Travel-Limited)

1. Isolators shall be the same as Type FSN, with leveling bolts and vertical travel limit stops to control extension when weight is removed. Travel limit stops shall be capable of serving as blocking during erection of equipment. Maintain 1/4-inch clearance around restraining bolts and between limit stops and spring.

2. Acceptable Models (Unit FSNTL isolators) with neoprene pad, if provided, selected from Unit DNP.

Type CT ..... A.B.
Type WSCL ..... K.D.
Type SLR ..... M.I.
Type FLS ..... K.N.C.
Series AWR ..... V.M.&C.
Type KW ..... V.E.C.

D. Unit FN (Floor Neoprene)

1. Isolators shall be neoprene-in-shear type with a steel reinforced top and base.

2. Metal surfaces shall be covered with Neoprene with ribbed top and bottom surfaces.

3. Bolt holes shall be provided in base and the top shall have threaded fastener.

4. Acceptable Models:

Type RV ..... A.B.
Type F ..... K.D.
Type ND ..... M.I.
Type RD ..... K.N.C.
Series RD ..... V.M.&C.
Type S or D ..... V.E.C.

E. Unit NP (Neoprene Pad)

1. Isolators shall be one layer of 1/4-inch to 3/8-inch thick 40 to 50 durometer ribbed or waffled neoprene loaded between 40 and 50 psi.

2. Acceptable Models:

Type NR ..... A.B.
Type Korpad ..... K.D.
Type W ..... M.I.
Type NPS ..... K.N.C.
Series Shear Flex ..... V.M.&C.
Type 100N ..... V.E.C.

F. Unit DNP (Double Neoprene Pad)

1. Form neoprene pad isolators with two permanently adhered layers of 1/4 inch to 3/8 inch thick ribbed or waffled 40 to 50 durometer neoprene, separated by a galvanized steel or aluminum plate.
Size the pads to be loaded within the manufacturer's recommended range.

2. Acceptable Models:

Type NR, double layer. ..... A.B.
Type Korpad, double layer ..... K.D.
Type WSW. ..... M.I.
Type NPS or RSP ..... K.N.C.
Type 100N ..... V.E.C.

G. Unit HS (Hanger Spring)

1. Isolation hangers shall consist of free-standing laterally stable steel spring set into neoprene cup, contained within steel housing manufactured with grommet (or other means) to prevent hanger rod from contacting hanger housing. Provide steel washer in neoprene cup to evenly distribute load onto neoprene.

2. Spring diameter and hanger housing lower hole sizes shall be large enough to permit hanger rod to swing through 30-degree arc before contacting housing.

3. Spring elements shall have minimum additional travel to solid equal to 50% of actual deflection.

4. Acceptable Models:

Type BSA ..... A.B.
Type VSP-30 ..... K.D.
Type 30 ..... M.I.
Type SH ..... K.N.C.
Type SH ..... V.M.&C.
Type SNC ..... V.E.C.

H. Unit HSN (Hanger Spring and Neoprene)

1. Isolation hangers shall consist of free-standing, laterally stable steel spring and neoprene element in series, contained within a steel housing.

2. Provide a neoprene neck bushing (or other means) where hanger rod passes through hanger housing to prevent rod from contacting hanger housing.

3. Spring diameters and hanger housing lower hole sizes shall be large enough to permit hanger rod to swing through 30-degree arc before contacting housing.

4. Spring elements shall have minimum additional travel to solid equal to 50% of actual deflection, and neoprene element shall have 0.30-inch minimum static deflection.

5. Acceptable Models:

Type BSRA ..... A.B.
Type VSX - 30 ..... K.D.
Type 30 N ..... M.I.
Type SRH or SFH ..... K.N.C.
Type RSH or RFH ..... V.M.&C.
Type SNRC ..... V.E.C.

I. Unit HN (Hanger Neoprene)

1. Isolation hangers shall consist of neoprene-in-shear element contained in a steel housing.

2. Provide Neoprene neck bushing (or other means) where hanger rod passes through hanger housing to prevent rod from contacting hanger housing.

3. The diameter of the hole in the housing shall permit the hanger rod to swing through a 30-degree arc before contacting the hanger housing.

4. Acceptable Models:

Type BRD-A ..... A.B.
Type H ..... K.D.
Type HD ..... M.I.
Type RH or FH ..... K.N.C.
Type RHD or RFD ..... V.M.&C.
Type C or CD ..... V.E.C.

J. Unit PCF (Precompressed Glass Fiber)

1. Precompressed glass fiber blocks shall be made of molded inorganic fiberglass that is individually coated and sealed with an impervious elastomeric membrane. Fiberglass shall be severely overloaded during manufacture to stabilize the material into a product that is permanent and has consistent, predictable dynamic properties.

2. Acceptable Models:

Type KIP ..... K.N.C.
Type F ..... V.E.C.

2.03 02 EQUIPMENT BASES

A. Unit BSR (Base - Steel Rail)

1. Steel rail bases shall consist of structural steel sections sized to provide rigid beam which will not twist, deform or deflect sufficiently to negatively affect operation of supported equipment or vibration isolation mounts.

2. Rail bases shall include side mounting brackets for attachment of vibration isolators.

3. Acceptable Models for Unit BSR bases:

Type C or CIS ..... A.B.
Type Steel Base Rail ..... K.D.
Type R or ICS ..... M.I.
Type KRB or KFB ..... K.N.C.
Type WFR or AR ..... V.M.&C.
Type WF Rail ..... V.E.C.

B. Unit BSF (Base - Steel Frame)Steel base frames shall consist of structural steel sections sized, spaced and connected to form rigid base which will not twist, rack, deform or deflect sufficiently to negatively affect operation of supported equipment or vibration isolation mounts.

1. Size frames to support equipment and motors plus any associated pipe elbow supports, duct elbows supports, electrical control elements or other components closely related and requiring resilient support in order to prevent vibration transfer to building structure.

2. Steel frame base thickness shall be at least 1/10 of longest dimension of base, but not more than 12-inch.

3. Frame bases shall include side mounting brackets for attachment to vibration isolators.

4. Acceptable Models for Unit BSF bases:

Type SW-1 ..... A.B.
Type Steel Base ..... K.D.
Type WFSL ..... M.I.
Type SFB or SRB ..... K.N.C.
Series WFB ..... V.M.&C.
Type UN..... V.E.C.

C. Unit BIB (Base - Inertia Base)

1. Form concrete inertia bases of stone-aggregate concrete (150 lb/cu ft) and steel reinforcing cast between welded perimeter structural steel channels.

2. Inertia bases shall be built to form rigid base which will not twist, rack, deform, deflect or crack sufficiently to negatively affect the operation of supported equipment or vibration isolation mounts.

3. Size inertia bases to support equipment and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements or other components closely related and requiring resilient support in order to prevent vibration transfer to building structure.

4. Inertia base thickness shall be at least 1/12 of longest dimension of inertia base but not less than 6-inch.

5. Inertia bases shall include side mounting brackets for attachment to vibration isolators.

6. Concrete shall meet Division 3 requirements.

7. Acceptable Models for Frame and reinforcement for BIB bases:

Type CPF..... A.B.
Type RCPF ..... K.D.
Type KSL ..... M.I.
Type CIB-L or CIB-H ..... P.N.C.
Series WPF ..... V.M.&C.
Type SN Frame..... V.E.C.

D. Unit BC (Base - Curb)

1. Curb type isolation bases shall be a prefabricated assembly consisting of extruded aluminum frame and steel spring isolation system that fits over the roof curb and under isolated equipment.

2. Aluminum frame shall be sufficiently rigid to support equipment load without twist or

deflection.

3. Select and position spring isolators along the curb to achieve the minimum static deflection specified. Static deflection shall be constant around base periphery.

4. Springs shall be free-standing, laterally stable with diameter of not less than 80% compressed height, and have additional travel to solid at least 50% of actual defection.

5. Provide resilient neoprene snubbers at corners of base to limit horizontal movement of equipment under wind load to 1/4-inch.

6. Seal around curb base with closed-cell neoprene or flexible vinyl. Sealing shall not inhibit vibration isolation of spring elements. Provide closed-cell sponge gasket or field caulking between the equipment and the isolation curb base, and between the isolation curb base and the roof curb.

7. Acceptable Models:

Type RTIC ..... A.B.
Type RSC ..... M.I.
Type KSR ..... K.N.C.
Series ATR ..... V.M.&C.
Type AR ..... V.E.C.

2.04 RESILIENT PENETRATION SLEEVE/SEAL

A. Fabricate from pipe (for pipe penetrations) or sheet metal section (for duct penetrations) 1-inch larger in each dimension than penetrating element, and install to provide sleeve through construction penetrated. Extend sleeve 1-inch beyond penetrated construction on each side. Tightly pack annular space between sleeve and penetrating element with glass fiber or mineral wool to within 1/4-inch of ends of sleeve. Completely fill remaining 1-inch space on each side with acoustical sealant to form airtight seal. Penetrating element shall be able to pass through sleeve without contacting sleeve.

2.05 RESILIENT LATERAL GUIDES

A. These units shall incorporate neoprene isolation elements which are specifically designed for providing resilient lateral bracing of vertically rising ducts or pipes.

B. Acceptable Models:

Type Custom ..... A.D.
Type Custom ..... K.D.
Type VSG ..... M.I.
Type RGN ..... K.N.C.
Type MDPA ..... V.M.&C.
Type VERG ..... V.E.C.

2.06 THRUST RESTRAINTS

A. Unit TR (Thrust Restraint)

1. Thrust restraints shall consist of a spring element in series with a neoprene pad designed to have the same deflection as specified for the isolators supporting the equipment with a maximum of 2-inches.

2. The spring element shall field-adjustable to allow for maximum of 1/4-inch movement during starting or stopping of equipment.

3. Furnish the assembly complete with rods and angle brackets for attachment to both the equipment and the adjacent fixed structural anchor.

4. Acceptable Models:

Type TRK.....A.B.
Type WBI.....M.I.
Type HSR .....K.N.C.
Type HTR.....V.E.C.

2.07 GROMMETS

A. Grommets shall be either custom made by combining a 40 and 50 durometer neoprene washer and a sleeve, or shall be one of the products listed below.

B. Provide grommets at all vibration isolators to prevent fastening bolts from directly contacting isolator base plate.

C. Acceptable Models:

Isogrommets.....MB Dynamics
Series W. .....Barry Controls
HG .....Mason Industries

2.08 ACOUSTICAL SEALANT

A. Acoustical sealants shall be one of following non-hardening sealants:

Acoustical sealant .....D.A.P.
BR-96 .....Pecra
Acoustical sealant .....Tremco
Acoustical sealant .....U.S.G.

PART 3 - EXECUTION

3.01 APPLICATION

A. Major Equipment

1. Unless otherwise shown or specified, set floor-mounted equipment provided under Division 15 on concrete housekeeping pads.

2. Install flexible duct connections at fan intakes and discharges, including fan powered variable volume boxes, and where shown on the drawings.

B. Miscellaneous Mechanical Equipment

1. Isolate air purgers, domestic water heaters, storage tanks, water-to-water heat exchangers, steam-to-glycol heat exchangers, air separators, and expansion tanks]from transmitting vibration to building structure by Unit NP or Unit HN isolators selected for 0.25 inch minimum static deflection unless their position in piping system requires higher degrees of isolation as specified below.

C. Pipe Isolation

1. Isolate pressurized piping, relief valve discharge piping, drain and engine exhaust piping that is connected to vibration – isolated equipment from transmitting vibration to building structure by vibration mounts, resilient pipe guides, and resilient penetration sleeve/seals

within the following limits.

a. Within mechanical rooms;
b. Within 50 feet total pipe length of connected vibration-isolated equipment;

2. Isolators for the first three support points adjacent to connected equipment shall achieve half of the specified static deflection of isolators supporting connected equipment.

a. When required static deflection of these pipe isolators is greater than 0.50-inch, provide Unit FSN or HSN isolators, whichever is applicable for mounting condition.
b. When the required static deflection is less than or equal to 0.50-inch, provide Unit FN or HN isolators, whichever is applicable for mounting condition.

3. For other pipe support isolators within specified limits, provide either Unit FN or HN, whichever is applicable to mounting condition, achieving 0.25-inch static deflection.

4. Where lateral support of pipe risers is required within specified limits, provide resilient lateral supports.

5. Isolate pipes within the specified limits that penetrate building construction from the building structure with resilient penetrating sleeve and seals.

6. Drain piping connected to vibration-isolated equipment shall not contact the building structure or other non-isolated systems unless it is resiliently mounted.

7. Pipe spring supports required for thermal movement compensation shall meet the requirements as specified in Section 15060. When there is a conflict between the requirement for thermal movement and the requirement of this Section, comply with the more stringent requirement.

8. For hydronic piping systems and for hydrostatically tested systems: Adjust hangers and provide pre-compressed supports, as applicable, to prevent damage to building construction and pipe insulation as systems are filled with water.

a. On failure to do so, repair any damage caused to building construction and pipe insulation without additional cost to the Owner.

D. Ductwork Isolation

1. Isolate the following ductwork from the building structure by either Unit FN or HN isolators.

a. All ductwork in the Penthouse, except where noted otherwise on the drawings.

2. Isolate ductwork within the specified limits which penetrates the floor construction with resilient penetration sleeve/seals.

3. Provide resilient lateral guides where lateral support of vertical ductwork runs is required within the specified limits.

3.02 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT

A. General

1. Locations of vibration isolation equipment shall allow inspection and adjustment.

2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.

B. Isolation Mounts

1. Squarely align vibration isolators above or below mounting points of supported equipment.

2. Locate isolators for equipment with bases on sides of bases which are parallel to equipment shaft unless this is not possible because of physical constraints.

3. If housekeeping pad is provided, isolators shall bear on housekeeping pad and isolator base plate shall rest entirely on pad. Maintain at least 2-inches between edge of isolator base and edge of pad.

4. Hanger rods for vibration isolated supports shall be connected to structural beams, not from the floor slab between beams and joists. Provide intermediate supports as necessary.

5. Position vibration isolation hanger elements as high as possible in hanger rod assembly but not in contact with building structure, and so that hanger housing may rotate full 360 degrees about rod axis without contacting any object.

6. Parallel-running pipes may be hung together on a trapeze which is isolated from building. Isolator deflections shall be the largest determined by the provisions for pipe isolation. Do not mix isolated and non-isolated pipes on the same trapeze.

7. No pipes or equipment shall be supported from other pipes or equipment.

8. Resiliently-isolated pipes shall not contact rigid building structure or equipment.

9. Installed and operating heights of vibration-isolated equipment mounted on Unit FSNTL isolators shall be identical. Limit stops shall be out of contact during normal operation.]

10. Adjust leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

11. Pipe elbows at floor-mounted equipment that require support shall be braced to the equipment base.

C. Bases

1. No equipment shall bear directly on vibration isolators unless its own frame is suitably rigid to span between isolators and direct support is approved by equipment manufacturer. This provision shall apply whether or not base frame is specified or indicated on drawings. If a base frame is required because of the equipment manufacturer's requirements and it is not specifically called for, the base frame recommended by equipment manufacturer shall be provided at no additional expense.

2. Unless otherwise indicated, provide minimum operating clearance of 1.5-inch between inertia bases or structural steel frames and concrete housekeeping pad or floor beneath equipment. Position isolator mounting brackets so that the required clearance is maintained. Check clearance space to ensure that no construction debris has been left to short-circuit or restrict proper operation of the vibration isolation system.

D. Flexible Duct Connections

1. Sheet metal ducts or plenum openings shall be squarely aligned with fan discharge, intake or adjacent duct section prior to installation of flexible connection, so that clear length is approximately equal all way around perimeter. Flexible duct connections shall not be installed until this provision is met.

2. The fan or adjacent duct section shall be able to move 1-inch in any direction without causing metal to metal contact or stretching flexible connection taut.

E. Thrust Restraints

1. Attach thrust restraints at centerline of thrust on the fan discharge and symmetrically on each side of the equipment.

2. Adjust restraints to limit equipment movement to the specified limit.

3. Install thrust restraints on the following:

a. In-line fans
b. Fans with a minimum 4-inch w.g. scheduled static pressure.

4. Thrust restraints may be omitted on centrifugal fans having a vertical upblast discharge arrangement, and on plug fans.

F. Resilient Penetration Sleeve/Seals

1. Penetration seals shall maintain airtight seal around the penetrating element and shall prevent contact of the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of construction penetrated with acoustical sealant.

3.03 VIBRATION ISOLATION SCHEDULE

EQUIPMENT	MOUNTING CONDITION	ISOLATOR TYPE	MIN. STATIC DEFLECTION (inches)	BASE TYPE
Screw Chillers	Supported Slab	FSNTL	1.5	--
Fans Within Air Handling Units	All	FSN	1.5	BSF
Air Handling Units	Supported Slab	DNP	0.35	--
Centrifugal or In-Line Fans Below 10" s.p.	Floor Suspended	FSN HSN	1.5 1.5	BSF --
All Other Fans	Suspended Roof	HSN BC	1.5 0.75	-- --
Fan Coil Units Cabinet Unit Heaters, Heat Pumps	Suspended	HSN	0.75	--
Unit Heaters	Suspended	HSN	0.75	--
In-Line Pumps	Suspended	HSN	1.0	--
Base-Mounted Pumps	Supported Slab	FSN	1.5	BIB

+ + END OF SECTION + +

SECTION 15071 - BASIC PIPING PRODUCTS AND METHODS - PLUMBING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes piping related items for plumbing and fire protection systems.

1.02 SUBMITTALS

A. Submit for review:

1. Product data for all items.

2. Certified accuracy for thermometers, pressure gauges, pressure differential gauges, flowmeters.

1.03 QUALITY ASSURANCE - EXPANSION JOINTS

A. Design and construct expansion compensators/joints in accordance with ANSI B31.1; Section VIII, Appendix bb of ANSI/ASME Boiler and Pressure Vessel Code; EJMA Standards and referenced Military Specifications.

B. Packless expansion compensators/joints shall have corrugated elements (bellows) of uniform curvilinear shape formed from seamless tubing with only one longitudinal seam per tube.

C. Expansion compensators/joints shall be suitable for not less than 5000 cycles at maximum operating pressures and temperatures.

D. Where required, bellows reinforcement may be in the form of additional fully-sealed plies or suitably designed reinforcing rings or equalizing rings. When rings are used, they shall be supported and guided as required to avoid excessive bellow deformation.

PART 2 - PRODUCTS

2.01 THERMOMETERS

A. Approved Manufacturers: H.O. Trerice Co., Weksler Instrument Corporation, Marshalltown, Weiss.

B. Description: Straight case, red reading mercury, 9-inch plastic or cast aluminum case, black finish, brass stem, adjustable angle type. Thermometers shall have an accuracy of 1 percent of full scale. Provide thermometers with expansion heads. Approved Model: Weksler Model AA5H.

C. Provide thermometers with insertion lengths as follows:

PIPE SIZE (INCHES)	INSERTION LENGTH (INCHES)
2-1/2 and smaller	2 to 2-1/2
3 to 6	2 to 4
8	5 to 6

D. Provide thermometers with matching brass for water service or stainless steel separable socket thermometer wells in accordance with manufacturer's recommendations.

E. Where thermometer wells are installed in piping 2-1/2 inches and smaller, install thermometers at elbows such that the stems protrude into the flowing medium.

2.02 PRESSURE GAUGES

A. Provide dial type gauges with black phenolic turret case, glass face and brass or stainless steel snap ring with white face and black numerals, 270 degree arc. The dial diameter shall be 4-1/2 inches.

B. Gauges shall have a phosphor-bronze bourdon tube with silver brazed to forged brass socket and tip, Delrin rack, stainless steel pinion, and Delrin bearings and bushings for rotating assembly.

C. Gauges shall have a guaranteed accuracy of 1.0 percent of full scale.

D. Provide gauges with 1/4 inch NPT bottom or back connection, brass body and core snubber.

E. Provide each gauge with a bar stock needle valve with brass body and handle. Gauge cock shall be suitable for 600 psig at 300 °F. Approved Manufacturer: Weksler Model BBV4.

F. Approved Manufacturers for Gauges and Accessories: Trerice Model 500XB, Weiss, Marshalltown or Weksler.

2.03 STRAINERS

A. Approved Manufacturers: Mueller Steam Specialties, Spirax Sarco, Hayward, Keckley, Metraflex, Spence.

B. Y-Type Strainers

1. For 2 inch and smaller.

a. ASTM A 62 bronze body with threaded ends, threaded brass cap with threaded blowoff connection, stainless steel screen, non-shock ratings of 250 psig saturated steam and 400 psig WOG, Spirax Sarco Model BT.

b. ASTM A 126 Grade B cast iron body with threaded ends, threaded blowoff connection, stainless steel screen, non-shock ratings of 250 psig saturated steam and 400 psig WOG, Spirax Sarco Model IT.

2. For 2-1/2 inch and larger, for systems rated at 150 psig:

a. ASTM A 126 Grade B cast iron flanged body and bolted, gasketed screen cover with threaded blow off connection, stainless steel screen ANSI Class 125, Spirax Sarco Model CI-125 or F-125.

C. Simplex Basket Strainers

1. For 2-1/2 inch and larger:

a. ASTM A 126 Grade B cast iron body and screen cover, flanged ends, stainless steel screen, quick-opening clamped cover, ANSI Class 125, Mueller Model 155M.

D. Screen mesh openings shall be as follows:

STRAINER SIZE	OTHER SERVICES
1/2" to 2"	20-mesh 0.033" opening
2-1/2" to 4"	0.062" perforation
5" and up	0.125" perforation

2.04 WATER METERS

A. Approved Manufacturers: Badger, Hersey, Neptune, Rockwell.

B. Meter shall be turbine or compound type used to measure total usage of water in gallons as required and approved by local water authorities.

2.05 VACUUM BREAKERS - LIQUID SERVICE

A. Approved Manufacturers: Bell and Gossett Model 26, ITT Hoffman, Cash, Watts, Spirax-Sarco.

B. Vacuum breaker shall automatically relieve vacuum from pipe or vessel installed.

C. Construct vacuum breaker of brass, bronze or stainless steel with 3/4-inch threaded connections.

D. Vacuum breaker shall be adjustable from 1/4 inch to 20 inches Hg vacuum relief setpoint.

E. Maximum working pressure shall be 150 psig and maximum operating temperature shall be 240 degrees F.

2.06 MANUAL AIR VENTS

A. Manual air vents shall be 1/2-inch ball valves with 1/2-inch hose ends.

2.07 BACKFLOW PREVENTERS

A. Approved Manufacturers: Watts, Wilkins, Beeco.

B. Backflow preventers in domestic water system shall utilize reduced pressure principle. Preventer shall have bronze body for size 2 inch and smaller, epoxy-coated cast iron for 2-1/2 inch and larger, stainless steel trim with relief vents and with strainer and shut-off valves. Preventer shall be Watts Regulator Series 909.

C. Backflow preventers installed in fire protection systems shall be listed for fire protection service.

2.08 EXPANSION JOINTS

A. Approved Manufacturers: The following manufacturers are approved for use:

1. Expansion Compensators/Joints: Flexonics, Hyspan, Metraflex, Keflex, Adsco, Microflex, American BOA, Inc.

B. Copper Tubing Expansion Compensators: Provide expansion compensators with shroud, positioning restraint, anti-torque device, seamless stain-less steel bellows and solder-type sweat ends in all-bronze construction or brass threaded ends (brass pipe) suitable for a maximum operating pressure to 200 psi with a maximum operating temperature to 600 degrees F. Expansion compensators shall have a maximum stroke of 1.75 inches in axial compression and 0.25 inches in extension. Approved Models: Model "HB" by Flexonics or Models "HPC-XSW" or "FPT" by Microflex or Model "HPMF" by Metraflex.

C. Flexible Metal Hoses

1. Approved Manufacturers: Flexonics, Flexible Hoses, Microflex, Metraflex, Hyspan.

2. Construct corrugated flexible hose of bronze helical corrugations encased in braided sheath of same material with threaded, soldered or flanged ends.

3. Construct corrugated flexible hose of Type 321 stainless steel helical corrugations encased in braided sheath of stainless steel wire, with threaded, soldered, welded, or flanged ends.

4. Hose shall be rated for piping systems in which they are installed.

2.09 PIPE SEALS FOR WATER-EXPOSED, NON-FLASHED CONSTRUCTION

A. Approved Manufacturers: Thunderline Corp. Model Link-Seal, Calpico Model CSL, Metraflex

"Metraseal."

B. Provide sealing element made of synthetic rubber material, especially compounded to resist aging, ozone, sunlight, water and chemical action and having low-temperature flexibility and resistance to high temperature environments. Elements shall be suitable for temperature ranges of -40°F to 225°F.

C. Bolts and metal parts shall be made of carbon steel and zinc phosphate plated to resist corrosion.

D. Pressure plates shall be made of plastic.

E. Provide manufacturer's matching wall sleeve with combination waterstop and anchor plate.

2.10 SEALANT MATERIALS - FOR NON-FIRE RATED CONSTRUCTION

A. Provide mineral fireproofing filler material in thicknesses required for each pipe sleeve.

B. Provide closed-cell polyethylene foam or open-cell polyurethane foam backup strip for filler material.

C. Provide butyl elastomer or epoxidized polyurethane terpolymer flexible vapor barrier sealant for sealing both ends of pipe sleeve.

D. See Section 15210 for vibration-isolated pipe penetration requirements.

E. Approved Manufacturers:

1. Mineral Fireproofing: Thermafiber by USG Acoustical Products Company.

2. Polyethylene Foam: Ethafoam by Dow Chemical Company.

3. Polyurethane Foam: Denver Foam by Plateau Supply.

4. Butyl Elastomer: Foster 95-44.

5. Epoxidized Polyurethane Terpolymer: Dymeric by Tremco.

2.11 SEALANT MATERIALS - FOR FIRE-RATED CONSTRUCTION

A. Sealant materials shall be UL listed and have a fire rating equal to the wall or floor penetrated.

B. All pipe penetration seal systems shall be UL approved and approved by the local authority having jurisdiction for the application.

C. Remove insulation from piping at the portion of the pipe passing through the sleeve.

D. For uninsulated metal pipes when each pipe penetrates through individual sleeve:

1. Provide smoke-tight and fire-tight seal using an intumescent elastomeric material in putty or caulk form.

2. Approved Manufacturers: Fire Stop System Sealant by Dow Corning. Fire Barrier Non-Sag Caulk CP 25N/S or Self-Leveling Caulk CP 25S/L by 3M Electrical Products Division, FSP Firestop Putty by Hevi-Duty/Nelson/Unit of General Signal.

E. For uninsulated metal pipes when multiple pipes penetrate through one sleeve and when each pipe penetrates through individual sleeve.

1. Provide smoke-tight and fire-tight seal using a foamed-in-place silicone elastomeric material to fill the annular space between the pipe and sleeve.

2. Provide alumina-silicate fire board or other suitable damming material.

3. Approved Manufacturers: Fire Stop System Two-Part Silicone RTV Foam by Dow Corning, Pensil Fire Stop System by General Electric Company.

F. For Insulated Metal Pipes

1. Provide smoke-tight and fire-tight seal using an intumescent elastomeric material with aluminum foil on one side in wrap/strip form.

2. Provide precut aluminum-faced fire barrier sheets for sealing either round or rectangular penetrations.

3. Approved Manufacturer: Fire Barrier Wrap/Strip FS-195 by 3M Electrical Products Division.

2.12 FDA AUTHORIZED SEALANT

A. The annular spaces between pipe, sleeve and interior wall shall be filled with white food-grade silicone rubber sealant (without traces of arsenic) that is authorized by the FDA.

B. Sealant shall meet the requirements of ASTM C920, Type S, Grade NS, Class 25, Use O.

C. Approved Manufacturers: Silicone Construction 1200 Sealant Certifiable Grades by General Electric Company, 732 by Dow Corning Corporation, Rhodorsil 3B by Rhone-Poulenc, Inc.

2.13 PIPE SLEEVES FOR INTERIOR FLOOR SLABS (OTHER THAN WATERPROOFED SLABS) AND GRADE BEAMS

A. Fabricate sleeves from standard-weight carbon steel pipe in length to match slab or grade beam thickness.

B. For pipes 8 inches in diameter and smaller, make sleeve inside diameter at least 2 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation). For pipe larger than 8 inches in diameter, make sleeve inside diameter at least 3 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation).

C. Where sleeve seals are UL Listed assemblies, size the pipe sleeve to the designated UL assembly standards.

2.14 PIPE SLEEVES FOR CONCRETE OR MASONRY INTERIOR WALLS, PARTITIONS AND FIRE-RATED WALLS

A. Fabricate sleeves from standard-weight carbon steel pipe in length to match finished wall thickness.

B. For pipes 8 inches in diameter and smaller, make sleeve inside diameter at least 2 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation). For pipes larger than 8 inches in diameter, make sleeve inside diameter at least 3 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation).

C. Pipes shall be uninsulated where passing through fire-rated walls and partitions.

2.15 PIPE SLEEVES FOR ABOVE GRADE EXTERIOR WALLS AND WATERPROOFED FLOOR SLABS

A. Fabricate sleeves from standard-weight carbon steel pipe with continuously welded dam/anchor metal ring extending radially a minimum of 2 inches from the outside diameter of the pipe sleeve. Approved Manufacturers: National Pipe Hanger Figure 840, Calpico.

B. Fabricate sleeves for above grade exterior walls to match finished wall thickness.

C. Fabricate sleeves for waterproofed floor slabs of sufficient length to extend at least 2 inches above the finished floor to permit flashing of the membrane waterproofing.

D. For pipes 8 inches in diameter and smaller, make sleeve inside diameter at least 2 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation). For pipes larger than 8 inches in diameter, make sleeve inside diameter at least 3 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation).

2.16 PIPE SLEEVES FOR BELOW GRADE FOOTINGS, EXTERIOR WALLS AND ROOF DECKS

A. Fabricate sleeves from standard-weight carbon steel pipe with continuously welded water dam/anchor metal ring extending radially a minimum of 2 inches from the outside diameter of the pipe sleeve. Approved Manufacturer: National Pipe Hanger Figure 840, Calpico.

B. Fabricate sleeves to match finished footing, wall or roof deck thickness.

C. For pipes 8 inches in diameter and smaller, make sleeve inside diameter at least 2 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation). For pipes larger than 8 inches in diameter, make sleeve inside diameter at least 3 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation).

D. Where sleeve seals are required, size the pipe sleeve to suit the seal manufacturer's standards.

2.17 PIPE SLEEVES FOR ROOF PENETRATIONS

A. Provide relief valve vent pipe penetrating the roof with special sleeves that permit a flow of air between the pipe and the sleeve.

B. Provide pipe seals as specified elsewhere in this Division for vents and piping penetrating the roof.

2.18 PIPE SLEEVES FOR GYPSUM WALLBOARD INTERIOR WALLS, PARTITIONS AND ACCESS FLOOR PANELS (ABOVE AND BELOW CEILINGS)

A. Box-in rectangular or round sleeve opening for piping, piping banks and ductwork with No. 20 gauge galvanized sheet metal.

B. Flange-out edges of sheet metal a minimum of 1-1/2 inches to secure sleeve to wall [or access floor panel].

PART 3 - EXECUTION

3.01 THERMOMETERS

A. Install in pipe with face positioned for easy reading from floor.

B. Thermometer ranges shall be:

SYSTEM	TEMPERATURE RANGE (°F)
Domestic Cold Water	0 to 120
Domestic Hot Water	20 to 180

3.02 PRESSURE GAUGES

A. Gauge ranges shall be as follows:

SYSTEM	PRESSURE RANGE (PSIG)
Domestic Cold Water	[0 to 100]
Domestic Hot Water	[0 to 100]

SYSTEM	PRESSURE RANGE (PSIG)
Treated Rain Water	[0 to 100]

B. Provide supports and protection for gages subject to vibration or physical damage.

C. Install pressure gauges where shown on drawings, where specified, and in the following locations:

1. Suction and discharge connections to pumps.
2. Downstream of pressure regulating or reducing valves.
3. Inlets to pressure vessels.
4. Outlets to pressure vessels.
5. Inlets and outlets to all heat exchangers.
6. Building domestic water service entry.

3.03 PRESSURE DIFFERENTIAL GAUGES

A. Provide support and protection for gages subject to vibration or physical damage.

3.04 LIQUID FLOW, PRESSURE AND LEVEL SWITCHES

A. Locate flow switches in straight horizontal run of pipe, maintaining at least five pipe diameters of straight pipe each side of switch. Paddle to be sized for proper length of size of pipe.

3.05 STRAINERS

A. Provide strainers at:

1. Inlet to all control valves.
2. Hydronic or gas pressure reducing or regulating valves.
3. Domestic cold water make-up water flow meters.
4. Pumps (unless provided with suction diffusers).
5. Other locations shown on drawings or specifications.

3.06 WATER HAMMER ARRESTERS

A. Provide manufactured compression units, of stainless steel, on both domestic cold and hot water lines. Install in upright position at all quick-closing valves and solenoids. Locate and size in accordance with Plumbing and Drainage Institute Standard No. WH-301. P.D.I. ratings are:

A =	2 - 11	Fixture Units
B =	12 - 32	Fixture Units
C =	33 - 60	Fixture Units
D =	61 - 113	Fixture Units
E =	114 - 154	Fixture Units
F =	155 - 330	Fixture Units

3.07 BACKFLOW PROTECTION EQUIPMENT

A. Plumbing fixtures and other equipment having domestic water connections shall have their water supplies protected against possible back-siphonage in event that normal water pressure drops.

B. Discharge outlets of faucets for lavatories and sinks shall clear top of overflow rim by at least 1" or as required by code.

C. Equip toilet and urinal flush valves with approved vacuum breakers.

D. Provide reduced pressure type backflow protection devices, approved by governing codes and policies, for hot and cold water supplies to or in immediate vicinity of [sump pumps,] [sewage ejectors,] [cooling towers,] [chemical treatment equipment] and [cold water supply to boilers,] [irrigation system] or any special water systems.

E. Pipe backflow preventer discharge funnel to nearest approved drain.

3.08 INSTALLATION - SEALS AND SLEEVES

A. For Pipe Sleeves Receiving Non-Fire-Rated Seals

1. Wedge filler materials between bars or insulated pipe, and sleeve over the full length of the pipe sleeve.

2. Recess the filler material 1/4-inch back from the end of the sleeve.

3. Trowel or gun a continuous bead of sealant for a complete seal over filler material at both ends of sleeve.

B. For Pipe Sleeves Receiving Fire-Rated or Watertight Seals

1. Remove insulation from piping at the portion of the pipe passing through the sleeve.

2. Install seals exactly in accordance with manufacturer's instructions to meet UL listing.

C. For FDA Authorized Sealant

1. When required, apply primer to surface receiving sealant in accordance with manufacturer's instructions. Properly apply sealant and allow to cure to meet FDA regulations.

E. Unless already provided, place sleeves to be embedded in concrete or masonry floors and walls in the forms before concrete is poured or masonry wall is erected. Sleeves shall have integral water stop flanges where sleeves are to receive either watertight or hydrostatic seals.

F. The Contractor shall be responsible for the correct size, location and alignment of all the sleeves for his work before and during concrete placement or masonry erection.

G. In finished areas, set floor sleeves flush with the top of the finished floor surface. In kitchens and similar service areas, set floor sleeves 2 inches above the finished floor, unless such areas are slab-on-grade.

H. Extend wall and partition sleeves through and cut flush with each surface, unless otherwise indicated or specified.

I. Locate piping in sleeve to allow for movement. Do not allow steel sleeves to touch copper piping at any time.

J. Grout opening between outside of sleeve and inside of core-drilled penetrations.

K. Install escutcheons on all exposed piping penetrations.

+ + END OF SECTION + +

SECTION 15080 - HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes insulation materials, fire-rated insulation systems, insulating cements, adhesives, mastics, sealants, factory-applied jackets, field-applied jackets and tapes.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated, include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts for each type of insulation and hanger.

2. Detail attachment and covering of heat tracing inside insulation.

3. Detail insulation application at expansion joints for each type of insulation.

4. Detail application of field-applied jackets.

5. Detail field application for each equipment type.

C. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction, indicting, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include date of test and test methods employed.

1.3 DELIVERY, STORAGE AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

B. Protect insulation against dirt, water, and mechanical damage.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test response Characteristics: Insulating and related materials shall have fire-test response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 15 Section "Hangers and Supports."

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.6 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory results.

B. Complete installation and concealment of plastic materials as rapidly as possible. in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

2.2 FIBERGLASS PIPE INSULATION

A. Acceptable Manufacturers, subject to compliance with requirements:

1. CertainTeed Corp.
2. Johns Manville, Micro-Lok.
3. Knauf Insulation GmbH, Pipe Insulation.
4. Owens-Corning,FIBERGLAS.

B. Pipe insulation, meeting ASTM Standard C 547, consisting of inorganic glass fibers bonded with thermosetting resin, molded into tubular sections split lengthwise, approximately 3.5 lb per cu ft, thermal conductivity of 0.23 Btu·in/h·sq ft· °F at 75 deg °F.

C. Jackets shall be factory-applied, composite with insulation, with maximum water vapor permeance of 0.02 perms, fabricated from white kraft paper bonded to aluminum foil, reinforced with fiberglass scrim. Acceptable Manufacturer, subject to compliance with requirements: Johns-Manville AP-T.

2.3 FIBERGLASS BOARD INSULATION

A. Acceptable Manufacturers, subject to compliance with requirements:

1. CertainTeed Corp., CertaPro
2. Johns Manville, 800 Series Spin-Glas.
3. Knauf Insulation GmbH,Insulating Board.
4. Owens Corning

B. Insulation for indoor work shall be semi-rigid board made from inorganic glass fibers bonded together with thermosetting resin, approximately 3 lb per cu ft density, with thermal conductivity of 0.23 Btu·in/h sq ft deg·F at 75 deg F. Include a factory-applied reinforced aluminum foil (FSK) vapor barrier jacket.

C. Insulation for indoor work shall be semi-rigid board made from inorganic glass fibers bonded together with thermosetting resin, approximately 4 lb per cu ft density, with thermal conductivity of 0.22 Btu·in/h sq ft deg F at 75 deg F. Include a factory-applied reinforced aluminum foil (FSK) vapor barrier jacket. Acceptable

D. Insulation for indoor work shall be semi-rigid board made from inorganic glass fibers bonded together with thermosetting resin, approximately 6 lb per cu ft density, with thermal conductivity of 0.22 Btu·in/h sq ft deg F at 75 deg F. Include a factory-applied reinforced aluminum foil (FSK) vapor barrier jacket.

2.4 FLEXIBLE DUCT WRAP INSULATION

A. Acceptable Manufacturers, subject to compliance with requirements:

1. CertainTeed Corp., SoftTouch
2. Johns Manville Corp.
3. Knauf Insulation GmbH, Friendly Feel
4. Owens Corning, SOFTR

B. Flexible blanket-type insulation shall consist of fiber glass bonded with thermosetting resin to form resilient blanket, with factory-applied foil-scrim-kraft facing of aluminum foil reinforced with fiber glass yarn and laminated to 40 pound chemically-treated fire-resistant kraft, approximately 0.75 pound per cubic foot, with thermal conductivity of 0.29 Btu·in/h·sq ft·deg F at 75 deg F.

2.5 2-HOUR FIRE RESISTANT-RATED FLEXIBLE DUCT WRAP

A. Acceptable Manufacturers subject to compliance with requirements:

1. Thermal Ceramics FireMaster FireWrap XL.

2. 3M Fire Barrier Duct Wrap 20A.

B. Insulation shall be a flexible, asbestos-free system consisting of two layers of a high-temperature, non-combustible, inorganic insulating blanket, 8.0 pcf density. Outer layer shall be encapsulated with scrim-reinforced aluminum foil; inner layer may be unfaced.

1. Insulation shall provide a 2-hour fire resistant-rating when tested and installed in accordance with the ASTM C411, C518, E84, E119, E136, E814 and E2336.

2. Surface Burning Characteristics (ASTM E84)

a. Flame Spread

1) Foil Encapsulated Blanket: <25

2) Unfaced Blanket: 0

b. Smoke Developed

1) Foil Encapsulated Blanket: <50
2) Unfaced Blanket: 0

3. Thermal Conductivity: 0.417 BTU-In./Hr.-SF-deg. F at 500 deg. F.

C. Insulation shall be IMC, ICBO, UMC, UBC, NFPA 96 and ASTM E2336 approved for zero-clearance design.

2.6 PRE-MOLDED PIPE-FITTING INSULATION AND COVERS

A. Acceptable Manufacturer, subject to compliance with requirements:

1. Pre-Molded Pipe Fitting Insulation: ICA Fittings' HAMFAB AB.

2. Pipe Fitting Covers:

a. Foster SEALFAS 30-36AF.
b. Knauf Proto.
c. Johns Manville Zeston 2000.

B. Pre-Molded Insulation: Fiberglass, molded in two matching half-sections, matching the density, thermal conductivity and thickness of the adjoining pipe insulation.

C. Covers: Polyvinyl chloride (PVC), 20 mils thick, meeting Federal Specification L-P-535E. Provide 2-layer precut insulation inserts matched to pipe insulation, vapor barrier, and required mastic adhesives and tapes.

1. Acceptable Manufacturers: Johns Manville, model Zeston 2000; Foster, model Sealfas Smoke-Safe 25/50; or Proto, model LoSmoke.

2.7 ALUMINUM JACKETS

A. Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.

1. Sheet and roll stock ready for shop or field sizing or factory cut and rolled to size.

2. Jacketing shall be 0.016 inch minimum aluminum with moisture barrier, secured in accordance with the jacket manufacturer's recommendations. Joints shall be applied so they will shed water and shall be sealed completely.

3. Moisture Barrier for Outdoor Applications: 3-mil thick, heat bonded polyethylene and kraft paper.

4. Factory-Fabricated Fitting Covers:

a. Same material, finish, and thickness as jacket.
b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
c. Tee covers.
d. Flange and union covers.
e. End caps.
f. Beveled collars.
g. Valve covers.
h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 REMOVABLE AND REUSABLE INSULATION JACKETS - GENERAL EQUIPMENT

A. Acceptable Manufacturer, subject to compliance with requirements:

1. Ohio Valley Industrial Services
2. Senteco, Inc. model Cal-Save Buckler.
3. Pacor, Inc.
4. Universal Removable Insulation Products (URIP), Inc.

B. Factory fabricate removable insulation jackets.

C. Provide fiberglass straps and nylon buckles to secure jackets to standard fittings.

D. Design jackets for standard fittings for installation and removal without tools, fasteners, or devices other than those attached to the jacket.

E. Provide stainless steel lined weep holes to identify leaks.

F. Jacket bodies shall extend a minimum of 3-inches past flanged end connections and shall provide a tight fit with adjacent pipe insulation. End flaps, where used, shall be insulated.

G. Each jacket shall have an identification label with manufacturer, date code, and maximum temperature rating and fitting identifications.

H. Jackets for flanged gate and globe valves, 2-inches and larger, shall have separately removable bonnet jackets to facilitate valve maintenance. Valve bonnet jackets shall have overlapping leaves, with insulation and stainless steel foil liners, to allow interchange of entire jacket assemblies between valves of varied configurations.

I. Jacket materials shall be flame-retardant and shall meet or exceed the requirements of UL 94, vertical burning test.

J. Rate jacket materials, including seams, thread and fasteners, which come in contact with hot surfaces for the fluid service temperatures.

K. Fabricate exterior surfaces of jackets of Teflon-coated fiberglass cloth, nominal 16 ounces per square yard, with a nominal one (1) mil coating thickness.

L. Jacket interior surfaces shall be 0.002-inch thick, Type 304 stainless steel foil reinforced with a nominal 19 ounce per square yard fiberglass cloth applied with high-temperature adhesive.

M. Jacket insulation materials and minimum thickness shall be the same as the adjacent piping as shown in the Pipe Insulation Schedule.

2.9 PIPE INSULATION PROTECTION SHIELDS

A. Provide pipe insulation protection shields as specified in Section 15060.

2.10 PVC JACKETS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Ceel Co.
2. Foster
3. Johns Manville Zeston.

B. Provide for exposed installation of insulated piping.

C. Furnish white-colored jackets.

1. For indoor applications, use 20 mil jacket thickness.

2.11 TAPES

A. Acceptable Manufacturer, subject to compliance with requirements: PermTape by Compac.

B. Vapor barrier type, self-sealing, with release paper, non-corrosive, fire-retardant, 3/4-inch and 3-inches wide by 6.9 mils thick.

2.12 BANDS

A. Furnish preformed metal butt snap straps and banding straps for metal jackets specified elsewhere in this Section.

2.13 SAFETY SPRAY HOSE SHIELDS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Drake Specialties

2. STEP-KO Products-LLC.

B. Safety shields shall be fire-resistant and constructed of reinforced 3-ply Teflon-coated fiberglass cloth.

PART 3 - EXECUTION

3.1 GENERAL

A. Apply insulation on clean, dry surfaces after leakage and other tests have been completed.

B. Piping, ductwork and equipment located within shafts, above removable or hard ceilings, in crawl spaces, and in pipe trenches shall be considered as "concealed". All other piping, ductwork and equipment shall be considered "exposed".

C. Safety Spray Hose Shields: Provide safety spray hose shields for rubber-type pump connectors, rubber-type pipe expansion joints, and flexible metal pipe hoses for all hydronic systems handling fluids at temperatures of 100 F and higher. Do not insulate the connectors, joints or hoses of these systems.

D. Install insulation neatly, accurately and without voids, in accordance with manufacturer's instructions and NIAC National Commercial and Industrial Insulation Standards.

E. Insulate fittings, strainers, valves and flanges using pre-molded covers with precut insulation inserts, or with removable insulation jackets.

F. Do not use staples in vapor barrier jackets.

G. Strainers and valves for heating hot water: Insulation is not required when the pipe diameter is 1-inch or less and the equipment is located more than eight (8) feet above the finished floor.

1. Insulate other strainers and valves with removable insulation jackets. Do not insulate strainer blowoff valves.

3.2 FIBERGLASS PIPING INSULATION

A. For Chilled Water and Glycol Systems

1. For piping located indoors, seal longitudinal and circumferential seams with factory-furnished sealing laps and tapes. For cold piping systems, use pre-molded PVC fitting and valve covers installed in accordance with manufacturer's recommendations.

2. For piping located outdoors, follow the same procedures as for indoor piping, with an additional aluminum jacket. Provide 1-1/2-inch overlap at the circumferential joints of metal jacket.

B. For Condensate Drains for Air Conditioning Equipment, Hot Water Heating Piping Systems

1. For piping located indoors apply insulation as specified and seal butt joints with fire-retardant tape.

3.3 PIPE INSULATION SCHEDULE

A. Insulate piping in accordance with the following schedule:

SERVICE	COMMENT	PIPE DIAMETER	MATERIAL	THICKNESS (INCHES)
Chilled Water	Indoors	All	Fiberglass	1
	Outdoors	All	Fiberglass	2
Heating Hot Water	200 deg. F. or lower	Less than 4"	Fiberglass	1.0
		4" and larger	Fiberglass	1.5
Chilled Beam Water	No insulation on piping runouts after Zone shutoff valves	N/A	N/a	N/a
	Mains, risers and within penthouse	All	Fiberglass	1.0

3.4 FIBERGLASS BOARD INSULATION

A. Fit insulation by scoring, cutting, and mitering to fit the contour of the ductwork.

B. Impale the insulation on pins welded to all four sides of the ductwork. Locate and weld pins on maximum 18-inch centers and no less than 3-inches from the edges of the ductwork. Secure insulation to pins with 1-inch diameter hold-down washers.

1. As an alternate to welded pins, provide "Gripnail" mechanical surface fasteners by Gripnail Corporation using pneumatic hammer especially designed for this work.

C. Seal joints, seams, breaks, and punctures in facing with adhesive and cover with 3-inch wide sealing tape. Flash supports with vapor barrier coating.

D. For rectangular ducts and plenums exposed to weather:

1. Pitch ductwork or insulation board minimum 1/4-inch per foot to prevent rainwater from accumulating on top of duct or plenum.

2. Apply a 1/16-inch coat of mastic by spray or trowel to the insulation board. Embed one layer of open mesh fiberglass or polyester reinforcing cloth into the mastic with seams overlapped at least 2-inches. Smooth out wrinkles in the cloth and apply 1/8-inch final coat of mastic covering the cloth completely. Allow proper drying time between steps in accordance with manufacturer's instructions.

3. As an alternative, cover insulation board with corrugated rolled aluminum jacketing installed in accordance with manufacturer's recommendations.

4. As an alternative, cover insulation board with Venture Tape VentureClad 1577CW-W white-colored jacketing system, A UL-Classified, 5-ply, 6.0 mils thick, self-adhesive material with mold-inhibiting agents, zero water vapor permeability, 35.4 lbf. puncture resistance (ASTM D 1000), 8.5 lbf. tear strength (ASTM D 624), 10/20 flame spread/smoke developed (UL 723), and minus 30 to 300 deg F continuous use temperature range. Comply with manufacturer's installation instructions.

E. Provide unused portions of louvers with inside blank-off panels, constructed of galvanized sheet metal and insulated interior face. Paint side attached to the louver with flat black paint.

3.5 FLEXIBLE DUCT WRAP INSULATION

A. Impale the insulation on pins welded to all four sides of the ductwork. Locate and weld pins on maximum 18-inch centers and no less than 3-inches from the edges of the ductwork. Secure insulation to pins with 1-inch diameter hold-down washers.

1. As an alternate to welded pins, provide "Gripnail" mechanical surface fasteners by Gripnail Corporation using pneumatic hammer especially designed for this work.

3.6 DUCTWORK INSULATION SCHEDULE

SERVICE	COMMENT	MATERIAL	THICKNESS (INCHES)
SUPPLY AIR: • Supply Ductwork • Single-Wall Plenums • Single-Wall Casings • Fire and Smoke Dampers • Sound Attenuators, Duct-Mounted • Coil Casings, Duct-Mounted, including those furnished with Air Volume Control Boxes • Inlets of Air Volume Control Boxes	68° F Indoors	None	--
OUTDOOR AIR: • Single-Wall Plenums • Indoor Ductwork • Exhaust Bypass Air located indoors	---	Fiberglass Board or Prefabricated Double wall Duct	2
LOUVERS: Blank-off Panels	Unused Portions of Louvers	Fiberglass Board	2
EXHAUST AIR: Exhaust Ductwork connected to and upstream of Energy Recovery Equipment	Indoor	None	--

3.7 EQUIPMENT INSULATION, GENERAL

A. Insulate equipment after it has been tested and approved as complying with specified performance.

B. Apply insulation and accessories to clean, dry surfaces.

C. Install insulation neatly, accurately and without voids, in accordance with manufacturer's instructions and NIAC National Commercial and Industrial Insulation Standards.

D. Do not insulate over equipment stampings, nameplates, code inspection plates or manholes. Neatly bevel the insulation at these locations.

E. Insulate access doors using separate removable insulation panels.

F. If specified insulation thickness does not cover standing seams and angles, insulate them by adhering a grooved 6-inch wide strip of insulation over the standing seam or angle. Insulation board thickness must be at least 1.5-inches greater than the height of the seam or angle covered.

G. Maintain a minimum clearance of 3/4-inch between the exterior of the insulation surface and obstructions.

H. For vessels required to be insulated by this specification, insulate the dished or flat ends also.

3.8 MINERAL FIBERBOARD EQUIPMENT INSULATION

A. Fit insulation by scoring, cutting and mitering to fit the contour of the equipment.

B. Attach insulation to equipment by brushing adhesive uniformly on all sides of equipment covering 100 percent of equipment surface. Press insulation into place, making complete contact with adhesive. Butt edges of insulation board tightly together without gaps.

C. Impale the insulation on pins welded to all sides of the equipment. Locate and weld pins on maximum 18-inch centers and no less than 3-inches from the edges of the equipment. Secure insulation to pins with 2-inch diameter hold-down washers.

1. As an alternative to welded pins, provide "Gripnail" mechanical surface fasteners by Gripnail Corporation using pneumatic hammer especially designed for this work.

D. Seal joints, seams, breaks, and punctures in facing with adhesive and cover with 3-inch wide sealing tape. Flash supports on cold equipment with vapor barrier coating.

E. For equipment located in mechanical rooms or exposed to weather, apply 1/16-inch coat of mastic by spray or trowel to the insulation board. Embed one layer of open mesh polyester reinforcing cloth into the mastic with seams overlapped at least 2-inches. Smooth out all wrinkles in the cloth and apply 1/8-inch final coat of mastic covering the cloth completely. Allow proper drying time between steps in accordance with manufacturer's instructions.

1. As an alternative, for outdoor locations only, cover insulation board with rolled corrugated aluminum jacket installed in strict accordance with manufacturer's recommendations.

3.9 CALCIUM SILICATE EQUIPMENT INSULATION

A. Attach insulation to equipment with No. 20 gauge non-corroding wire on 12-inch centers. Provide welded clips or angles as anchors for wire.

B. Protect corners with aluminum or galvanized steel corner beads.

C. Fill seams and voids with lightweight hydraulic insulating and finishing cement.

D. Attach a layer of 3/4-inch hexagonal wire mesh to cover and stretch tightly over all the insulation.

E. Apply a 1/2-inch layer of insulating cement in two coats over the mesh. Mix the outer coat with portland cement and trowel smooth.

F. Apply sealer to the outer coat to permit painting.

3.10 INSTALLATION OF EQUIPMENT INSULATION

A. For Pumps Serving the Chilled Water, and Hot Water Heating Systems and Steam Pressure Reducing Valves: Provide removable insulation jackets as specified in this Section.

B. For Air Separators, Expansion Tanks, Air Purgers, Sidestream Filters:

1. Follow procedure for installing board type insulation.

2. Fit insulation by scoring, cutting and mitering to fit the contour of the equipment.

3. Fill voids with insulating cement.

4. Insulate the water boxes or heads of evaporators by fabricating an enclosure from No. 18 gauge galvanized steel sheet. Attach insulation to the inside of the enclosure with adhesive. Slip enclosure over the insulation on the shell and draw tight.

C. For Steam-to-Water Heat Exchangers, Flash Tanks, Steam Condensate Pumps and Receivers:

1. Follow procedure for installing calcium silicate insulation.

2. Stretch 3/4-inch wire mesh tightly over the entire insulation.

3. Apply finishing cement to two 1/4-inch base coats followed by a 1/8-inch finish coat troweled to a smooth hard finish.

D. For Diesel Engine Exhaust Muffler and Black Steel Exhaust Piping

1. Place first layer of insulation and fasten with stainless steel wire on 12-inch centers.

2. Apply subsequent layers of insulation, with joints staggered. Secure each layer with 1/2-inch stainless steel straps on 12-inch centers and a final wrap of 1-inch hex wire.

3. Cover insulation with 1/2-inch coat of white insulating finishing cement (Smooth Kote).

E. As an alternate to specified insulation for flanges, tanks, heat exchangers, expansion joints, or equipment listed in the following Paragraph, provide removable insulation jackets as specified elsewhere in this Section.

3.11 MECHANICAL EQUIPMENT INSULATION SCHEDULE

A. Insulate equipment in accordance with the following schedule.

SERVICE	MATERIAL	THICKNESS (INCHES)
Chilled Water, Heating Hot Water Pumps	Fiberglass Board	2
Expansion Tanks, Air Separators, Air Purgers and Sidestream Filters Serving the Chilled Water and Heating Hot Water Systems	Fiberglass Board	2
Chiller Evaporators (if not by chiller manufacturer)	Elastomeric Board	2

+ + END OF SECTION + +

15101 - VALVES – PLUMBING

PART 1 - GENERAL

1.01 SUMMARY

A. This section describes valves used in plumbing and fire protection piping systems.

1.02 SUBMITTALS

A. Submit for review:

1. Product data, including materials of construction of component parts and their arrangement, pressure and temperature ratings, end connection details, dimensions and required clearances, weights, and installation instructions.

2. Provide statement that ball and butterfly valves will be provided with extended stems to match insulation thickness.

B. Submit the following to the Owner for record for all safety relief valves in accordance with Conditions of Contract and Division 1:

1. ASME Test Documentation: All safety relief valves shall be provided with complete ASME test documentation for each specific valve. This documentation shall include manufacturer, model number, serial number, set pressure, test pressure, valve size, orifice size, service, capacity and relief valve number.

1.03 DELIVERY, STORAGE AND HANDLING

A. Prepare valves for delivery as follows:

1. Ensure valves are dry and internally protected against rust and corrosion.

2. Protect valve ends against damage to threads, flange faces and weld-end preparations.

3. Pack valves in best position for handling. Set globe and gate valves closed to prevent rattling; set ball and plug valves open to minimize exposure of bearing/sealing surfaces; set butterfly valves closed or slightly open; and block swing check valves with soft material in either closed or open position.

B. Use following precautions during storage:

1. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.

2. Protect valves from weather or other harmful environmental conditions. Store valves indoors where possible and maintain valve temperature higher than ambient dew point temperature. If outdoor storage is necessary, support valves off ground or pavement in watertight enclosures.

C. Use following procedures during handling:

1. Use sling to handle valves which have sizes that require handling by crane or lift.

2. Rig valves to avoid damage to exposed valve parts.

3. Do not use handwheels, stems or bypass connections as lifting or rigging points.

PART 2 - PRODUCTS

2.01 DOMESTIC COLD AND HOT WATER

A. Manufacturers: Stockham, Watts, Apollo.

B. Provide extended stem on ball and butterfly valves to suit insulation.

C. Shut-off Valves:

1. Valves - 2 inches and Smaller: Ball valves Class 600, two piece design, bronze body, chrome plated ball, reinforced teflon seats, blowout proof stem, threaded ends, Stockham Fig. S-216-R-T.

2. Three-piece full-port design, serviceable in line, blowout-proof stem, ASTM A 584 bronze body, chrome-plated brass ball, reinforced PTFE stem packing and seats, plated carbon steel handle with vinyl insulating cover, threaded ends, Watts B-6800.

3. Valves - 2-1/2 inches and Larger: Butterfly type, cast iron, lug type body with extended neck, rated at 200 psi CWP. Replaceable EPT sleeve, bronze disc, Type 416 stainless steel stem, EPT O-Ring stem seal. Lever operated for sizes up to 4" - Stockham LG-712; gear operated for sizes 5" and over - Stockham LF-722.

4. Valves - 2-1/2 inches and Larger: Gate valves, Class 125, iron body, bronze mounted, non-rising stem, solid wedge bronze disc, flanged ends, Stockham Fig. G-612.

D. Check Valves:

1. Valves - 2 inches and Smaller: Class 125, bronze body, swing type bronze disc, threaded ends, Stockham Fig. B-320-B.

2. Valves - 2-1/2 inches and Larger: Class 125, cast iron body, bolted cap, flanged ends, swing type bronze disc, replaceable seat ring, Stockham Fig. G-931.

E. Balancing Valves:

1. Globe Valves: Class 125 all bronze construction with threaded ends. Stockham Fig. B-13-T.

2. Bronze body, balancing type valve with bronze plug, equipped with readout ports. 125 psi working pressure. Valves 1/2" dia. and 3/4" dia. shall be Type TBV-S; larger type shall be Type STA-D, as manufactured by Tour and Andersson Inc., or equal as manufactured by Armstrong.

2.04 PUMP DISCHARGE CHECK VALVES

A. At Sewage Pumps:

1. Cast iron body with rubber flapper, swing type check valve with long pattern design, flanged ends. APCO Series 104-P3.

B. At Sump Pumps:

1. Under 2 Inch: Class 125, semi-steel body, bronze trim, water style, silent type. APCO Series 300.

2. 2 Inch and Over: Iron body with natural rubber lining and Buna-N flapper APCO Series 100.

PART 3 - EXECUTION

3.01 INSTALLATION - SAFETY RELIEF VALVES

A. Install safety relief valves with inlet down, stem vertical and discharge down.

3.02 INSTALLATION - PRESSURE-REDUCING VALVES

A. Install pressure-reducing valve stations complete with strainer, gauges, and shutoff valves.

B. Provide a shutoff valve on both sides of the pressure-reducing valve station.

C. Provide bypass around pressure-reducing station.

3.03 GENERAL REQUIREMENTS

A. Do not install valves with stem down.

B. Discharge lines from relief valves shall be piped to within 4" of floor and extend to floor drains wherever floors are not pitched to drains.

C. Lubricants for lubricated plug cocks shall be as recommended by manufacturer for service for which valve is used.

D. Install chain operators where the center of valve handwheels is more than 10 feet above the floor. Provide chain hooks where required to prevent fouling of chains on equipment and to clear walkways. Terminate chains approximately 3 feet-6 inches above the floor. Provide worm gear operators or impact handwheels for all valves 6 inches and larger. Impact handwheels and chain operators shall be Babbitt Steam Specialty or approved equal. Chain operators are not required on valves 2 inches and smaller, and on valves with threaded ends.

+ + END OF SECTION + +

15112 - GENERAL DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This section describes valves used in HVAC hydronic piping systems.

1. Calibrated Balancing Valves.
2. Differential Pressure Controllers.
3. Ball Valves.
4. Butterfly Valves.
5. Check Valves.
6. Safety, Safety Relief and Relief Valves.
7. Self-Contained Temperature Regulators.
8. Automatic Fill Valves.

1.2 SUBMITTALS

A. Submit for review:

1. Product data, including, but not limited to materials of construction of component parts and their arrangement, pressure and temperature ratings, end connection details, dimensions and clearance requirements, weight, and installation instructions.

   a. Clearly demonstrate in the submittal that the design operating pressure and coincident operating temperature are within the manufacturer's pressure and temperature rating for the valve being submitted. Failure to do so will be a cause for rejection of the submittal.

2. Ball and Butterfly Valves for Insulated Piping: Provide detailed information on extended stems where valves are installed in insulated piping.

B. Submit data for each safety, safety relief, and relief valve for review:

1. Provide safety relief valves with complete ASME test documentation for each specific valve, including manufacturer, model number, serial number, set pressure, test pressure, valve size, orifice size, service, capacity and relief valve number.

1.3 DELIVERY, STORAGE AND HANDLING

A. Prepare valves for delivery as follows:

1. Ensure valves are dry and internally protected against rust and corrosion.
2. Protect valve ends against damage to threads, flange faces and weld-end preparations.
3. Pack valves in best position for handling. Set globe and gate valves closed to prevent rattling; set ball and plug valves open to minimize exposure of bearing/sealing surfaces; set butterfly valves closed or slightly open; and block swing check valves with soft material

in either closed or open position.

B. Use following precautions during storage:

1. Do not remove valve end protectors unless necessary for inspection; then reinstall for storage.

2. Protect valves from weather or other harmful environmental conditions. Store valves indoors where possible and maintain valve temperature higher than ambient dew point temperature. If outdoor storage is necessary, support valves off ground or pavement in watertight enclosures.

C. Use following procedures during handling:

1. Use sling to handle valves, which have sizes that require handling by crane or lift.

2. Rig valves to avoid damage to exposed valve parts.

3. Do not use handwheels, stems or bypass connections as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to HVAC valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.

2. Handwheel: For valves other than quarter-turn types.

3. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller.

4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With NPS 2-inch (DN 50) stem extensions and the following features:

1. Gate Valves: With rising stem.

2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

3. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.

2. Solder Joint: With sockets according to ASME B16.18.

3. Threaded: With threads according to ASME B1.20.1.

2.2 CALIBRATED BALANCING VALVES FOR HYDRONIC SERVICE

A. Type 3, Y-Pattern, Globe Type Manual Calibrated Balancing Valve (1/2 to 16 Inches Pipe Size)

1. Acceptable Manufacturers, subject to compliance with requirements:

a. Armstrong Pumps, Inc. "CBV".
b. Danfoss STV Series.
c. Tour & Andersson (grooved available through Victaulic Company of America) "STAD", "TBV" & "STAF".

2. Body: Brass, bronze (dezincification resistant alloy), cast-iron or steel body, plug or globe pattern with calibrated orifice.

3. Stem Seals: EPDM O-rings.

4. Disc: Bronze (dezincification resistant alloy).

5. Seat: PTFE.

6. End Connections: Threaded, socket, or flanged.

7. Pressure Gage Connections: Integral seals for portable differential pressure meter.

8. Handle Style: Handwheel, with memory stop to retain set position. Dead tight shut-off.

9. CWP Rating: Minimum 125 psig (860 kPa).

10. Maximum Operating Temperature: 230 deg F (110 deg C).

2.3 BALL VALVES FOR SHUT-OFF AND THROTTLING (NOT BALANCING) SERVICE (2 INCHES AND SMALLER)

A. Furnish ball valves with extended stems to suit insulation thickness when installed in insulated piping systems.

B. Two-Piece Ball Valve

1. Acceptable Manufacturers, subject to compliance with requirements:

a. Apollo
b. Crane
c. Flow-Tek
d. KF Industries
e. KTM (Tyco)
f. Milwaukee
g. Nibco
h. W-K-M

2. 600 psi WOG, two-piece bronze body, brass stem, full port ASTM B62 hard chrome-plated brass ball, replaceable reinforced TFE seats, threaded ends.

3. 250 PSI Steam Service Ball Valves: Designed for ON-OFF steam service at 250 PSIG/406 deg. F saturated steam condition. Two-piece ASTM A216 carbon steel body, 316 S.S. stem, quarter-turn plated carbon steel handle, full port 316 S.S. ball, multi-fill PTFE seat, reinforced PTFE stem packing, reinforced PTFE thrust washer, reinforced

PTFE body seal, and threaded ends.

C. Hose End Ball Valve

1. Acceptable Manufacturers, subject to compliance with requirements:

a. Apollo
b. Crane
c. Flow-Tek
d. KTM (Tyco)
e. Milwaukee
f. Nibco
g. W-K-M

2. Full port **[Hard chrome-plated brass] [ASTM A276 Type 316 stainless steel]** ball, reinforced TFE seats, TFE stuffing box, two-piece bronze body, **[bronze] [316 S.S.]** stem, dust cover with chain, 3/4-inch hose-end connection, threaded or soldered ends, 600 psi WOG.

2.4 BUTTERFLY VALVES FOR SHUT-OFF AND THROTTLING (NOT BALANCING)SERVICE (2-1/2 INCHES AND LARGER)

A. Type 2 Butterfly Valve, High Performance

1. Acceptable Manufacturers, subject to compliance with requirements:

a. ABZ Valves & Controls
b. Bray/McCannalok
c. DeZurik
d. Flowseal (a Crane Co.)
e. Jamesbury
f. Keystone (Tyco)
g. Milwaukee

2. High performance type, ANSI Class 150, carbon steel full-lug body, double-offset 316 stainless steel disc, 17-4 PH stainless steel blow-out proof stem and bi-directional seat design.

a. Resilient-Seated

1) PTFE (polytetrafluoroethylene)stem seals, RTFE (reinforced tetrafuoroethylene) seat, polyester backing O-ring and 316 stainless steel stem bearings.
2) Seat Leakage: Comply with ANSI B16.104 Class VI permissible leakage.
3) Valve Body Hydraulic Test: Comply with ASME/ ANSI B16.5 Pipe Flanges and Flanged Fittings.
4) Temperature Rating: -20 deg. F to 450 deg. F. @ 150 PSIG for RTFE seat.

b. Metal-Seated

1) Graphite stem packing, 316 stainless steel/ flash chrome seat and 316 stainless steel stem bearings.
2) Seat Leakage: Comply with ANSI B16.104 Class IV permissible leakage.
3) Valve Body Hydraulic Test: Comply with ASME/ ANSI B16.5 Pipe Flanges and Flanged Fittings.
4) Temperature Rating: -20 to 550 F @ 150 PSIG.

3. Insulated Piping: Provide extended valve stems to suit insulation thickness when installed in insulated piping systems.

4. Provide multi-position lever handles for valves 6" and smaller; gear operators for valves 8" and larger.

   a. Provide infinite-position lever handle with memory stop for valves 4” and smaller where used for throttling (not balancing) service.

2.5 CHECK VALVES

A. Swing Type

1. Acceptable Manufacturers, subject to compliance with requirements:

   a. APCO
   b. Crane
   c. Stockham
   d. Powell
   e. Milwaukee
   f. Walworth.

2. Type 1 Check Valve (2 Inches and Smaller): ANSI Class 125, 200 WOG Non-Shock, ASTM B 62 bronze body and cap, swing-type bronze or brass disc, renewable plugs and discs, threaded ends.

3. Type 2 Check Valve (2 Inches and Smaller): ANSI Class 300, 600 WOG Non-Shock, ASTM B 61 bronze body and cap, swing-type disc, threaded ends, Y-pattern, renewable discs and side plugs.

4. Type 3 Check Valve (2-1/2 Inches and Larger): ANSI Class 125, 200 WOG Non-Shock, ASTM A 126 Class B cast iron body and bolted cap, renewable seat and discs, flanged ends.

5. Type 5 Check Valve (2 Inches and Smaller): ANSI Class 150, 300 WOG, ASTM B 62 bronze body, bronze disc and seat threaded or soldered ends.

6. Type 6 Check Valve (2-1/2 Inches and Larger): ANSI Class 250, ASTM A 126, Class B cast iron body, trimmed bronze renewable seat, discs and side plugs, flanged ends.

7. Type 7 Check Valve (2-1/2 Inches and Larger): 125 pound, cast iron body, bronze disc and seat, flanged ends.

B. Silent or Non-Slam Type

1. Acceptable Manufacturers, subject to compliance with requirements:

   a. Mueller Steam Specialty
   b. APCO
   c. DPT, Inc.
   d. Metraflex
   e. Milwaukee

2. Type 4 Check Valve (2-1/2 Inches and Larger): 200 PSI-WOG to 12”/ 150 PSI-WOG 14” thru 24” ANSI Class 125 flanged cast iron globe type body, stainless steel trim (disc and seat), stainless steel spring.

3. Type 8 Check Valve (2 Inches and Smaller): 200 PSI-WOG ANSI Class 125 cast iron

body, threaded or socket weld ends, stainless steel disc, 420 S.S. stem, 302 S.S. spring, EPDM replaceable seal.

4. Type 9 Check Valve (2 Inches and Smaller): 400 PSI-WOG ANSI Class 250 bronze body, threaded ends, brass disc, 420 S.S. stem, 302 S.S. spring, EPDM replaceable seal.

5. Type 10 Check Valve (2-1/2 Inches and Larger): 200 PSI-WOG ANSI Class 150, flanged bronze globe type body, bronze disc, 302 S.S. spring.

2.6 SAFETY, SAFETY RELIEF & RELIEF VALVES

A. Relief Valves (Hydronic Service, 2 Inch Inlet and Smaller)

1. Acceptable Manufacturers, subject to compliance with requirements:

a. ITT Bell & Gossett
b. Contramatics
c. Spence
d. Spirax Sarco

2. 125 psig, bronze body, threaded connections, ASME rated.

2.7 AUTOMATIC FILL VALVES

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Amtrol.
2. ITT Bell and Gossett.
3. Spence Engineering.
4. Taco.
5. Watts.

B. Cast-iron, brass, or bronze body, with spring-loaded diaphragm, corrosion-resistant seats, and strainer, which may be either integral with valve body or separate. Valve size, capacity, and reduced pressure setting shall be as shown on drawings. Valve shall be factory-set, but field-adjustable.

2.8 CHAINWHEELS

A. Acceptable Manufacturer: Babbitt Steam Specialty.

B. Description: Impact handwheel and chain valve operator.

1. Provide chain hooks as required to prevent fouling of chains on equipment, and to clear walkways.

2. Provide worm gear operators or impact handwheels for all valves 4 inches and larger.

PART 3 - PRODUCTS

3.1 CALIBRATED BALANCING VALVES

A. Provide for balancing of all hydronic systems, including brine systems.

3.2 SELF-CONTAINED DIFFERENTIAL PRESSURE CONTROLLERS

A. Install on the return piping in accordance with manufacturer's installation instructions. Connect the

pressure sensing capillary tubing from the pressure controller to the paired-off calibrated balancing valve on the supply piping.

B. Training: The dp controller manufacturer's representative shall train the Balancing and Mechanical Contractors on the installation and set-up of the dp controllers.

C. On-Site Assistance: The dp controller manufacturer's representative shall be available on site, as required, to assist the Mechanical and/or Balancing Contractors during installation and balancing of the project.

3.3 BALL VALVES SCHEDULE

SERVICE	TYPE	STYLE
Hydronic Systems, including Inhibited Aqueous Glycol Solutions – Cabinet Unit Heaters, Unit Heaters, Door Air Curtain Heaters, Fan Coil Units, Convectors, Radiant Ceiling Panels, Panel Radiators, Re-heat Coils, Small Heating & Cooling Coils, Chilled Beams, Induction Units, Expansion Tanks and Fin Tube Radiation.	Standard Type specified	Two-Piece
Hydronic Systems, including Inhibited Aqueous Glycol Solutions – Strainer blow-offs and equipment drains.	Hose End	Two-Piece

3.4 BUTTERFLY VALVES SCHEDULE

SERVICE	TYPE
Hydronic Systems	High Performance

3.5 CHECK VALVE SCHEDULE

A. Use check valves in accordance with the following schedule:

SERVICE	SIZE	LOCATION	CHECK VALVE TYPE
Chilled Water, Heating Hot Water, Glycol	2-inches and smaller	Pump discharge	9
		Elsewhere	5
	2-1/2-inches and larger	Pump discharge	10
		Elsewhere	7

B. Install swing check valves in horizontal piping, such that gravity helps close the disc, not in vertical piping.

3.6 GENERAL REQUIREMENTS

A. Discharge lines from relief valves shall be piped to within 4" of floor and extend to floor drains wherever floors are not pitched to drains.

B. Install shut-off valves at the inlet and outlet of each individual heat transfer coil and piece of equipment. Units having multiple coils shall have individual valves on inlet and outlet of each coil.

C. Install calibrated balancing valves on the return side of each individual heat transfer coil.

D. Valves shall be of the same size as the pipe in which they are installed, unless shown otherwise on the contract drawings.

1. At pumps, valves shall be pipe line size, not pump suction inlet or discharge outlet connection size.

2. Provide reducers, as specified, for installation of control valves.

E. Install valves with the stem on or above the horizontal.

1. Install valves with the stem horizontal if requirements of headroom, access and chain operation must be met.

2. Install globe valves with the pressure under the seat.

F. Pack valves and adjust glands.

G. Provide chain operators for valves in Mechanical Rooms, where the center of the valve handwheel is 10 feet or more above the floor.

1. Chain operators are not required on valves 2 inches and smaller, and on valves with threaded ends.

2. Provide chain hooks where required to prevent fouling of chains on equipment and to clear walkways. Terminate chains approximately 42 inches above the floor.

+ + END OF SECTION + +

15120 - BASIC PIPING PRODUCTS AND METHODS - HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section describes piping accessories for HVAC Systems.

1.2 REFERENCE CODES AND STANDARDS

A. Comply with the following in accordance with Division 1 for expansion tanks.

1. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME):

a. Boiler and Pressure Vessel Code, Section VIII - Pressure Vessels.

B. Comply with the following in accordance with Division 1 for expansion joints.

1. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME):

a. Boiler and Pressure Vessel Code

1.3 SUBMITTALS

A. Submit for review:

1. Product data for all items.

2. Certified accuracy for thermometers, pressure gages, and pressure differential gages, flowmeters.

B. Submit for review for all expansion tanks:

1. Product Data: Show tank dimensions, capacities, fitting sizes and locations, and accessories.

2. ASME Stamp and National Board Certification.

3. Field Test Report: See Part 3.

C. Submit for review for all flow meters:

1. A certified flow versus differential pressure graph and certified data substantiating tube proportions and performance. The data shall include:

a. Coefficient values and tolerance.
b. Effects of upstream configuration.
c. Head loss as a function of the velocity head expended.
d. Discharge coefficient that is independent of beta diameter ratio and line size.

1.4 QUALITY ASSURANCE - EXPANSION JOINTS

A. Design and construct expansion compensators/joints in accordance with ANSI B31.1; Section VIII, Appendix bb of ANSI/ASME Boiler and Pressure Vessel Code; EJMA Standards and referenced Military Specifications.

B. Packless expansion compensators/joints shall have corrugated elements (bellows) of uniform curvilinear shape formed from seamless tubing with only one longitudinal seam per tube.

C. Expansion compensators/joints shall be suitable for not less than 5000 cycles at maximum operating pressures and temperatures.

D. Where required, bellows reinforcement may be in the form of additional fully sealed plies or suitably designed reinforcing rings or equalizing rings. When rings are used, they shall be supported and guided as required to avoid excessive bellow deformation.

PART 2 - PRODUCTS

2.1 THERMOMETERS

A. Acceptable Manufacturers, subject to compliance with requirements: Trerice, Weksler, Marshalltown, Weiss.

B. Description: Straight case, mercury-free blue-colored organic fluid, 9-inch plastic or cast aluminum case, black finish, brass stem, adjustable angle type. Thermometers shall have an accuracy of 1 percent of full scale. Approved Model: Weksler Model AA5H.

C. Provide thermometers with insertion lengths as follows:

PIPE SIZE (INCHES)	INSERTION LENGTH (INCHES)
2-1/2 and smaller	2 to 2-1/2
3 to 6	2 to 4
14 and larger	8

D. Provide thermometers with matching brass (for water service) or stainless steel (for steam service) separable socket thermometer wells in accordance with manufacturer's recommendations.

E. Where thermometers are installed in piping with insulation 2 inches thick or greater, provide thermometer wells with extension necks. Omit extension necks where thermometers are used on bare pipe or pipe with insulation less than 2 inches thick.

F. Where thermometer wells are installed in piping 2-1/2 inches and smaller, install thermometers at elbows such that the stems protrude into the flowing medium.

2.2 PRESSURE GAGES

A. Acceptable Manufacturers, subject to compliance with requirements: Trerice Model 500XB, Weiss, Marshalltown or Weksler.

B. Provide dial type gages with black phenolic turret case, glass face, and brass or stainless steel snap ring with white face and black numerals, 270-degree arc. The dial diameter shall be 4-1/2 inches.

C. Gages shall have a phosphor-bronze bourdon tube with silver brazed to forged brass socket and tip, Delrin rack, stainless steel pinion, and Delrin bearings and bushings for rotating assembly.

D. Gages shall have a guaranteed accuracy of 1.0 percent of full scale.

E. Provide with 1/4 inch NPT bottom or back connection, brass body and core snubber (except for steam service), and 1/4-inch carbon steel siphon for steam service.

F. For all HYDRONIC SERVICES provide each gage with a needle valve with brass body seat, stem and handle, and Teflon packing. Valve shall be suitable for 2000 psig and 300 degrees F duty.

Acceptable Manufacturers, subject to compliance with requirements: Trerice Model 735.2.

2.3 COMBINATION PRESSURE/TEMPERATURE TEST STATIONS

A. Acceptable Manufacturers, subject to compliance with requirements: Pete's Plug II by Peterson Equipment Company, Sisco P/T Plugs, Trerice, and Flow Design.

B. Stations shall be 1/4 inch NPT fitting designed to receive a 1/8-inch O.D. temperature or pressure probe.

C. Stations shall be solid brass with Nordel seals, grooved test plug cap, and chain.

D. When installed in insulated lines, test connection shall be Pete's XL plug, extended stem type.

E. Compatible with the test stations, furnish one (1) pressure and temperature test kit to the Owner consisting of a 0 to 100 psi gage with gage adapter, a 25 to 125 degrees F and a 0 to 200 degrees F pocket testing thermometer, and protective carrying case. Test kit shall be Series 1500 as manufactured by Peterson Equipment Company. Test kit shall become the property of the Owner upon completion of testing.

2.4 PRESSURE DIFFERENTIAL GAGES

A. Acceptable Manufacturers, subject to compliance with requirements: Mid-West Instrument Model 106, Preso, and Flow Design.

B. Pressure differential gages shall have aluminum body and copper alloy internal components and Buna-N seals, with a 6-inch diameter unidirectional dial and an accuracy of 1 percent of full scale.

C. Range shall be 0 to 5 psi.

D. Provide with 1/4-inch NPT bottom or back connection, brass body and core snubber for each leg.

E. Provide each leg of each gage with a gage cock with brass body and plug and a T-shaped handle. Gage cock shall be suitable for 200-psig duty. Acceptable Manufacturers, subject to compliance with requirements: Trerice Series 865.

2.5 MULTIPORT PRESSURE GAGE MANIFOLD VALVES

A. Acceptable Manufacturers, subject to compliance with requirements: Flow Conditioning Corp., Model TV-2, 3 or 4.

B. Manifold valve shall have brass body with two, three or four ports as required for system pressure signal connections, one test port for a calibration gage and one port for pressure gage. System pressures shall be read by depressing appropriate spring-return pushbutton.

2.6 STRAINERS

A. Acceptable Manufacturers, subject to compliance with requirements: Mueller Steam Specialties, Spirax Sarco, Metraflex, and Spence.

B. Y-Type Strainers

1. For 2 inch and smaller, other than steam and condensate service, either of the following strainers is acceptable:

a. ASTM A 62 bronze body with soldered ends, threaded brass cap with threaded blowoff connection, stainless steel screen, non-shock ratings of 150 psig saturated steam and 200 psig WOG, Spirax Sarco Model TBT.

b. ASTM A 126 Grade B cast iron body with threaded ends, threaded blowoff connection, stainless steel screen, non-shock ratings of 250 psig saturated steam and 400 psig WOG, Spirax Sarco Model IT.

2. For 2-1/2 inch and larger, for systems rated at 150 psig:

a. ASTM A 126 Grade B cast iron flanged body and bolted, gasketed screen cover with threaded blow off connection, stainless steel screen ANSI Class 125, Spirax Sarco Model CI-125 or F-125.

C. Simplex Basket Strainers

1. For 2-inch and smaller:

a. ASTM A 126 Grade B cast iron body and screen cover, threaded ends, stainless steel screen, O-rings for sealing both cover and basket, threaded blowoff connection, quick-release cover knobs, rated for non-shock WOG of 200 psig, Mueller Model 125.

2. For 2-1/2 inch and larger:

a. ASTM A 126 Grade B cast iron body and screen cover, flanged ends, stainless steel screen, quick-opening clamped cover, ANSI Class 125, Mueller Model 155M.

D. Screen mesh openings shall be as follows:

STRAINER SIZE	STEAM AND CONDENSATE	OTHER SERVICES
1/2" to 2"	20-mesh 0.033" opening	20-mesh 0.033" opening
2-1/2" to 4"	0.045" perforation	0.062" perforation
5" and up	0.045" perforation	0.125" perforation

E. Provide a screen blowdown valve for each strainer. The valve shall be the full size of the blow-off tapping. Provide ball valve with 1/2-inch hose end. Where blow-off tapping is greater than 1-1/2 inches, provide 1-1/2 inch ball valve with reducer for 1/2-inch hose end.

F. Provide strainers designed to operate at a minimum of 15 percent above the operating temperature and pressure of the pipeline in which they are installed.

G. Select the length of the nipple connecting the blow-off valve to the strainer basket flange so that the blow-off valve is clear of the insulation.

2.7 VACUUM BREAKERS - LIQUID SERVICE

A. Acceptable Manufacturers, subject to compliance with requirements: Bell and Gossett Model 26, ITT Hoffman, Cash, Watts, Spirax-Sarco.

B. Vacuum breaker shall automatically relieve vacuum from pipe or vessel installed.

C. Construct vacuum breaker of brass, bronze, or stainless steel with 3/4-inch threaded connections.

D. Vacuum breaker shall be adjustable from 1/4 inch to 20 inches Hg vacuum relief setpoint.

E. Maximum working pressure shall be 150 psig and maximum operating temperature shall be 240 degrees F.

2.8 MANUAL AIR VENTS

A. Manual air vents shall be 1/2-inch ball valves with 1/2-inch hose ends.

2.9 AUTOMATIC AIR VENTS

A. Acceptable Manufacturers, subject to compliance with requirements: Spirax Sarco, Amtrol, Bell and Gossett, Taco, Armstrong, Metraflex, Watts, Watson-McDaniel.

B. For venting of hydronic piping systems: Cast iron body, ASTM A 126, Class B, with all brass or stainless steel float, float mechanism, and valve seat, and neoprene valve head. Automatic air eliminators shall be float-operated (normally open) suitable for 150 psig, 1100 kPa maximum water pressure service and 225 degrees F, 105 degrees C temperature. Approved Model: Spirax/Sarco Model 13WS.

C. For venting of steam piping systems: ASTM A 126 Grade B cast iron body and cover, stainless steel element and valve trim, rated for 250 psig saturated steam, Spirax Sarco Model VS 204.

2.10 AIR SEPARATORS

A. Acceptable Model: Taco, Armstrong, Rolairtrol Type RL by ITT Bell and Gossett, (2 inches and larger), ITT Bell and Gossett Model IAS (smaller than 2 inches), Amtrol, John Wood.

B. Provide air separator with NPT or flanged tangential nozzles.

C. Provide air separator with NPT vent and drain tappings. Omit internal strainer.

D. The air separator shall be designed, constructed, and stamped for 125 psig at 350 degrees in accordance with Section VIII, Division 1 of the ANSI/ASME Boiler and Pressure Vessel Code.

2.11 AIR PURGERS

A. Acceptable Manufacturers, subject to compliance with requirements: Armstrong, Taco, ITT Bell and Gossett, Amtrol.

B. Sizes 4 inches and smaller shall be one piece, 125 psi pressure rating, and cast iron.

C. Provide air purger with a vent tapping at the top and a drain tapping at the bottom; install a manual air vent on the vent tapping and a hose-end ball valve on the drain tapping.

D. Air purger size shall match the size of the pipe in which it is installed.

2.12 AUTOMATIC FILL VALVES

A. Acceptable Manufacturers, subject to compliance with requirements: ITT Bell and Gossett, Amtrol, Spence Engineering, Taco, Watts.

B. Cast-iron, brass, or bronze body, with spring-loaded diaphragm, corrosion-resistant seats, and strainer, which may be either integral with valve body or separate. Valve shall be factory-set and be field-adjusted. Valve shall be Watts Regulator Series U5B.

2.13 EXPANSION TANKS

A. Acceptable Manufacturers, subject to compliance with requirements: ITT Bell and Gossett, Taco, Amtrol, Armstrong, John Wood, Wessels.

B. Carbon steel expansion tank with drain connection, system connection, gage glass tappings with gage glass, and tapping for Airtrol tank fitting. Construct, test and label tank with taps, supports, and lifting rings, in accordance with ASME Pressure Vessel Code, Section VIII, Division 1 for 125 psig working pressure and 240°F working temperature.

C. Diaphragm-type expansion tank with shell of welded carbon steel, flexible field-replaceable elastomeric diaphragm separating system fluid from compressed air charge. Provide taps for air charging valve and system connection. Provide vertical tanks with steel legs or base for floor mounting, and horizontal tanks with steel saddles for suspension. Construct label and stamp tank with taps, supports, and lifting rings in accordance with ASME Pressure Vessel Code, Section VIII, Division 1 for 125 psig working pressure, and 240°F working temperature.

D. Provide each tank with a drain plug, an automatic air vent (as specified in this Section), and an ASME-rated relief valve set at 5 psig above the maximum operating pressure or 10 percent above the maximum operating pressure (whichever is greater).

2.14 SUCTION DIFFUSERS

A. Acceptable Manufacturers, subject to compliance with requirements: ITT Bell and Gossett, Taco, Metraflex, Armstrong, Mueller Steam Specialties Model 1011, Aurora.

B. Suction diffusers shall consist of carbon steel or cast iron body with inlet vanes and combination diffuser - strainer - orifice cylinder with 3/16" diameter openings. Permanent magnet shall be located within flow steam and shall be removable for cleaning. Orifice cylinder shall be equipped with disposable fine mesh strainer, which shall be removed after system start-up. Unit shall be provided with adjustable support foot to carry weight of suction piping.

C. Diffuser shall be rated for 175 psig working pressure and 225 degrees F operating temperature. Provide diffuser with NPT gage taps on the inlet, and a 3/4 inch plugged NPT drain connection.

2.15 FLOW METERS (HVAC)

A. Heating Hot Water, Chilled Water, and Chilled Beam Water Commercial Grade Hydronic Meter:

1. Acceptable Manufacturer: Onicon F-1200.

2. Description: Meters shall be dual turbine insertion type.

3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served. Refer to Schedule on Drawings for range and meter size.

4. Sensor:

a. Accuracy: 2%
b. Provide standard temperature range

5. Display: Shows rate of flow, with register to indicate total volume over given time period.

6. Operating Instructions: Included complete instructions with each flowmeter.

7. Provide with integral temperature sensors and thermowells. Provide stainless steel thermowells for pipes 6" and larger.

8. provide BAS Interface panel as shown on BAS drawings. System to be BACnet/IP compatible.

2.16 EXPANSION JOINTS

A. Acceptable Manufacturers, subject to compliance with requirements: The following manufacturers are approved for use:

1. Expansion Compensators/Joints: Flexonics, Hyspan, Metraflex, Keflex, Adsco, Microflex, American BOA, Inc.

B. Steel Pipe Expansion Compensators/Joints

1. For Pipe Sizes 2-1/2 Inches and Smaller: Provide expansion compensators with steel shroud, anti-torque device, seamless stainless steel bellows and positioning restraint, suitable for a maximum operating pressure to 300 psi with a maximum operating temperature to 600 degrees F and with threaded or weld end connections to suit piping system. Expansion compensators shall have a maximum stroke of 1.75 inches in axial compression and 0.25 inch in extension. Approved Models: Model "H" by Flexonics or Model "HPC-MPT" by Microflex or Model "HPT" by Metraflex.

2. For Pipe Sizes 3 Inches and Larger: Provide packless bellows expansion joints with heavy external casing (with drain coupling), Type 18-8 stainless steel bellows (not less than 2 corrugations) and not less than 4 inches axial travel, internally & externally guided bellows and internal carbon steel or stainless steel liner (if required), suitable for a maximum operating pressure to 150 or 300 psi to suit piping system and with fixed or floating flanged or weld end connections to suit piping system. Provide intermediate anchor base for double design. Expansion joints shall be suitable for calculated thermal expansion and suitable for a minimum of 1000 full pressure/temperature cycles per current EJMA (Expansion Joint Manufacturer's Association) Standards. (Provide tie-rods where required). Approved Models: Flexonics Model "SX" or Model "MX" by Microflex or Model "MG" by Metraflex.

C. Copper Tubing Expansion Compensators

1. For Pipe Sizes 2-1/2 Inches and Smaller: Provide expansion compensators with shroud, positioning restraint, anti-torque device, seamless stain-less steel bellows and solder-type sweat ends in all-bronze construction or brass threaded ends (brass pipe) suitable for a maximum operating pressure to 200 psi with a maximum operating temperature to 600 degrees F. Expansion compensators shall have a maximum stroke of 1.75 inches in axial compression and 0.25 inches in extension. Approved Models: Model "HB" by Flexonics or (Models "HPC-XSW" or "FPT" by Microflex) or Model "HPFF" by Metraflex.

D. Flexible Metal Hoses

1. Acceptable Manufacturers, subject to compliance with requirements: Flexonics, Flexible Hose, Microflex, Metraflex, Hypsan.

2. Construct corrugated flexible hose of bronze helical corrugations encased in braided sheath of same material with threaded, soldered, or flanged ends.

3. Construct corrugated flexible hose of Type 321 stainless steel (helical) annular corrugations encased in braided sheath of stainless steel wire, with threaded, soldered, welded, or flanged ends.

4. Hose shall be rated for piping systems in which they are installed and rated for 1.5 times operating pressure.

2.17 PIPE SEALS FOR WATER-EXPOSED, NON-FLASHED CONSTRUCTION

A. Acceptable Manufacturers, subject to compliance with requirements: Thunderline "Link-Seal", Metraflex "Metraseal", Innerlynx.

B. Provide sealing element made of synthetic rubber material, especially compounded to resist aging, ozone, sunlight, water and chemical action and having low-temperature flexibility and resistance to high temperature environments. Elements shall be suitable for temperature ranges of -40°F to 225°F.

C. Bolts and metal parts shall be made of carbon steel and zinc phosphate plated to resist corrosion.

D. Pressure plates shall be made of plastic.

E. Provide manufacturer's matching wall sleeve with combination waterstop and anchor plate.

2.18 SEALANT MATERIALS - FOR NON-FIRE RATED CONSTRUCTION

A. Provide mineral fireproofing filler material in thicknesses required for each pipe sleeve.

B. Provide closed-cell polyethylene foam or open-cell polyurethane foam backup strip for filler material.

C. Provide butyl elastomer or epoxidized polyurethane terpolymer flexible vapor barrier sealant for sealing both ends of pipe sleeve.

D. See Section 15070 for vibration-isolated pipe penetration requirements.

E. Acceptable Manufacturers, subject to compliance with requirements:

1. Mineral Fireproofing: Thermafiber by USG Acoustical Products Company.

2. Polyethylene Foam: Ethafoam by Dow Chemical Company.

3. Polyurethane Foam: Denver Foam by Plateau Supply.

4. Butyl Elastomer: Foster 95-44.

5. Epoxidized Polyurethane Terpolymer: Dymeric by Tremco.

2.19 SEALANT MATERIALS - FOR FIRE-RATED CONSTRUCTION

A. Sealant materials shall be UL listed and have a fire rating equal to the wall or floor penetrated.

B. All pipe penetration seal systems shall be UL approved and approved by the local authority having jurisdiction for the application.

C. For uninsulated metal pipes when each pipe penetrates through individual sleeve:

1. Provide smoke-tight and fire-tight seal using an intumescent elastomeric material in putty or caulk form.

2. Acceptable Manufacturers, subject to compliance with requirements: Fire Stop System Sealant by Dow Corning. Fire Barrier Non-Sag Caulk CP 25N/S or Self-Leveling Caulk CP 25S/L by 3M Electrical Products Division, FSP Firestop Putty by Hevi-Duty/Nelson/Unit of General Signal.

D. For uninsulated metal pipes when multiple pipes penetrate through one sleeve and when each pipe penetrates through individual sleeve.

1. Provide smoke-tight and fire-tight seal using a foamed-in-place silicone elastomeric material to fill the annular space between the pipe and sleeve.

2. Provide alumina-silicate fireboard or other suitable damming material.

3. Acceptable Manufacturers, subject to compliance with requirements: Fire Stop System Two-Part Silicone RTV Foam by Dow Corning, Pensil Fire Stop System by General Electric Company.

E. For Insulated Metal Pipes

1. Provide smoke-tight and fire-tight seal using an intumescent elastomeric material with aluminum foil on one side in wrap/strip form.

2. Provide precut aluminum-faced fire barrier sheets for sealing either round or rectangular penetrations.

3. Acceptable Manufacturers, subject to compliance with requirements: Fire Barrier Wrap/Strip FS-195 by 3M Electrical Products Division.

2.20 PIPE SLEEVES FOR INTERIOR FLOOR SLABS (OTHER THAN WATERPROOFED SLABS) AND GRADE BEAMS

A. Fabricate sleeves from standard-weight carbon steel pipe in length to match slab or grade beam thickness.

B. For pipes, 8 inches in diameter and smaller, make sleeve inside diameter at least 2 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation). For pipe larger than 8 inches in diameter, make sleeve inside diameter at least 3 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation).

C. Where sleeve seals are UL Listed assemblies, size the pipe sleeve to the designated UL assembly standards.

2.21 PIPE SLEEVES FOR CONCRETE OR MASONRY INTERIOR WALLS, PARTITIONS AND FIRE-RATED WALLS

A. Fabricate sleeves from standard-weight carbon steel pipe in length to match finished wall thickness.

B. For pipes, 8 inches in diameter and smaller, make sleeve inside diameter at least 2 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation). For pipes larger than 8 inches in diameter, make sleeve inside diameter at least 3 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation).

2.22 PIPE SLEEVES FOR ABOVE GRADE EXTERIOR WALLS AND WATERPROOFED FLOOR SLABS

A. Fabricate sleeves from standard-weight carbon steel pipe with continuously welded dam/anchor metal ring extending radially a minimum of 2 inches from the outside diameter of the pipe sleeve. Acceptable Manufacturers, subject to compliance with requirements: National Pipe Hanger Figure 840, Calpico.

B. Fabricate sleeves for above grade exterior walls to match finished wall thickness.

C. Fabricate sleeves for waterproofed floor slabs of sufficient length to extend at least 2 inches above the finished floor to permit flashing of the membrane waterproofing.

D. For pipes, 8 inches in diameter and smaller, make sleeve inside diameter at least 2 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation). For pipes larger than 8 inches in diameter, make sleeve inside diameter at least 3 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation).

2.23 PIPE SLEEVES FOR BELOW GRADE FOOTINGS, EXTERIOR WALLS AND ROOF DECKS

A. Fabricate sleeves from standard-weight carbon steel pipe with continuously welded water dam/anchor metal ring extending radially a minimum of 2 inches from the outside diameter of the pipe sleeve. Acceptable Manufacturers, subject to compliance with requirements: National Pipe

Hanger Figure 840.

B. Fabricate sleeves to match finished footing, wall or roof deck thickness.

C. For pipes, 8 inches in diameter and smaller, make sleeve inside diameter at least 2 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation). For pipes larger than 8 inches in diameter, make sleeve inside diameter at least 3 inches larger than the outside diameter of the finished pipe (or outside diameter of pipe insulation).

D. Where sleeve seals are required, size the pipe sleeve to suit the seal manufacturer's standards.

2.24 PIPE SLEEVES FOR ROOF PENETRATIONS

A. Provide relief valve vent pipe penetrating the roof with special sleeves that permit a flow of air between the pipe and the sleeve.

B. Provide pipe seals as specified elsewhere in this Division for vents and piping penetrating the roof.

2.25 PIPE SLEEVES FOR GYPSUM WALLBOARD PARTITIONS AND ACCESS FLOOR PANELS (ABOVE AND BELOW CEILINGS)

A. Box-in rectangular or round sleeve opening for piping, piping banks and ductwork with No. 20 gage galvanized sheet metal.

B. Flange-out edges of sheet metal a minimum of 1-1/2 inches to secure sleeve to wall.

PART 3 - EXECUTION

3.1 THERMOMETERS

A. Install in pipe with face positioned for easy reading from floor.

B. Thermometer ranges shall be:

SYSTEM	TEMPERATURE RANGE (°F)
Chilled Water, Chilled Beam Water	0 to 120
Heating Hot Water	30 to 240

C. In piping close to supply and return of each major heating or cooling system component (such as heat exchangers, chillers, cooling towers, AHU coil banks), whether indicated on drawings or not, provide 3/4" separable socket with cap, similar to type used for thermometers for use in testing, adjusting or operation of system.

3.2 PRESSURE GAGES

A. Ranges shall be as follows:

SYSTEM	PRESSURE RANGE (PSIG)
Chilled Water, Chilled Beam Water	0 - 100
Heating Hot Water	0 - 100

B. Provide supports and protection for gages subject to vibration or physical damage.

C. Install pressure gages where shown on drawings, where specified, and in the following locations:

1. Suction and discharge connections to pumps.

2. Downstream of pressure regulating or reducing valves.

3. Inlets and outlets to all heat exchangers and pressure vessels.

3.3 PRESSURE DIFFERENTIAL GAGES

A. Provide support and protection for gages subject to vibration or physical damage.

3.4 STRAINERS

A. Provide strainers at:

1. Inlet to all automatic control valves.

2. Hydronic or gas pressure reducing or regulating valves.

3. Domestic cold water make-up water flow meters.

4. Pumps (unless provided with suction diffusers).

5. Other locations shown on drawings or specifications.

3.5 AIR SEPARATORS AND VENTING

A. Provide small terminal heating and cooling equipment, including, but not limited to, converters, unit heaters, unit ventilators, small water coils, series of finned tube radiation, and similar equipment with manual air vents.

B. For chilled water or heating hot water (not glycol solution) coils as in air handling units, and where shown on drawings, provide automatic air vents with valved inlet and discharge piped to floor drains.

C. Provide accessible manual air vent on high points of hydronic systems. Where high points are not readily accessible, provide 1/4" piping or tubing to manual air vent in accessible location. System connection shall be valved.

3.6 EXPANSION TANKS

A. Mount vertical expansion tanks on concrete housekeeping pads with vibration isolation equipment per Section 15070 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT.

B. Charge each tank to a pressure equal to the static pressure at the tank plus 5 psig.

C. Hydrostatically test the expansion tanks and connected piping systems at the system design pressure of the piping connected in accordance with Section 15060. Repair leaks by replacing defective fittings or tanks and retest. Repair leak damage to the building at no additional cost to the Owner. Submit field test report certifying that all tanks are tight, leak-free, and as specified.

D. Upon completion of the cleaning, filling, flushing and draining of the water piping systems, pressurize the expansion tanks to the scheduled minimum pressure using oil-free compressed air or nitrogen.

3.7 FLOW METERS

A. Install flow meters in accordance with manufacturer’s installation instructions.

B. Locate flow meters in the pipeline with the approach and departure distances as recommended by the manufacturer. Provide straightening vanes where the approach and departure lengths for the flow meters are shorter than recommended by the manufacturer.

3.8 INSTALLATION - SEALS AND SLEEVES

A. For Pipe Sleeves Receiving Non-Fire-Rated Seals

1. Wedge filler materials between bars or insulated pipe, and sleeve over the full length of the pipe sleeve.

2. Recess the filler material 1/4 inch back from the end of the sleeve.

3. Trowel or gun a continuous bead of sealant for a complete seal over filler material at both ends of sleeve.

B. For Pipe Sleeves Receiving Fire-Rated or Watertight Seals

1. Remove insulation from piping at the portion of the pipe passing through the sleeve.

2. Install seals in accordance with manufacturer's instructions to meet UL listing.

C. Unless already provided, place sleeves to be embedded in concrete or masonry floors and walls in the forms before concrete is poured or masonry wall is erected. Sleeves shall have integral waterstop flanges where sleeves are to receive either watertight or hydrostatic seals.

D. The Contractor shall be responsible for the correct size, location and alignment of all the sleeves for his work before and during concrete placement or masonry erection.

E. In finished areas, set floor sleeves flush with the top of the finished floor surface.

F. In Mechanical Rooms and areas with similar service, set floor sleeves 4 inches above the finished floor, unless such areas are slab-on-grade.

G. Extend wall sleeves through and cut flush with each surface.

H. Locate piping in sleeve to allow for movement. Do not allow steel sleeves to touch copper piping at any time.

I. Grout opening between outside of sleeve and inside of core-drilled penetrations.

+ + END OF SECTION + +

15141 - MECHANICAL SUPPORTING DEVICES - PLUMBING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes hangers and supports for piping and equipment in plumbing systems.

1.02 REFERENCE CODES AND STANDARDS

A. Comply with the following:

1. Society for Protective Coatings:

a. PA-1 Shop, Field, and Maintenance Painting

2. Applicable Plumbing Code

a. International Plumbing Code
b. 2003 Virginia Uniform Statewide Building Code (VUSBC)

1.03 SUBMITTALS

A. Submit for record:

1. Product data, including installation instructions for each type of support and anchor, materials of construction, finish and rated load capacities.

2. Shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances and assembly methods of components.

3. Maintenance data on items requiring maintenance.

4. Submit the guide or anchor manufacturer's identification of each guide or anchor type, its designated location and line size.

1.04 QUALITY ASSURANCE

A. Materials, design and manufacturer of pipe hangers and supports shall conform to MSS SP-58.

B. Selection and application of pipe hangers and supports shall conform to MSS SP-69.

C. Fabrication and installation practices of pipe hangers and supports shall conform to MSS SP-89.

D. All work shall conform to the ANSI/ASME Codes for Pressure Piping specified above.

E. Comply with the referenced plumbing code.

PART 2 - PRODUCTS

2.01 APPROVED MANUFACTURERS

A. The following manufacturers are approved for use:

1. Pipe Hangers: Grinnell, Carpenter & Patterson, National Pipe Hanger, B-Line, Pipe Shields, Inc.

2. Pipe Clamps: Grinnell, Carpenter & Patterson, National Pipe Hanger, B-Line, Pipe Shields, Inc.

3. Pipe Insulation Protection Shields: Grinnell, Carpenter and Patterson, National Pipe

Hanger, B-Line.

4. Wall Brackets: Grinnell, B-Line, Carpenter & Patterson, National Pipe Hanger.

5. Hanger Inserts: Grinnell, National Pipe Hanger, B-Line.

6. Spring Hangers: Grinnell, Power Piping Company, Carpenter & Patterson, National Pipe Hanger, B-Line.

7. Pipe Supports for Rooftop Piping and Piping Located at Grade: Grinnell, Carpenter & Patterson, National Pipe Hanger, B-Line.

8. Trapeze Hangers: Unistrut, Grinnell (Power-Struct), National Pipe Hanger, B-Line.

9. U-Bolts: Grinnell, B-Line, Carpenter & Patterson, National Pipe Hanger.

10. Guides: Power Pipe Supports, Grinnell, Flexonics, Metraflex, NPS Industries, Inc., Hyspan, Keflex, National Pipe Hanger, B-Line.

11. Anchors: National Pipe Hanger, B-Line.

B. Specific manufacturer's model numbers are cited in the following paragraphs to establish the desired quality and performance of the work. Equivalent products by the other approved manufacturers listed above are also acceptable.

2.02 GENERAL

A. Hot-dip galvanize hangers and strut located outdoors after fabrication in accordance with ASTM A123.

B. Pre-galvanize strut channels in accordance with ASTM A653 G90.

C. Paint hangers and clamps for support of bare copper piping with copper colored epoxy.

D. Zinc-plate hangers not in direct contact with copper pipe in accordance with ASTM B633.SC3.

2.03 HANGER RODS

A. Hanger rods shall be threaded at both ends or continuous threaded rods of circular cross-section. Use adjusting locknuts at upper attachments and hangers.

B. Provide hanger rods for the following pipe sizes as tabulated as a minimum for single rigid rod hangers, subject to the load ratings of MSS-SP-58. Hanger rods may be reduced one (1) size for double rod hangers with 3/8 inch minimum diameter.

PIPE SIZE - INCHES	MIN. ROD DIA. - INCHES
1/2 to 2	3/8
2-1/2 to 3	1/2
4 to 5	5/8
6	3/4
8 to 12	7/8
15	1

2.04 HORIZONTAL NON-INSULATED WASTE, VENT AND STORM WATER PIPING HANGERS

A. Uninsulated pipes 2 inch and smaller:

1. Adjustable steel swivel ring (band type) hanger, B-Line B3170.

2. Malleable iron ring hanger, B-Line B3198R or hinged ring hanger, 3198H.

3. Adjustable steel clevis hanger, B-Line B3104 or B3100.

B. Uninsulated pipes 2-1/2 inch and larger:

1. Adjustable steel clevis hanger, B-Line B3100.

2.05 UNINSULATED COPPER TUBING SUPPORTS

A. Size hangers to fit copper tubing outside diameters.

1. Adjustable steel swivel ring (ban type) hanger, B-Line B3170 CT.

2. Malleable iron ring hanger, B-Line B3198RCT or hinged ring hanger B3198HCT.

3. Adjustable steel clevis hanger, B-Line B3104CT.

B. For supporting vertical runs use epoxy painted or plastic coated riser clamps, B-Line B3373CT or B3373CTC.

2.06 INSULATED HORIZONTAL PIPING HANGERS

A. Domestic Cold and Hot Water and Rain Water Piping

1. 2 inch and Smaller Pipe: Use adjustable steel clevis. B-Line B3104 with B3151 or B3380 series.

2. 2-1/2 inch and Larger Pipes: Adjustable steel clevis. B-Line B3100 with B3151 and B3380 shields.

2.07 PIPE INSULATION PROTECTION SHIELDS

A. Furnish and install pipe insulation protection shields on all insulated piping and tubing. All shields shall be galvanized steel. Length and gauge thickness of shields shall be based on MSS SP-58.

B. Use calcium silicate insulation at each pipe insulation protection shield. Calcium silicate insulation shall be at least the length of the protection shield.

C. Support spacing shall be as specified in Part 3 of this Section.

D. Approved Pipe Insulation Protection Shields: B-Line B-3151, Grinnell, Carpenter & Paterson, National Pipe Hanger.

2.08 VERTICAL SUPPORTS

A. Riser clamp sized to fit outside diameter of pipe, B-Line B3373.

B. Riser clamp sized to fit outside diameter of copper tubing, B-Line B3373CT.

C. Clevis type, plastic coated B-3104F or 3100F for piping 2" diameter and over.

2.09 HANGERS FOR HORIZONTAL GLASS, ALUMINUM, BRASS PIPING OR TO ELIMINATE ELECTROLYTIC ACTION

A. Light-duty clevis hanger - plastic coated, B-Line B3104C.

2.10 BEAM CLAMPS

A. For Piping 1-inch in Diameter and Smaller: C-Clamps shall have lock nuts and cup point set screws, B-Line B351L, or B3036L. Use top flange C-clamps when attaching a hanger rod to the top flange of structural shapes, B-Line B3034 or B3033. Refer to manufacturers recommendation

for set screw torque. Use retaining straps to maintain the position on the beam where required.

B. For Piping Larger than 1-inch in Diameter: Steel clamps shall be B-Line B3050, or B3055. Malleable iron or forged steel beam clamps with cross bolt shall be B-Line B3054 or B3291-B3297 Series as required to fit beams.

2.11 CONCRETE INSERTS

A. Use cast in place spot concrete inserts where applicable, either steel or malleable iron body, B-Line B2500 or B3014. Spot inserts shall allow for lateral adjustments and have means for attachment to forms. Select inserts to suit threaded hanger rod sizes, B-line N2500 or B3014N series.

B. Use continuous concrete inserts where applicable. Channels shall be 12 gauge, ASTM A 570 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 load rating of 2,000 lbs/ft. in concrete, B-Line B221, 321, or 521. Select channel nuts suitable for strut and rod sizes.

2.12 BRACKETS

A. Welded strut bracket and pipe straps, B-Line B3064 and B2000 series.

B. Welded steel brackets, B-Line B3066 or B3067, with roller chair or adjustable steel yoke pipe roll. B-Line B3120 or B3110.

2.13 PIPE REST

A. Carbon steel adjustable pipe saddle and nipple attached to steel base stand sized for pipe elevation. B-Line B3093 and B3088T or B3090 and B3088. Pipe saddle shall be screwed or welded to appropriate base stand.

2.14 TRAPEZE HANGERS - DIRECT MOUNTING HANGERS

A. Trapeze hangers shall be constructed from 12 gauge roll formed ASTM A570 Gr. 33 structural steel channel, 1-5/8 x 1-5/8 minimum, B-Line B22 strut.

2.15 HANGER FOR HORIZONTAL AWWA PIPING (FLANGED OR BELL-SPIGOT)

A. Cast iron pipe, B-Line B3102.

2.16 GUIDES AND ANCHORS - GENERAL

A. Laminations, linings and insulation of guides shall have a Flame Spread rating of 25 and Smoke Developed rating of 50 when tested in accordance with ASTM E 84.

B. Design anchors, guides and restraints for imposed loadings.

C. Design guides to accommodate pipe insulation thicknesses specified in Section 15250 with a minimum 1/8 inch clearance between inside diameter of guiding cylinder and outside diameter of insulation.

2.17 GUIDES

A. Spider Guides: Furnish guides of steel consisting of a bolted two-section outer cylinder and base with a two-section four-lug guiding spider arranged for bolting to pipe. Finish with one shop coat of paint. Unit shall permit axial movement of the pipe and shall be sized for insulated piping, as required. For guiding uninsulated copper pipe, the interior surface of guiding cylinder shall be factory laminated with a layer of DuPont "Nomex" woven fabric, minimum 1/8 inch thick. Approved Model: B-Line B3281 through B3287.

2.18 ANCHORS

A. Locate anchors where shown on the drawings.

B. Fabricate anchors of steel consisting of integral pipe bolting clamps with T-bar base. Finish with one (1) shop coat of paint. Approved Model: National Pipe Hanger No. 975.

2.19 SUPPLEMENTAL STEEL

A. Attach hangers to the building structural beams. Where hangers do not correspond with the building structural beams, provide supplemental steel members fastened to the building structural steel beams. Provide two (2) coats of primer on the supplemental steel. Submit details of hanger attachments to the building structure to the Architect for approval before drilling or burning holes in the structure.

B. Design and fabricate supports using structural quality steel bolted framing materials. Channels shall be roll formed, 12 gauge ASTM A 570 Grade 33 steel, 1-5/8" x 1-5/8" or greater as required by loading conditions. Use clamps and fittings designed for use with the strut system.

2.20 U-BOLTS

A. Heavy-Duty Carbon Steel: B-Line Numbers B3188 and B3188N5.

2.21 SHOP PAINTING

A. Shop-paint all carbon steel hangers and supports.

2.22 DIELECTRIC CONTROL

A. For copper tubing in contact with metallic pipe clamps, brackets or supports, provide an insulating pipe clamp assembly with plastic cushion. Pipe clamp assembly shall eliminate metal-to-metal contact and form an insulating liner to prevent galvanic action between copper tubing and metallic clamps, brackets and supports.

2.23 PIPE SUPPORT STANCHIONS

A. Stanchions shall be pipe mounted, B-Line Numbers B3090, B3093, and B3095.

PART 3 - EXECUTION

3.01 INSTALLATION - PIPE HANGERS AND SUPPORTS

A. Support horizontal pipe runs using hangers and supports. Space the hangers so that the supported load does not exceed the load recommended by the hanger manufacturer. Space the hangers so they do not exceed the support spacing requirements listed in this Section. The supported load shall not overstress the building structural members.

B. Support vertical pipe at each floor using riser clamps. When run in a shaft, support riser clamps on both sides of the clamp. Support vertical plastic piping (all sizes) and metal piping less than 1-1/4 inch every 8 feet with pipe clamps.

C. Support cast iron pipe under each section and at each hub.

D. Wall brackets may be used where pipes are adjacent to walls or other vertical surfaces which may be used for support.

E. Provide hangers and supports not more than 12 inches from each face of a horizontal elbow for all piping 6 inches in diameter and larger.

F. Furnish embedded inserts for pipe hangers installed in concrete slabs or masonry walls for installation during concrete forming or masonry erection.

G. For the support of two or more pipes of similar temperatures running adjacent to each other at the same elevation and at the same slope, structural steel trapeze hangers are permitted. Limit the

longitudinal hanger spacing to suit the smaller diameter pipe.

H. Support riser piping independently from the connected horizontal piping.

I. Provide isolation hangers and supports as specified under Section 15210.

J. Do not use pipe hooks, chains or perforated steel strap for pipe supports.

K. Do not support piping from ceiling supports, [raised floor supports] ductwork, equipment, [cable trays], electrical conduit or other piping.

L. Piping shall not be hung from metal floor deck, metal roof deck or steel joists.

M. Cut off excess hanger rod lengths. Secure rods by use of locknuts or elastic stop nuts.

N. Support the base of all vertical pipe stacks (except soil pipe stacks and copper water pipe risers) with a base leg. Cut the top of the base leg to shape and completely weld to the heel of the base elbow. Weld leg support to a bearing plate and bolt to the floor. Locate base leg on the vertical pipe centerline.

O. Secure pipe hangers attached to concrete structure and slabs with embedded inserts, anchor bolts or concrete fasteners, or, with specific written approval from the Architect, power-driven inserts. Do not drill or shoot without specific written approval of the Architect. Location and types will be reviewed for compatibility with building structure systems only. Use a safety factor of 5 in selection of all inserts and expansion bolts. [Select and design inserts and expansion bolts for seismic loadings specified elsewhere.]

P. Install hanger inserts prior to installation of concrete or masonry. The Contractor shall be responsible for the correct location and position of the inserts for his work.

Q. Support all vertical drops to plumbing fixtures and equipment.

R. Provide maximum support spacing as listed below. Locate one support within one foot on both sides of all concentrated pipe-mounted loads (valves, meters, pumps, etc.). Also, adjust the span, if required, to meet the load ratings of the supports/hangers.

1. Support cast iron and ductile iron piping using clevis hangers every 5 feet (for 5-foot sections of pipe) or every 10 feet (for 10-foot sections of pipe) with at least one hanger per section.

2. Support for Cast Iron Drainage as follows:

Nominal Pipe Size Inches	Maximum Support Spacing	
2" - 4"	5' - 0"	And change of direction at joints and fittings
5" to 12"	6' - 0"	

S. Provide all supports for piping under raised-floor areas. Coordinate location of supports with raised-floor pedestals.

3.02 INSTALLATION OF GUIDES

A. Install all guides as shown on the contract drawings. When not shown on the contract drawings, locate the first pipe guide at a maximum distance of 4 pipe diameters from each end of expansion joints or pipe loops. Locate second guide at a distance of 14 pipe diameters from the first guide.

B. Place spider guides on the pipe prior to the application of insulation, if required. After the insulation is applied, bolt or weld the body of the pipe guide to the structure and bolt the upper cap in place.

3.03 INSTALLATION OF ANCHORS

A. Where anchors do not correspond with building structure, provide supplemental steel supports extended and fastened to the building structure.

B. Design supplemental steel supports for the seismic loadings specified elsewhere.

+ + END OF SECTION + +

15161 – PUMPS – PLUMBING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes pumps used in plumbing systems.

1.02 SUBMITTALS

A. Submit for review:

1. Submit manufacturer's product data for all products specified showing gallons per minute (GPM), total dynamic head (psi), discharge pressure, minimum net positive suction head (npsh), casing material, shaft material, bearings, brake hp, motor hp, speed in rpm, and efficiency.

2. Certified Dimensioned Drawings and Operating Weights.

3. Certified Pump Performance Curves: Submit pump curve for each pump with operating points plotted.

1.03 QUALITY ASSURANCE

A. Select pumps to operate at or near their point of peak efficiency. In addition, the design impeller diameter shall be selected so that the design capacity of each pump (GPM and TDH) shall not exceed 90% of the capacity obtainable with maximum impeller diameter at the design speed for that model.

B. The pump curve shall be continuously rising from maximum capacity up to the shut-off point.

C. Pumps shall be centrifugal type with non-overloading characteristics. The pumps shall not overload the motor above its horsepower nameplate rating under any operating conditions with rating based on continuous operation. When pumps are specified to have ball bearings, the bearing units shall be sized to provide a minimum life of 35,000 hours, based on the Anti- Friction Bearing Manufacturers Association Standards. Impellers shall be statically and dynamically balanced.

D. Pump motors shall comply with the requirements of Section 15902.

PART 2 - PRODUCTS

2.01 DOMESTIC HOT WATER CIRCULATING PUMP

A. Manufacturers: Bell & Gossett, Thrush.

1. In-line pump with all-bronze case; flanged connections; cast bronze single suction impeller; stainless steel shaft with trust collar; oil lubricated bronze sleeve bearings, internal mechanical seal, and resiliently-mounted flexible coupled motor.

2. Pump shall be provided with thermal overload protector.

3. Provide approved steel support for the circular which shall be fastened to the building construction.

4. Aquastat: Provide in the hot water return piping ahead of the circulator, an immersion aquastat, similar to Honeywell Type L444A for controlling the operation of the circulator.

B. As manufactured by ITT Bell and Gossett; Taco; Thrush.

PART 3 – EXECUTION

3.01 GENERAL – PUMPS

A. Provide vibration isolation devices as specified in Section 15210.

3.02 TESTING – PUMPS

A. Test pumps at start-up in accordance with manufacturer's instructions and report the following data:

1. Current (amperes, each phase) at design differential head and flow.)
2. Current at no flow head.
3. Current, differential head and flow at maximum flow available.
4. Flow versus head for performance compliance at design point.
5. Motor surface steady-state temperature at design point, together with ambient temperature.
6. Observations on vibration and abnormal noise from impeller, bear-bearings, and motor.

+ + END OF SECTION + +

SECTION 15180 - HYDRONIC PIPING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes pipe and pipe fittings used in HVAC Systems.

1.02 SUBMITTALS

A. Submit the following to the Architect for review in accordance with Division 1:

1. Product Data: Manufacturer's technical product literature for pipe, fittings, couplings**,** and bolting.

2. Quality Assurance Submittals

a. Field Quality Control Reports.
b. Chemical Cleaning Effluent Disposal Plan.

1.03 DELIVERY, STORAGE AND HANDLING

A. Protect flange faces with wood, plastic or soft metal.

B. Factory apply plastic piping end-caps. Maintain end-caps in place until pipe is erected.

C. Store pipe and fittings inside for protection from moisture and dirt, or with weatherproof packaging.

PART 2 - PRODUCTS

2.01 PIPING PRODUCTS

A. Use the following piping products schedule.

ITEM	SERVICE
	HYDRONIC (INCLUDING AQUEOUS BRINE SOLUTIONS) PIPING, REFRIGERANT VENT, SAFETY VALVE VENT AND DRAIN PIPING
Piping - 2-1/2" and larger	Standard weight ERW or seamless carbon steel, ASTM A 53/A 53M or ASTM A 106, Grade B, dimensions to ANSI B36.10M.
Piping - 2" and smaller	Seamless hard copper Type "L" tubing, ASTM B 88.
Fittings - 2-1/2" and larger	Steel butt weld fittings, ANSI B16.9. Steel or ductile-iron (Victaulic) grooved end fittings.
Fittings - 2" and smaller	Copper Tubing: Wrought copper solder joint pressure fittings, ANSI B16.22.
Joining Materials - 2-1/2"and larger	Welded or grooved joint couplings.
Joining Materials - 2" and smaller	95/5 (tin/antimony) solder, conforming to ASTM B32
Flanges - for Piping 2-1/2" and larger	1. Forged carbon steel, slip-on, ASTM A105/A 105M, Grade raised-face or flat-face, dimensions to ANSI B16.5, Class 150. 2. Flange bolts: Alloy steel to ASTM A 193/A 193M, Grade B7, threaded for full length, heavy hex nuts. 3. Gaskets: Non-asbestos with synthetic fibers and SBR binders. Acceptable

ITEM	SERVICE
	HYDRONIC (INCLUDING AQUEOUS BRINE SOLUTIONS) PIPING, REFRIGERANT VENT, SAFETY VALVE VENT AND DRAIN PIPING
	Manufacturers, subject to compliance with requirements: Garlock Style 3200.
Unions - for Piping 2" and smaller	Brass solder.
Dielectric Fittings	Isolation flanges, unions and nipples. Use steam service gaskets for fluids over 100 deg F, and standard service gaskets elsewhere. Acceptable Manufacturers, subject to compliance with requirements: Epco, Perfection, or Victaulic.

ITEM	SERVICE
	PUMPED OR GRAVITY COOLING COIL CONDENSATE PIPING (In locations other than Mechanical Rooms)
Piping - 2-1/2" and larger	Hard-drawn seamless copper tubing, Type L, ASTM B88.
Piping - 2" and smaller	Hard-drawn seamless copper tubing, Type L, ASTM B88.
Fittings - 2-1/2" and larger	Wrought copper solder joint pressure fittings, ANSI B16.22
Fittings - 2" and smaller	Wrought copper solder joint pressure fittings, ANSI B16.22
Joints - 2-1/2" and larger	Soldered, 95/5 (tin/ antimony), ASTM B32
Joints - 2" and smaller	Soldered, 95/5 (tin/ antimony), ASTM B32
Flanges - for Piping 2-1/2" and larger	1. Flanges: 150 pound cast bronze, ANSI B16.24 2. Flange Bolts: hex machine bolts with heavy hex nuts, ASTM A307, Grade B. 3. Gaskets: Non-asbestos with synthetic fibers and SBR binding. Acceptable Manufacturers, subject to compliance with requirements: Garlock Style 3200.
Unions - for Piping 2" and smaller	Wrought copper solder unions, ANSI B16.22.
Dielectric Fittings	Isolation flanges, unions and nipples. Use steam service gaskets for fluids over 100 gaskets and star elsewhere. Acceptable Manufacturers, subject to compliance with requirements: EPCO, Calpico, Perfection

ITEM	SERVICE
	REFRIGERANT
Piping -	Seamless copper air-conditioning and refrigeration tubing, Type ACR, Hard-drawn,

ITEM	SERVICE
	REFRIGERANT
2-5/8" and smaller	ASTM B280.
Joints - 2-5/8" and smaller	Brazed, per AWS Brazing Manual
Fittings - 2-5/8" and smaller	Wrought copper brazing fittings, ANSI B16.22
Joining Materials - 2-5/8" and smaller	AWS classification BCuP5 alloy (15% silver, 5% phosphorus, 80% copper) per AWS A5.8. Acceptable Manufacturers, subject to compliance with requirements: Handy and Harmon Silfos 15. Acceptable Manufacturer, subject to compliance with requirements: Handy and Harmon "Handy Flux."

ITEM	SERVICE
	COOLING COIL CONDENSATE (in MECHANICAL ROOMS only)
Piping - 2" and Smaller	PVC Type 1, Grade 1, Schedule 80
Piping - 2-1/2" and Larger	PVC Type 1, Grade 1, Schedule 40
Joints & Fittings - 2" & Smaller	PVC Type 1, Grade 1, Socket ends, Schedule 80
Joints and Fittings - 2-1/2" and Larger	PVC Type 1, Grade 1, Socket ends, Schedule 40
Primer for Joint Solvent	Nibco Purple Primer
Solvent Cement	Nibco PVC solvent cement

2.02 NIPPLES

A. Pipe nipples shall be of the same material as the pipeline in which they are installed and shall conform to ASTM A 733.

B. Unthreaded part shall not be less than 1-1/2".

2.03 GROOVED END PIPING

A. Victaulic grooved mechanical pipe couplings, fittings, valves and other grooved components may be used in the penthouse only as an option to welding, threading or flanged methods. All grooved components shall be by Victaulic Company of America, and conform to local code approval and/or as listed by ANSI-B-31.1, B-31.3, B-31.9, ASME, UL/ULC, FM, IAPMO or BOCA. Grooved end product manufacturer to be ISO-9001 certified. Grooved couplings shall meet the requirements of ASTM F 1476.

B. Pipe/Grooved (Standard/Lightwall):

1. Carbon Steel, ASTM A 53A 53M or ASTM A 106/A 106M, Grade B - Roll or cut grooved-ends as appropriate to pipe material, wall thickness, pressures, size and method of joining. Pipe ends to be grooved in accordance with Victaulic current listed standards conforming to ANSI/AWWA C-606.

C. Victaulic Mechanical Couplings for Joining Carbon Steel Pipe:

1. Victaulic Mechanical Couplings: Manufactured in two segments of cast ductile iron, conforming to ASTM A 536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D 2000. Mechanical Coupling bolts shall be zinc plated (ASTM B 633) heat treated carbon steel

track head conforming to physical properties of ASTM A-449 and A 183, minimum tensile strength 110,000 psi (758450 kPa) as provided standard Victaulic.

a. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, and NFPA 13.

1) Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket rated to +250 degrees F. Victaulic Style 107H.
2) Victaulic Style 07, Zero-Flex.

b. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings shall be placed in close proximity to the vibration source. Victaulic Installation-Ready Style 177 or Style 75 and 77.

c. 14" through 24": Victaulic AGS series with lead-in chamfer on housing key and wide width FlushSeal® gasket.

1) Rigid Type: Housing key shall fill the wedge shaped AGS groove and provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9. Victaulic Style W07.
2) Flexible Type: Housing key shall fit into the wedge shaped AGS groove and allow for linear and angular pipe movement. Victaulic Style W77.

2. Flange Adapters: For use with grooved end pipe and fittings, for mating to ANSI Class 125 / 150 flanges. Victaulic Style 741/ W741.

D. Victaulic Grooved End Fittings: Fittings shall be cast of ductile iron conforming to ASTM A 536, Grade 65-45-12, forged steel conforming to ASTM A 234/A 234M, Grade WPB 0.375" wall, or factory-fabricated from Std. Wt. Carbon Steel pipe conforming to ASTM A 53/A 53M, Type F, E or S, Grade B. Fittings provided with an alkyd enamel finish or hot dip galvanized to ASTM A 153/ A 153M. Zinc electroplated fittings and couplings conform to ASTM B633.

2.04 PIPE WRAP TAPE

A. Protect uninsulated bare steel piping and bare copper tubing, and their fittings, installed underground, in concrete slabs or in masonry walls with protective tape as follows:

1. Service Temperature minus 55 degrees F to 175 degrees F: Spirally-wrapped 3M Scotchrap 50 All-Weather Corrosion Protection Tape.

2. Service Temperature 176 degrees F to 250 degrees F: Spirally-wrapped Corrosion Control Products Co. Tapecoat HT-M High Temperature Tape.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Unless shown otherwise, route piping in the most direct manner, parallel to building lines.

B. Locate piping to maintain clearance around equipment, and minimum piping headroom of 7 feet 6 inches, except where otherwise shown.

C. When installing piping, maintain sufficient space between parallel pipes, and between pipe and adjacent surfaces, to permit proper application and sealing of pipe insulation.

1. Space piping so that insulation and flanges, if any, have at least 2 inch clearance after maximum movement.

D. Where a well or control instrument is installed in piping 2-1/2 inches and smaller, increase the pipe size by at least one pipe size to avoid restricting the flow in the pipe, unless otherwise indicated.

E. Close open ends of piping and equipment, when it is not being worked on, with flange covers, caps or plugs.

F. In hydronic systems, connect branch lines to the bottom half of the line, unless otherwise indicated.

G. Do not use pipes smaller than 3/4-inch, unless otherwise indicated.

H. Do not bend steel pipe.

I. Clean piping materials before installation to remove grease, loose dirt, mill scale and other foreign matter.

J. Provide valved vents at all high points of water piping, and valved drains at all low points of water piping for draining and flushing. Locations shall be determined by the Contractor.

K. Provide escutcheons at locations where piping, installed exposed to view, penetrates walls, partitions, floors and ceilings.

L. Install automatic control valves and accessories furnished under other specification sections.

M. Provide unions or companion flanges where indicated, and in following locations whether or not indicated:

1. In bypasses around control valves and equipment.

2. In connection to equipment between shutoff valves and equipment, on the supply and return piping connections.

3. Unions and flanges for servicing and disconnect are not required in installations using grooved mechanical joint couplings. (The couplings shall serve as unions and disconnect points.)

N. Maintain the following minimum pitches:

Safety and relief valve discharge	1" in 4'
Cooling coil condensate drain	1" in 8'
Hydronic heating and cooling	1" in 50'
All other	1" in 50'

O. Do not install pipes in electrical equipment rooms, elevator machine rooms or similar areas containing electrical equipment, other than branches serving equipment in these rooms.

P. Do not install pipes over electrical equipment, unless permitted by the National Electrical Code (NEC), and written permission is obtained in advance from the Owner.

1. Where (NEC) does permit piping to be installed above electrical equipment, provide galvanized steel drip pans over the electrical equipment at no additional cost to the Owner.

Q. Where horizontal hydronic piping is reduced in size, use flat-on-top eccentric reducers.

R. Do not use bullhead tees in hydronic supply systems.

3.02 WELDED PIPE JOINTS

A. Weld joints in the following piping:

1. Carbon steel pipe 2-1/2 inches and larger.

2. Carbon steel piping of any size, which is inaccessible in shafts, chases, walls, underground, or under slab.

3. Elsewhere as specified.

B. Perform welding using qualified welders and procedures following specified reference standards.

C. Provide only long radius 90 degree elbows. Mitered welds for elbows are not acceptable.

D. Welded branch connections are acceptable in place of welding tees provided installations conform to requirements of the applicable ANSI/ASME Code for Pressure Piping, B31.9, as applicable.

E. Weldolets, or similar code-approved fittings, are acceptable for branch connections. Branch connectors may be a maximum of one pipe size smaller than the main or branch main.

F. Welders, welding procedures, performance of welders and welding operators shall comply with the requirements of ANSI/ASME B31.9 and the ANSI/ASME Boiler and Pressure Vessel Code, Section IX.

1. Keep records and certifications required by code on file and available for inspection.

~~G.~~ Whenever welding is done close to walls, floors or building structure, thoroughly clean surfaces to remove weld splatter.

1. Remove weld splatter from the surface of all welds, pipe and pipe supports.

H. Inspect welded pipe joints as follows:

1. Visually examine all welded pipe joints for imperfections.

2. Evaluate imperfections revealed by examination in accordance with the criteria in the ANSI/ASME B31.9 code, as applicable.

3. Remove weld defects by grinding or chipping and repair or replace weld joints.

I. Welding shall be electric arc welded.

J. Welding shall conform to procedure for metallic arc welding of steel pipe, fittings, and flanges under provisions of ANSI Piping Code and ASME Boiler and Pressure Vessel Code. Filler metal shall comply with ASME Specifications SA-233 for iron or steel arc welding electrodes, Classification E-6010, and shall provide physical properties in deposited metal comparable to the base metal.

1. Clean each complete bead or layer with hammer and wire brush.

2. Remove weld splatter from pipe ends, surface or weld before laying down next successive bead or layer.

3.03 VICTAULIC MECHANICAL PIPE COUPLINGS]

A. Victaulic mechanical pipe couplings may be used for aboveground hydronic piping systems, in lieu of welded steel piping, in Penthouse only, but not within shafts.

B. Install couplings in accordance with Victaulic's installation instructions.

C. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.

D. Gaskets shall be of an elastomer grade suitable for the intended service, and shall be molded and produced by the coupling manufacturer.

E. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools and installation of grooved joint products. The representative shall periodically visit the jobsite and review contractor is following best recommended practices in grooved product installation. (A distributor's representative is not considered qualified to conduct the training or jobsite visit(s)).

3.04 THREADED PIPE JOINTS

A. Seal threaded joints with a non-corrosive, non-hardening compound or PTFE tape applied on the male thread. Do not caulk threaded joints.

B. Threadolets, or similar ASME code-approved fittings, are acceptable for branch connections. Branch connectors may be one pipe size smaller than the main or branch main.

C. Ream or file pipe ends to size of bore, remove chips and cuttings. Cut pipe ends square.

3.05 SOLDERED PIPE JOINTS

A. For hydronic piping connections, provide lead-free 95/5 (tin/antimony) solder. Make solder joints in accordance with the ASTM B 828.

B. As an alternative, "tees" for on-site tube branches can be mechanically pulled out of copper pipe, in lieu of tee fittings, by the use of T-DRILL, a product of T-DRILL Industries. Use in accordance with manufacturer's instructions. Joints must be brazed, not soldered.

C. For refrigeration copper piping connections, comply with ANSI/ASME B31.5. Braze joints on refrigeration piping, do not solder.

3.06 FLANGED CONNECTIONS

A. Lubricate bolts or studs over entire thread length with anti-seize compound consisting of copper flakes and graphite dispersed in water-resistant grease.

1. Acceptable Manufacturer, subject to compliance with requirements: Jet-Lube Koper-Kote.

3.07 EQUIPMENT PIPING

A. Provide piping from cooling coil drain pans, relief valves, any pump glands, and other drainage, to spill over open sight drains, floor drains, or other discharge points, and terminate with plain end,45 degree bevel cut, unthreaded pipe.

B. Where the suction or discharge of a pump is smaller than the system pipe size noted on drawings, provide reducing elbows or fittings at the suction and discharge connections to the pump.

1. Strainers, valves, flexible connectors, expansion joints, and other pipe-mounted accessories shall be full line size.

3.08 ELECTROLYSIS CONTROL

A. See Section 230529 for isolation between piping and pipe supports.

B. Isolate non-ferrous piping passing through openings in structural steel with nonconductive material permanently attached to the pipe.

C. Make connections between non-ferrous metallic piping and ferrous piping, fittings, or equipment with dielectric fittings, nipples or unions specified in this Section.

3.09 PIPING SYSTEM DRAINS

A. Pitch each piping system to low points where entire system can be emptied through drains.

B. Pitch outside water piping so that water can be drained from underground piping through drains installed in building served.

3.10 PIPING SYSTEM TESTING

A. Before testing, complete the installation of each pipe line, including final supports and anchors. Clean piping and equipment of foreign matter as they are installed and in accordance with all applicable codes and standards.

B. Pressure test piping in accordance with the applicable ANSI/ASME Code for Pressure Piping (B31), the International Mechanical Code, and applicable NFPA Standards.

C. Pressure vessels, tanks, pumps, rotating and other mechanical equipment shall not be subject to the piping field pressure test.

D. Equipment, instruments and piping specialties which are not to be included in the test shall be either disconnected from the piping and the end of the pipe, blanked off by a blind flange, plug or cap, or isolated by insertion of a line blind or spool piece as required. Disconnect instrument air lines and close openings.

E. Test piping in sections as required.

F. Provide systems to be pressurized with gauges and pressure-relieving devices.

G. Lines containing check valves shall have the source of test pressure located on the high-pressure side of the valves.

H. Line control valves shall be set and maintained in a wide-open position.

I. Refrigerant Piping and Tubing: Perform pneumatic testing in accordance with ANSI/ASME B31.9, except for the following:

1. Perform pneumatic test using dry nitrogen.

2. Prior to application of full pneumatic test pressure, conduct a preliminary test at 10 psig for 10 minutes before applying final test pressure.

3. Test pressure shall be 200 psig.

4. After the preliminary test, apply pressure gradually in stages of not more than 25 psig until test pressure is reached, allowing a minimum of 10 minutes between stages. Maintain test pressure for a minimum of thirty (30) minutes without fluctuation; then reduce pressure to operating pressure and begin checking for leaks.

5. Check all joints, welds, valves, etc. for leaks with a thick soap-water solution or with a special fluid made specifically for this purpose. Hold pressure for minimum of eight (8) hours.

6. Provide protection of persons and property during leak testing.

J. Hydronic Piping: Perform hydrostatic testing in accordance with ANSI/ASME B31.1 and B31.9, as applicable, except for the following:

1. Test pressure shall be as indicated elsewhere in this Section.

2. Maintain test pressure for thirty (30) minutes before examining all joints, welds, valves, etc. and hold test pressure for four hours.

3. Test pressures shall be as tabulated below:

SYSTEM	HYDROSTATIC TEST PRESSURE (PSIG)	DURATION (HOURS)	SEE NOTE NO.
Hydronic Piping (including Aqueous Brine Solutions)	125	4	----
Hydronic Relief Valve Vent and Drain Water	125	4	----
Cooling Coil Condensate	Static Fill - No Leakage	0.5	See below

NOTE 1: Test pressure shall be 150 psig, or 150 percent of the operating pressure, whichever is greater.

K. Testing of Cooling Coil Condensate Piping

1. Test the piping system by plugging the lowest point, filling with water to the top of the drain pan, and allowing to stand for 15 minutes. Repair leaks and retest until no leaks exist.

2. If leaks occur during testing, stop the test, repair the leaks by replacing defective sections and fittings, and repeat the entire test. Repairs made by caulking are not acceptable.

3. Repair damage to the building, contents and work of other trades caused by leaks, flooding or draining during testing.

3.11 FLUSHING OF PIPING SYSTEMS

A. Complete pressure testing before flushing piping systems.

B. Flush clean with new potable water, and drain at all low points. Connected equipment, including coils, shall be isolated and flushed individually with a hose.

C. Flushing for piping and equipment shall be complete when water samples taken at all low points indicate clean discharge with no visible solids. If not clear, continue flushing and sampling until discharge is clear.

3.12 CLEANING OF PIPING SYSTEMS

A. Submit a plan for disposal of the chemical cleaning effluent to the Owner for approval. Obtain written permission from the Owner to drain effluent on the site from cleaning and flushing operations. Otherwise, dispose of effluent offsite in a manner acceptable to all codes and regulations.

B. Complete flushing before cleaning piping systems. Cleaning shall be performed in accordance with the following procedures:

1. For Other Services Not Identified Below: Fill piping system with water and alkaline cleaning material at a concentration recommended by the chemical treatment contractor to remove dirt, oil and grease. Include all connected equipment in the cleaning. Heat water to 140 degrees F and circulate for 24 hours.

2. After 24 hours, flush system with clean potable water and sample effluent at all low points until discharge is clear, with no visible solids). Flush all equipment again separately.

3. For Refrigerant Piping: Provide nitrogen at design pressure to blow free of dirt and debris.

C. Clean all strainers every eight hours during cleaning procedures.

D. After cleaning, immediately fill each system and chemically treat as specified in Division 15.

3.13 PAINTING OF PIPING

A. Prime and field paint outdoor, weather-exposed, uninsulated steel piping using materials specified in Division 09.

B. Prime and field-paint indoor, exposed, uninsulated steel piping, installed in finished spaces, using materials specified in Division 09.

3.14 PIPE WRAPPING

A. Protect uninsulated bare steel piping and bare copper tubing, and their fittings, installed underground, in concrete slabs or in masonry walls, and which are not part of a factory pre-insulated underground piping system, with protective tape as follows:

1. Service Temperature -55 deg. F to 175 deg. F: Spirally-wrapped 3M Scotchrap 50 All-Weather Corrosion Protection Tape.

2. Service Temperature 176 deg. F to 250 deg. F: Spirally-wrapped Corrosion Control Products Co. Tapecoat HT-M High Temperature Tape.

B. Apply tape to piping and tubing in accordance with manufacturer's installation instructions. Prepare surfaces and apply primer as directed by tape manufacturer.

3.15 AIR VENTS

A. Provide at high points.

3.16 CONTROL VALVE PIPING AND VALVE BYPASS PIPING

A. Valves and strainers at automatic control valves shall be full line size indicated on the contract drawings.

1. Reduce pipe size at the inlet and outlet of control valves with reducing fittings.

2. Provide straight length of inlet and outlet piping as recommended by the control valve manufacturer, or as shown on drawings, whichever is greater.

B. Provide bypass pipe around automatic control valves, where shown on the contract drawings.

1. For a control valve assembly with one control valve, bypass pipe shall be the same size as control valve.

2. For a control valve assembly with two or more control valves, bypass pipe shall be the

same size as largest control valve.

3. Bypass piping shall have a full line size manual throttling valves, normally closed.

3.17 INSTALLATION WORK FOR AUTOMATIC CONTROLS

A. Provide work specified in Division 15.

+ + END OF SECTION + +

SECTION 15190 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels
5. Stencils.
6. Valve tags.
7. Warning tags.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.03 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS, SUBJECT TO COMPLIANCE WITH REQUIREMENTS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Seton.
2. Brady.
3. Pipemarker (Brimar Industries, Inc.).

4. Kolbi Pipe Marker Co.

2.02 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch (0.8-mm), stainless steel, 0.025-inch (0.64-mm), aluminum, 0.032-ainch (0.8-mm), or anodized aluminum, 0.032-inch (0.8-mm minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

3. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances.

a. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

4. Fasteners: Stainless-steel rivets or self-tapping screws.

5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) thick, and having predrilled holes for attachment hardware.

2. Letter Color: Black.

3. Background Color: White.

4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances.

a. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

7. Fasteners: Stainless-steel rivets or self-tapping screws.

8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

1. Equipment schedule shall be included in operation and maintenance data.

2.03 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color**:** Yellow.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances.

1. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.04 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches (38 mm) high.

2.05 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) thick, and having predrilled holes for attachment hardware.

B. Letter Color: See PART 3.

C. Background Color: See Part 3.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by

3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances.

1. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches (38 mm) high.

2.06 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.

1. Tag Material: Brass, 0.032-inch (0.8-mm), and having predrilled or stamped holes for attachment hardware.

2. Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper: tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.07 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches (100 by 178 mm).

2. Fasteners: Brass grommet and wire or reinforced grommet and wire.

3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

4. Color: Yellow background with black lettering.

2.08 UNDERGROUND PIPING WARNING TAPE

A. Acceptable Manufacturer, subject to compliance with requirements: Panduit HTDU-6B-W.

B. Install tape on top of all underground piping within 12" of grade.

C. Tape: Triple-laminate, consisting of aluminum foil, polyester film, and polyethylene, 6 inch wide.

PART 3 - EXECUTION

3.01 GENERAL

A. Identify piping and ductwork, exposed and accessible, after they have been tested, insulated or painted.

3.02 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.03 EQUIPMENT LABEL INSTALLATION

A. Coordinate final equipment designations with the Owner.

B. Furnish equipment with the manufacturer's identification plate information, showing the name of equipment, manufacturer's name and address, date of purchase, model number and performance data.

C. Install or permanently fasten labels on each major item of mechanical equipment.

D. Locate equipment labels where accessible and visible.

3.04 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Section 09911.

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels [with painted, color-coded bands or rectangles] [, complying with ASME A13.1,] on each piping system.

1. Identification Paint: Use for contrasting background.

2. Stencil Paint: Use for pipe marking.

C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Pipe Label Color Schedule:

1. Chilled-Water (including Chilled Beam Water) Piping:

a. Background Color: Green.
b. Letter Color: White.

2. Heating Water Piping:

a. Background Color: Yellow.
b. Letter Color: Black.

3.05 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes (Background/Letter):

1. Cold-Air and Neutral Air Supply Ducts: Blue/White.

2. General Exhaust-, Outside-, Relief: Green/White.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

3.06 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

a. Chilled Water: 1-1/2 inches (38 mm) round.
b. Hot Water: 1-1/2 inches (38 mm), round.
c. Gas: 1-1/2 inches (38 mm), round.

2. Valve-Tag Color:

a. Chilled Water: Natural.
b. Hot Water: Natural.
c. Gas: Natural.

3. Letter Color:

a. Chilled Water: Black.
b. Hot Water: Black,
c. Gas: Black.

3.07 SIGNAGE – ACCESS PANEL

A. Place a sign on all access panels providing accessibility to openings in grease ducts; “ACCESS PANEL – DO NOT OBSTRUCT”.

3.08 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

3.09 IDENTIFICATION OF PIPING AND VALVES

A. Locate markers as follows:

1. Adjacent to each valve and fitting, except on plumbing fixtures and equipment.

2. At each branch and riser take-off.

3. At each pipe passage through wall, floor, and ceiling construction.

4. At each pipe passage to underground.

5. On horizontal pipe runs - every 20 feet.

B. Pipe Identification: Legends to be used for piping and equipment identification shall be as listed on the "Symbols" and "Abbreviations" sheets of the contract drawings. The color fields and legend colors shall be selected from Table 2 of ANSI Standard A13.1, using the criteria that fluids with a temperature above 100 degrees F or with a pressure equal to or above 150 psig are categorized as "inherently hazardous". The size of legend letters shall be selected ANSI Standard A13.1.

C. Where pipes are too small or not readily accessible for application of pipe markers, securely fasten a brass identification tag at least 1 1/2 inches in diameter, with depressed 1/2-inch high black letters and numerals, at locations specified for pipe markers.

D. Valve Identification: Identify valves with a tag. Permanently stamp and mark valve tags with a service designation, normal valve position, and an identifying number as large as possible. Each valve shall have a unique number coordinated with the service designations shown on the contract drawings. Coordinate with the Owner before finalizing the valve tag numbering system.

3.10 FIRE PROTECTION SYSTEMS

A. Provide signs and tags as described in the referenced NFPA Standard 13.

3.11 EXHAUST FANS

A. Each fan shall also be identified as to the nature of its exhaust.

+ + END OF SECTION + +

SECTION 15200 - NOISE CONTROL (ACOUSTICAL TREATMENT AND PERFORMANCE)

PART 1 - GENERAL

1.1 SUMMARY

A. This section describes sound attenuators and acoustical liner.

1.2 SUBMITTALS

A. Submit for review:

1. Manufacturer's product data for all products.

2. Sound Attenuators: Test data of static pressure drop, dynamic net insertion loss ratings and self-generated noise sound power levels of factory-built sound attenuators. Base certification data for pressure drop and insertion loss on tests of the same attenuator for both measurements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Industrial Acoustics Co. (IAC)

2. Vibro-Acoustics

3. Dynasonics

4. Commercial Acoustics

5. Kinetics Noise Control

6. Semco

7. McGill AirSilence LLC

8. Price Industries

2.2 DESIGN CRITERIA

A. All products, unless noted otherwise, shall have a composite fire and smoke rating, when tested in accordance with ASTM E84, test procedures, not to exceed Flame Spread of 25 and Smoke Developed of 50.

B. Acoustical Liner and Rigid Liner Board: Liner and adhesive shall be odorless. No materials shall support mold, fungus or bacterial growth.

2.3 GENERAL – ALL SOUND ATTENUATORS

A. Sound attenuators shall be factory-fabricated of incombustible materials, and be a manufacturer's standard product.

B. The self-generated noise shall not exceed the amount shown on the sound attenuator schedule or

the contract drawings.

2.4 CONSTRUCTION – PACKLESS RECTANGULAR AND TUBULAR SOUND ATTENUATORS

A. Materials of Construction, Stainless Steel or Galvanized Steel

1. Duct-Mounted: Match material of construction to material of ductwork in which it is installed, as specified in SECTION 15840.

2. Mounted within Air Handling Units and/or Exhaust Air Energy Recovery Units.

a. Supply Airflow, Return Airflow, Outside Airflow: Galvanized Steel.
b. Exhaust Airflow: Type 304 Stainless Steel.

B. No sound-absorptive materials shall be used in the sound attenuators; attenuation of air-transmitted noise shall be by controlled-impedance membranes and broadly-tuned resonators.

1. Silencers shall not fail structurally when subjected to a differential air pressure of 8-inches water gauge between the inside and outside of the casing.

C. Determine sound attenuator ratings in accordance with ASTM E 477.

2.5 ACOUSTICAL DUCT LINER

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Johns-Manville Permacote Linacoustic HP & Spiracoustic PLUS.

2. Certainteed ToughGard R.

3. Knauf Sonic XP.

4. Owens-Corning QuietR & QuietZone.

B. Rectangular Ducts: Flexible acoustical duct liner shall meet ASTM C 1071 with the air surface coated with an acrylic coating formulated with an immobilized EPA-registered anti-microbial agent resistant to mold, fungus and bacterial growth as determined by ASTM G 21 and G22.

1. 'C' (Conductance) Value: ASTM C 177, 0.24 at 75 degrees.

2. Noise Reduction Coefficient: NRC = .70 based on Type "A" mounting, tested in accordance to ASTM C 423.

3. Maximum Velocity: 5,000 fpm.

4. Adhesive: Meeting ASTM C 916.

5. Fasteners: Manufactured duct liner galvanized steel pins, welded or mechanically fastened.

C. Round Ducts: Rigid preformed, round duct liner with the air surface coated with an acrylic coating formulated with EPA registered anti-microbial agent resistant to mold, fungus and bacterial growth as determined by ASTM G 21 and G22.

1. 'C' (Conductance) Value: ASTM C 177, 0.23 at 75 degrees.

2. Noise Reduction Coefficient: NRC = .75 based on Type "A" mounting, tested in

accordance to ASTM C 423.

3. Maximum Velocity: 5,000 fpm.

PART 3 - EXECUTION

3.1 INSTALLATION - SOUND ATTENUATORS

A. Install sound attenuators in accordance with manufacturer's recommendations, in order not to compromise attenuator performance and/or increase air pressure drop.

B. Install attenuators with flanges or connection hardware compatible with the associated single-wall or double-wall ductwork. Seal joint connections to prevent air leakage with embedded fabric tape type sealant in accordance with SECTION 15840.

C. Multiple Sound Attenuators: Where multiple sound attenuators are grouped together in parallel within a duct system or air handling unit, seal them airtight with EC-800 sealant by 3M Company, or Sika "Sikaflex 1A."

D. Duct Transitions: Provide g r a d u a l transition fittings between attenuators and connecting ductwork where attenuators are of a different size than the ductwork.

E. Insulation: Externally insulate sound attenuators to match adjacent ductwork insulation as specified in SECTION 15250.

3.2 INSTALLATION – ACOUSTICAL DUCT LINER

A. Install acoustical liner in ducts in the following locations:

1. In all acoustical air transfer ducts: [1.5 PCF 1.0" Thick].

2. Other locations where shown on contract drawings.

B. Surface Preparation: Before applying duct liners, remove grease, dirt, rust and scale from ductwork surfaces. Apply adhesive to clean, dry surfaces.

C. Apply duct liners to sheet metal in accordance with referenced SMACNA HVAC Duct Construction Standards (latest edition), NAIMA Fibrous Glass Duct Liner Standard, and manufacturer's instructions.

D. Adhesive: Apply adhesive uniformly to 100 percent of ductwork surfaces receiving liners.

E. Sheet Metal Nosings: Install sheet metal nosing equal to liner thickness where required by SMACNA HVAC Duct Construction Standards, latest edition.

F. Edge Coating: Coat all exposed trailing edges and transverse joints with adhesive.

G. Neatly butt edges and transverse joints without gaps.

H. Fill all voids, joints and seams with joint and seam filler.

I. Fastening: Secure the acoustical liner with mechanical fasteners in accordance with the referenced SMACNA HVAC Duct Construction Standards. Pin length shall limit acoustical liner compression to 1/8-inch.

J. Duct Dimensions: Dimensions indicated on contract drawings are clear inside dimensions. Where acoustical liner is to be applied, maintain inside dimensions, as shown on contract drawings, by

increasing outside dimensions of ductwork.

+ + END OF SECTION + +

SECTION 15251 – PLUMBING THERMAL INSULATION

PART 1 - GENERAL

1.01 SUMMARY

A. This section describes the insulation of piping, used in plumbing system.

1.02 SUBMITTALS

A. Submit for record:

1. Product data and installation instructions for insulations, mastics, sealants, coatings, adhesives and jacketing materials.

1.03 DELIVERY, STORAGE AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with affixed manufacturer's stamp or label, showing fire hazard ratings.

B. Protect insulation against dirt, water, and mechanical damage.

1.04 QUALITY ASSURANCE

A. The Contractor shall have a minimum of five years of satisfactory experience on projects using similar materials and techniques as required for this project.

B. Insulating materials adhesives and accessories, including PVC fitting, valve and flange covers, shall have a composite fire and smoke rating, when tested in accordance with ASTM E84, NFPA 255 or UL 723 test procedures, not to exceed Flame Spread of 25 and Smoke Developed of 50, suitable by building code for installation in raised-floor areas and in return air plenums.

PART 2 - PRODUCTS

2.01 APPROVED MANUFACTURERS

A. The following manufacturers are approved:

1. Fiberglass Piping and Ductwork Insulation: Johns Manville, Knauf, Owens-Corning.

2. Elastomeric Insulation: Armstrong, Rubatex.

3. Jackets and Accessories: Foster, Childers, Compac, Epolux, Hamfab, Pabco, Armstrong, Schuller, Owens-Corning, Pittsburgh-Corning, U.S. Gypsum, Ceel-Co, General Aluminum Supply Corporation, Pipe Shields, Inc., Proto, TCI Industries.

4. Removable Insulation Jackets: Insulation Innovations.

2.02 FIBERGLASS PIPE INSULATION

A. Pipe insulation, meeting ASTM Standard C 547, consisting of inorganic glass fibers bonded with thermosetting resin, molded into tubular sections split lengthwise, approximately 3.5 lb per cu ft, thermal conductivity of 0.23 Btu·in/h·ft^2·°F at 75°F. Approved Manufacturer: Johns-Manville Micro-Lok AP-T. Jackets shall be factory-applied, composite with insulation, with maximum water vapor permeance of 0.02 perms, fabricated from white kraft paper bonded to aluminum foil, reinforced with fiberglass scrim.

2.03 ELASTOMERIC INSULATION

A. Flexible elastomeric cellular insulation, meeting ASTM Standard C 534, in sheet or tubular form, thermal conductivity of 0.27 Btu·in/h·ft^2·°F at 75°F. Approved Manufacturer: Armstrong AP Armaflex - for roof drains and piping outdoors.

B. Adhesive for elastomeric insulation shall be Armstrong Model 520.

C. Flexible, tubular, self-seal, elastomeric insulation conforming to ASTM C 177 or C 518 with thermal conductivity of 0.27 at 75°F. Manufacturer: Armstrong, Armaflex 2000 - for piping up to 2" dia. installed inside the building.

D. Elastomeric Insulation on Piping Located Outdoors

1. Elastomeric insulation shall receive a 10 x 10 fiber glass or polyester mesh adhered to outside of insulation with Armstrong 520 adhesive. Apply two coats of Armstrong WB Armaflex, white acrylic latex finish in accordance with manufacturer's instructions.

2.04 REMOVABLE INSULATION JACKETS - FOR FITTINGS AND VALVES

A. Factory fabricate all removable insulation jackets.

B. Use fiberglass straps and nylon buckles to secure jackets to standard fittings.

C. Design jackets for standard fittings for installation and removal without tools, fasteners or devices other than those attached to the jacket.

D. Provide stainless steel lined weep holes to identify leaks.

E. Jacket bodies shall extend a minimum of 3 inches past flanged end connections and shall provide a tight fit with adjacent pipe insulation. End flaps, where used, shall be insulated.

F. Each jacket shall have an identification label with manufacturer, date code, and maximum temperature rating and fitting identifications.

G. Jackets for flanged gate and globe valves, 2 inches and larger, shall have separately removable bonnet jackets to facilitate valve maintenance. Valve bonnet jackets shall have overlapping leaves, with insulation and stainless steel foil liners, to allow interchange of entire jacket assemblies between valves of varied configurations.

H. Jacket materials shall be flame-retardant and shall meet or exceed the requirements of Underwriters Laboratories, Inc. vertical burning test (UL 94).

I. All jacket materials, including seams, thread and fasteners, which come in contact with hot surfaces shall be rated for the fluid service temperatures.

J. Fabricate exterior surfaces of jackets of Teflon-coated fiberglass cloth, nominal 16 ounces per square yard, with a nominal one (1) mil coating thickness.

K. Jacket interior surfaces shall be 0.002 inch thick, Type 304 stainless steel foil reinforced with a nominal 19 ounce per square yard fiberglass cloth applied with high-temperature adhesive.

L. Jacket insulation materials and minimum thickness shall be the same as the adjacent piping as shown in the Pipe Insulation Schedule.

M. Approved Manufacturer: Insulation Innovations "Cal-Save Buckler."

2.05 PIPE INSULATION PROTECTION SHIELDS

A. Provide pipe insulation protection shields as specified in Section 15141.

2.06 TAPES

A. Vapor barrier type, self-sealing (with release paper) non-corrosive, fire-retardant, 3/4 inch and 3 inches wide by 6.9 mils thick. Approved Manufacturer: PermTape by Compac.

2.07 BANDS

A. Preformed metal butt snap straps and banding straps furnished with metal jackets specified elsewhere in this Section.

2.08 PREMOLDED PIPE-FITTING INSULATION AND COVERS

A. Fiberglass, molded in two matching half-sections, matching the density, thermal conductivity and thickness of the adjoining pipe insulation. For fiberglass, use Types 450/650/850 by Hamfab, Inc.

B. Polyvinyl chloride (PVC), 20 mils thick, meeting Federal Specification L-P-535E. Provide 2-layer precut insulation inserts matched to pipe insulation, vapor barrier, and required mastic adhesives and tapes. Approved Products "Zeston 2000 25/50 Rated PVC Insulated Fitting Covers" by Johns Manville, "Sealfas Smoke-Safe 25/50" by Foster or "LoSmoke" by Proto.

PART 3 - EXECUTION

3.01 GENERAL

A. Apply insulation on clean, dry surfaces after leakage and other tests have been completed.

B. Piping equipment located within shaft spaces, above acoustical tile or GWB ceilings, in crawl spaces, and in pipe trenches shall be considered as concealed. Other piping and equipment shall be considered exposed.

C. Where piping is heat-traced, provide the insulation thickness scheduled for heat-traced lines and not the thickness scheduled for the specific piping system. Insulate piping after tracing has been installed and tested for continuity.

D. Do not insulate domestic water pipes that are chrome-plated for applications in exposed finished areas except for piping to handicapped fixtures.

E. Install insulation neatly, accurately and without voids, in accordance with manufacturer's instructions and NIAC National Commercial and Industrial Insulation Standards.

F. Insulate fittings, strainers, valves and flanges using premolded covers with precut insulation inserts, or with removable insulation jackets.

G. Do not use staples in vapor barrier jackets.

3.02 FIBERGLASS PIPING INSULATION

A. For Rainwater Conductors, Domestic Cold and Hot Water Systems

1. For piping located indoors apply insulation as specified and seal butt joints with fire-retardant tape.

2. Insulate horizontal rainwater conductors, including elbow turning up and down, and first vertical drop.

3. Insulate roof drains body.

4. For piping located outdoors, apply insulation as specified, seal butt joints with fire-retardant tape, and cover with a stainless steel jacket and fitting covers. Provide 1-1/2 inch overlap at the circumferential joints of metal jacket.

3.03 PIPE INSULATION SCHEDULE

A. Insulate piping in accordance with the following schedule:

SERVICE	COMMENT	PIPE DIAMETER	MATERIAL	THICKNESS (INCHES)
Storm Drainage Piping (All Horizontal Runs)	---	All	Fiberglass or Elastomeric	1 0.5
Electric Water Coolers and Ice Maker Drain Lines and Traps and Air Conditioning System Drain Horizontal Piping	---	All	Fiberglass or Elastomeric	0.5
Domestic Hot , Cold and Hot Water Return	---	All	Fiberglass or Elastomeric	1 0.5
Body of Roof Drains	Blanket Insulation	All	Fiberglass or Elastomeric	0.5

+ + END OF SECTION + +

SECTION 15303 - AUTOMATIC WET-PIPE SPRINKLER SYSTEM

PART 1 - GENERAL

1.01 PRINCIPAL WORK IN THIS SECTION

A. Complete hydraulically calculated automatic wet-pipe sprinkler system as shown on Contract Drawings.

B. Sprinkler system shall be hydraulically calculated and designed by a qualified NICET III designer or licensed professional engineer.

1.02 CODES AND STANDARDS

↗. The fire sprinkler system and all related work shall comply with the rules and regulations of the following, which are hereby made a part of this Specification:

☙. Building Codes

1. DE Building Code: IBC 2009 with amendments:

☙. National Fire Protection Association Standards

1. NFPA 13, Standard for the Installation of Sprinkler Systems – 2010
2. NFPA 30, Flammable and Combustible Liquids Code - 2012 Edition
3. NFPA 72, National Fire Alarm Code® - 2012 Edition
¼ NFPA 45 - Fire Protection for Laboratories Using Chemicals – 2004 Edition
½ NFPA 101, Life Safety Code® - 2012 Edition

Ð. Listing Laboratory

1. Underwriters Laboratories (UL) Equipment List – Latest Edition

€. Insurance Underwriter

1. FM Global Requirements and Approval Guide – Latest Edition
2. FM Global Property Loss Prevention Data Sheets – Latest Edition

1.03 WORK DESCRIPTION

A. Work provided by this Contractor under this Section shall include but not limited to the following:

1. Complete hydraulically calculated automatic wet-pipe sprinkler system.

2. Hydrant flow test within twelve months of first shop drawing submittal.

3. Waterflow and valve supervisory switches.

4. Sleeve installation.

5. Cutting and patching.

6. All hanging, bracing, and restraint of sprinkler system piping including fasteners, inserts and anchors.

7. Installation shall be based on actual survey and all of the architectural, structural, heating, ventilating, plumbing, and electrical drawings.

8. Water supply and environmental conditions evaluation.

9. Work required per Execution Section.

1.04 SUBMITTALS

A. Shop Drawings

1. Prepare shop drawings in accordance with NFPA 13.

2. Shop drawings shall be at minimum scale of 1/8" = 1'-0" for plans, and 1/4" = 1'-0" for details.

3. Show all piping, sprinkler, and hanger types & locations.

4. Show occupancy hazard classification of each area.

5. Show roof construction, including ceiling and roof heights, ceiling plan, room names and numbers.

6. Show locations of Test Connections & Drains & Fire Seals & Signs

7. Submit shop drawings to Factory Mutual/Global, the Owner's insurance authority, in the number required. Partial submittals will not be accepted.

B. Hydraulic Calculations

1. Calculations shall be provided for each hazard classification.

2. The calculations to include remote area of the sprinkler system to the point of flow test.

3. The calculation of friction losses to include inside and/or outside hose stream flow at point of connection plus sprinkler flow.

4. Include friction losses from existing equipment i.e. backflow preventer, check valves, control valves, etc.

5. 10 psi excess pressure shall be provided for the sprinkler system and indicated on the calculation.

C. Material & Equipment Data Sheets

1. Submit manufacturer’s data of all equipment utilized including pumps, controllers, valves, specialties, hangers, sprinklers, piping, and pipe sizes.

D. Equipment Operating Manuals & Packing Instructions.

E. Water supply and environmental conditions evaluation.

F. Following approval of submittal from insurance authorities, provide submittal with the insurance authorities' letter and stamp of approval and/or comments to BALLINGER.

1.05 OWNER DOCUMENTS

A. The installing contractor shall provide the property owner or the property owner's authorized representative with the following:

1. NFPA 13 Material and Test Certificate For Aboveground Piping

2. Letter of Approval from Insurance Underwriter

3. Certificate of Occupancy from AHJ.

4. As-built Drawings and Hydraulic Calculations.

5. Equipment Operating Manuals & Packaging instructions.

6. All literature and instructions provided by the manufacturer describing proper operation and maintenance of all equipment and devices installed.

7. NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.

1.06 WATER SUPPLY

A. The source of water supply shall be the municipal water supplemented with an onsite fire pump.

B. Contractor shall provide the water flow test conducted in accordance with NFPA 291 within twelve (12) months of shop drawing submittal.

C. Water supplies and environmental conditions shall be evaluated for the existence of microbes and conditions that contribute to microbiologically influenced corrosion (MIC) and/or unusual corrosive properties.

PART 2 - PRODUCTS

2.01 Approved Manufacturers

A. Sprinklers:

1. Globe Fire Sprinkler Corporation
2. Reliable
3. Viking Corp
4. Victaulic

B. Pipe:

1. Allied Tube.
2. American Tube and Pipe.
3. Wheatland Tube.
4. United States Pipe and Foundry.

C. Grooved Couplings:

1. Victaulic
2. Tyco

D. Valves:

1. Reliable
2. Tyco
3. Victaulic
4. Nibco
5. Kennedy Valve
6. Watts
7. Mueller
8. Elkhart
9. Croker

E. Fire Protection Specialties:

1. Reliable
2. Tyco
3. Globe Fire Sprinkler Corporation
4. Viking Corp

6. Victaulic
7. AFG Manufacturing Inc.
8. Potter – Roemer

F. Sprinkler Flow & Tamper Switch:

1. Potter Electric Signal
2. System Sensor

G. Fire Department Connections:

1. Croker
2. Potter Roemer
3. Elkhart

H. Fire/Smoke Seals:

1. 3M or approved equivalent.

2.02 FIRE SPRINKLERS

A. All sprinklers shall be U.L. Listed and F.M. approved.

B. Provide sprinklers of the types indicated on the Drawings.

C. Provide upright sprinkler heads within 7' -0" of the finished floor and at other locations where the sprinkler head is subject to physical damage.

D. Provide spare sprinklers of each type and temperature rating used. Comply with NFPA 13 as to the number of spare heads required.

E. Provide a special sprinkler wrench for the installation and replacement for each type of sprinkler used.

F. High temperature sprinklers of proper degree rating shall be installed per NFPA 13.

G. Sprinklers on exposed piping shall be listed and approved bronze upright type, in upright position.

H. Sprinklers in suspended ceiling shall be fully concealed type with flat plate.

I. Sprinklers shall only be painted by the sprinkler manufacturer.

J. Escutcheons used with sprinklers shall be part of a listed sprinkler assembly.

K. Cover plates used with concealed sprinklers shall be part of the listed sprinkler assembly.

L. Sprinklers subject to mechanical injury shall be protected with listed guards.

2.03 FIRE SPRINKLER SYSTEM PIPE

A. All piping in fire protection systems shall be U.L. listed and F.M. approved.

B. Aboveground piping shall be:

1. Welded and seamless carbon steel pipe per ANSI/ASTM A-53.
2. Black and hot-dipped zinc-coated (galvanized) welded and seamless steel pipe per ASTM A-795.
3. Wrought steel pipe per ANSI/ASME B36.10M
4. Electric-resistance welded steel pipe per ASTM A-135.

C. Wet sprinkler pipe shall be Schedule 40 for sizes up to 1½”.

D. Wet sprinkler pipe shall be Schedule 10 for sizes 2” and above.

E. Pipe for dry systems shall be Schedule 40.

F. Pipe for dry systems shall be galvanized.

G. All sprinkler piping, drain and test piping, Fire Department connection piping, etc. installed through exterior walls shall be galvanized.

H. All threaded pipe and fittings shall have threads cut to ASME B1.20.1, Pipe Threads, General Purpose (Inch).

2.04 FLANGES & FITTINGS

A. All flanges, fittings and couplings in fire protection systems shall be U.L. listed and F.M. approved.

B. All flanges, fittings and couplings shall be rated for a minimum operating pressure of 175 psi.

C. Rubber-gasketed outlet fittings shall meet the following requirements:

1. UL listed and FM approved.
2. Installed in accordance with listing and manufacturer's installation instructions.
3. Have all disks retrieved.
4. Have smooth bores cut into the pipe, with all cutting residue removed.

D. Grooved End Fittings and Mechanical Tees

1. The use of grooved end couplings, fittings and mechanical tees shall be limited to those of one common manufacturer.

2. Grooved fittings shall be joined by a listed combination of fittings, gaskets, and grooves.

3. Grooves cut or rolled on pipe shall be within tolerances per the manufacturer.

4. Mechanical tees may be used on piping 3-inches and larger and shall not be of the hinged U-Bolt type.

E. Plain end fittings shall not be used.

F. Cast Iron

1. Cast iron threaded fittings, Class 125 and 250 per ASME B16.4.

2. Cast iron pipe flanges and flanged fittings per ASME B16.1.

G. Malleable Iron

1. Malleable iron threaded fittings, Class 150 and 300 steel per ASME B16.3

2. Wrought carbon steel and alloy steel for moderate and elevated temperatures per ASTM A-234.

3. Steel pipe flanges and flanged fittings per ASME B16.5.

2.05 HANGING, BRACING, AND RESTRAINT OF SYSTEM PIPING

A. HANGERS

1. All hangers, bracing and restraints shall be shall be U.L. listed and F.M. approved.

2. All sprinkler piping must be supported from building structure.

3. The spacing between hangers shall not exceed the value given for the type of pipe as indicated in NFPA 13.

4. Hanger rod size shall be the same as that approved for use with the hanger assembly, and the size of rods shall not be less than that given by NFPA 13.

5. Sprinkler pipe under ducts shall not be supported from ductwork but shall be supported from building structure with trapeze hangers where necessary or from steel angles supporting ductwork in accordance with NFPA 13.

6. For trapeze hangers, the minimum size of steel angle or pipe span between purlins or joists shall be such that the available section modulus of the trapeze member meets the requirements of NFPA.

2.06 FIRE PROTECTION VALVES

A. Valves in fire protection systems shall be U.L. Listed and F.M. approved.

B. Valves shall be rated for a minimum operating pressure of 175 psi.

C. Valves controlling connections to water supplies and to supply pipes to sprinklers shall be listed indicating valves.

D. Listed water control valve assembly with a reliable position indication connected to a remote supervisory station shall be permitted.

E. Sprinkler control valves shall be ball or butterfly type with built in supervisory switch.

1. 2" through 3" dia. valves shall be butter-ball type rated at 175 psi.
2. 4" dia. and greater valves shall be butterfly type rated at 175 psi.
3. Valves under 2" dia. shall be all bronze solid wedge, O.S. & Y. Type.

F. Drain valves and test valves shall be approved.

G. Listed riser assemblies are permitted.

H. All valves shall be accessible and location identified.

2.07 SUPERVISORY SWITCHES

A. Supervisory valve switches shall be UL listed and FM approved.

B Supervisory switches shall be installed on each control valve in the sprinkler system.

C. Switches shall be installed in accordance with Manufacturer’s installation instructions, listings and approvals.

D. Switch outputs shall consist of two SPDT switches (Form C contacts) with 24V contacts.

E. The entire installed assembly shall be tamperproof and arranged to cause an alarm if the housing cover is removed or if the unit is removed from its mounting.

2.08 WATERFLOW SWITCHES

A. Waterflow switches shall be UL listed and FM approved.

B. Waterflow switches shall be installed on the sprinkler system piping as designated on the drawings and/or as specified herein.

C. Switches shall be installed in accordance with Manufacturers installation instructions, listings and approvals.

D. Switches shall have a preset time delay which is field adjustable to accommodate fluctuations in supply pressure.

E. Switch outputs shall consist of two SPDT switches (Form C contacts) with 24V contacts.

F. Sprinkler system flow shall actuate an exterior weather proof horn/strobe at an approved location.

G. Switches shall be finished in red baked enamel.

2.09 INSPECTOR'S TEST

A. Provide inspector's test connections, as indicated on the drawings for testing each waterflow alarm device.

B. Special discharge nozzle shall have same size orifice as majority of sprinklers installed. See details on drawings.

C. Provide 1-inch sight glass where inspector's test discharge cannot be readily observed while operating valve.

2.10 DRAINS

A. Provide 2-inch drain valves at system control valves.

B. All drains shall discharge to sanitary. Verify capability of existing drains to accept full flow discharge.

C. Provide all auxiliary drains where necessary and extended to approved location.

D. Plugs used for auxiliary drains shall be brass.

E. All drain piping downstream of drain valve shall be galvanized.

2.11 CEILING AND WALL PLATES

A. Install polished chrome finished ceiling and wall plates wherever exposed sprinkler piping passes through ceiling and walls. Plates shall be one piece steel.

2.12 IDENTIFICATION SIGNS

A. Provide identification signs for all sprinkler alarm devices and control valves.

B. Provide hydraulic data plates on all sprinkler floor control assemblies.

C. Provide all necessary identification signs for piping, control valves, main drain valves, auxiliary drains, test drains, and all other signs, which may be required by NFPA.

D. Signs shall be secured to valve wheels, by means of light copper chains, and shall be of colors, printing, and materials required by NFPA.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Install paired flanges and numbered test blanks to provide partial protection during construction.

B. Maintain a "test blank log" at the site during construction to assure removal of all blanks at completion of job.

C. Do not install valves with stem down and insure handle clearance for proper operation and repair.

D. Where sprinklers have had paint applied by other than the sprinkler manufacturer, they shall be

replaced with new listed sprinklers of the same characteristics, including orifice size, thermal response, and water distribution.

3.02 FIRE SPRINKLER PIPE INSTALLATION

A. Unless shown otherwise, route piping in the most direct manner, parallel to building lines.

B. Install sprinkler piping as high as possible using necessary fittings and auxiliary drains to maintain maximum clear head room.

C. Locate piping to maintain clearance around equipment for removal.

D. Close open ends of piping and equipment, when it is not being worked on, with flange covers, caps or plugs.

E. Do not use pipes smaller than 1-inch, unless specifically otherwise documented.

F. Bending of steel or copper pipe is not permitted.

G. Clean piping and equipment of metal cuttings to remove grease, loose dirt, mill scale and other foreign matter prior to installation and in accordance with all applicable codes and standards.

H. Provide auxiliary drains with valve at all low points of piping which traps more than 5 gallons of water.

I. Drain valves shall be provided with 3/4" hose connection.

J. Reduce pipe sizes with reducing fittings. Bushings shall not be permitted.

K. Fire Rated Penetration Seals:

1. Where piping passes through fire rated construction or smoke barrier the annular space between the pipe and the rated wall or floor construction shall be sealed with a UL listed fire rate seal system.

2. The fire seal rating shall correspond to the fire resistance rating of the construction through which it passes.

3. Contractor shall mark wall above ceilings or unfinished areas with 3" high letters and numbers, identifying the UL approved seal and sleeve assembly or design number.

4. Coordinate identification method with engineer and construction manager.

3.03 THREADED PIPE JOINTS

A. The following piping shall have threaded joints:

1. Carbon steel pipe 2-1/2" and smaller, as specified elsewhere in this Section.

B. Seal threaded joints with a non-corrosive, non-hardening compound or PTFE tape applied on the male thread. Caulking of threaded joints is not permitted.

C. Ream or file pipe ends to size of bore, remove chips and cuttings.

D. Cut pipe ends square.

3.04 WELDED PIPE AND FITTINGS

A. Welding shall be permitted as a means of joining sprinkler piping in accordance with the following 6.5.2.2 through 6.5.2.6

B. When welding sprinkler pipe, the pipe shall be shop welded.

C. Welding shall not be performed where there is impingement of rain, snow, sleet, or high wind on the weld area of the pipe product.

D. Torch cutting and welding shall not be permitted as a means of modifying or repairing sprinkler systems.

E. Welded fittings used to join pipe shall be listed fabricated fittings or manufactured in accordance with NFPA 13.

F. Fittings shall be joined in conformance with a qualified welding procedure as set forth in this section and shall be an acceptable product under this standard, provided that materials and wall thickness are compatible with other sections of this standard.

G. When the pipe size in a run of piping is reduced, a reducing fitting designed for that purpose shall be used in accordance with NFPA 13.

H. Welding Requirements

1. Welds between pipe and welding outlet fittings shall be permitted to be attached by full penetration welds, partial penetration groove welds, or fillet welds.

2. The minimum throat thickness shall be not less than the thickness of the pipe, the thickness of the welding fitting, or in. (4.8 mm), whichever is least.

3. Circumferential butt joints shall be cut, beveled, and fit so that full penetration is achievable. Full penetration welding shall not be required.

4. Where slip-on flanges are welded to pipe with a single fillet weld, the weld shall be on the hub side of the flange and the minimum throat weld thickness shall not be less than 1.25 times the pipe wall thickness or the hub thickness, whichever is less.

5. Face welds on the internal face of the flange shall be permitted as a water seal in addition to the hub weld.

6. When welding is performed, the following shall apply:

a. Holes in piping for outlets shall be cut to the full inside diameter of fittings prior to welding in place of the fittings.
b. Discs shall be retrieved.
c. Openings cut into piping shall be smooth bore, and all internal slag and welding residue shall be removed.
d. Fittings shall not penetrate the internal diameter of the piping.
e. Steel plates shall not be welded to the ends of piping or fittings.
f. Fittings shall not be modified.
g. Nuts, clips, eye rods, angle brackets, or other fasteners shall not be welded to pipe or fittings, except as permitted by NFPA 13.
h. Completed welds shall be free from cracks, incomplete fusion, surface porosity greater than in. (1.6 mm) diameter, and undercut deeper than 25 percent of the wall thickness or in. (0.8 mm), whichever is less.
i. Completed circumferential butt weld reinforcement shall not exceed in. (2.4 mm).

I. Welding Qualifications

1. A welding procedure shall be prepared and qualified by the contractor or fabricator before any welding is done.

2. Qualification of the welding procedure to be used and the performance of all welders and welding operators shall be required and shall meet or exceed the requirements of AWS B2.1, Specification for Welding Procedure and Performance Qualification, ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications, or other applicable qualification standard as required by the authority having jurisdiction.

3. Successful procedure qualification of complete joint penetration groove welds shall qualify partial joint penetration (groove/fillet) welds and fillet welds in accordance with the provisions of this standard.

4. Welding procedures qualified under standards recognized by previous editions of this standard shall be permitted to be continued in use.

5. Contractors or fabricators shall be responsible for all welding they produce.

6. Each contractor or fabricator shall have available to the authority having jurisdiction an established written quality assurance procedure ensuring compliance with the welding requirements.

J. Welding Records

1. Welders or welding machine operators shall, upon completion of each welded pipe, place their identifiable mark or label onto each piece adjacent to a weld.

2. Contractors or fabricators shall maintain certified records, which shall be available to the authority having jurisdiction, of the procedures used and the welders or welding machine operators employed by them, along with their welding identification.

3. Records shall show the date and the results of procedure and performance qualifications.

3.05 SPRINKLER SYSTEM ACCEPTANCE TESTING

A. Before testing, verify the installation of each pipe line, including supports, hangers, anchors and sprinklers is complete.

B. Provide two days notice of testing to the Owner. Testing shall be witnessed by EH&S, Local Fire Official, Engineer and/or Owner Representative.

C. Hydrostatic Test

1. All piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at 200 psi and shall be maintained without pressure loss for 2 hours.

2 Portions of systems normally subjected to system working pressures in excess of 150 psi shall be tested at a pressure of 50 psi in excess of system working pressure.

3. Loss shall be determined by a drop in gauge pressure or visual leakage.

4. The test pressure shall be read from a gauge located at the low elevation point of the system.

5. Additives, corrosive chemicals such as sodium silicate, or derivatives of sodium silicate, brine, or similar acting chemicals shall not be used while hydrostatically testing systems or for stopping leaks.

6. Piping between the exterior fire department connection and the check valve in the fire department inlet pipe shall be hydrostatically tested in the same manner as the balance of the system.

7. Provision shall be made for the proper disposal of water used for flushing or testing.

8. Test Blanks

a. Test blanks shall have painted lugs protruding in such a way as to clearly indicate their presence.
b. The test blanks shall be numbered, and the installing contractor shall have a

record keeping method ensuring their removal after work is completed.

c. When subject to hydrostatic test pressures, the clapper of a differential-type valve shall be held off its seat to prevent damaging the valve.

9. Pumps and other mechanical equipment shall not be subject to the piping field pressure test.

10. Provide systems to be pressurized with gauges and pressure-relieving devices.

11. Lines containing check valves shall have the source of test pressure located on the high-pressure side of the valves. Line control valves shall be set and maintained in a wide-open position.

D. Waterflow Switches

1. Waterflow switches including the associated alarm circuits shall be flow tested through the inspector's test connection and shall result in an audible alarm on the premises within 5 minutes after such flow begins and until such flow stops.

E. Main Drain Valves

1. The main drain valve shall be opened and remain open until the system pressure stabilizes.

2. The static and residual pressures shall be recorded on the contractor's material and test certificate.

F. Control Valves

1. All control valves shall be fully closed and opened under system water pressure to ensure proper operation.

3.06 COOPERATION WITH OTHER TRADES

A. Coordinate with the work of the other trades toward the general purpose of having the construction progress as rapidly and as smoothly as possible with a minimum of interference between one trade and another.

+ + END OF SECTION + +

SECTION 15322 - ELECTRIC MOTOR DRIVEN CENTRIFUGAL FIRE PUMPS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Provide an electric motor driven, split case, centrifugal fire pump for the building fire suppression systems. Also provide an electric motor driven pressure maintenance jockey pump. The work described in this section also includes the installation of the fire and jockey pump controllers and related control components.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 15303 - Automatic Wet Pipe Sprinkler Systems.

1.03 SUBMITTALS

A. Shop Drawings and Product Data - Prior to installation, submit and obtain approval from the fire official and the Owner's Insurance Carrier for use and installation within this project.

B. After approval by the above agencies submit the same materials, bearing this approval, to the Design Professional for review.

C. Any work installed prior to agency approval or Design Professional review is subject to rejection.

D. Any deviation from the design documents and/or specifications must be clearly identified prior to award of bids, in an accompanying statement indicating said deviation.

E. Submittals are to be complete. Partial Submittals shall not be accepted.

F. After approval by the aforementioned agencies, submit one complete record set of documents bearing the approval of the aforementioned agencies to the Owner.

G. Upon completion of the project, submit one complete, CAD-based record set of As-Built documents to the engineer and another to the Owner. These As-Built drawings shall be on CD in AutoCad Release 2010 format.

H. The submittal shall include the materials and information described in NFPA 20 as highlighted by the following. This list shall not be construed as a complete listing.

1. Centrifugal fire pumps
2. Jockey pumps
3. Electric motor drives
4. Fire pump controller
5. Jockey pump controller
6. Fire pump pressure recorder
7. Fire pump flow meter
8. Fire pump test header
9. Piping and wiring diagrams
10. Hydraulic calculations
11. Pump operating data, design GPM, suction pressure requirements, discharge pressure, motor hp and rpm
12. Factory Test reports
13. Certified pump performance curves
14. Certified pump test report
15. Service contracts

F. Description, type, model, location and catalog cuts of products specified in Part 2. SHOULD MORE THAN ONE ITEM OR A SPECIFIC ITEM WITH MULTIPLE OPTIONS APPEAR ON A SINGLE CUT SHEET, THE ITEM OR ITEMS SHALL BE SPECIFICALLY INDICATED.

G. Operation and maintenance manuals, including pump and drive parts list and recommended spare

parts

1.04 QUALITY ASSURANCE

A. Comply with the requirements of the following Regulatory Agencies, Codes and Reference Standards:

B. Building Codes: Building Code: IBC 2009 with amendments:

C. National Fire Protection Association Standards

1 . NFPA 13, Standard for the Installation of Sprinkler Systems – 2010
2 . NFPA 30, Flammable and Combustible Liquids Code - 2012 Edition
3 . NFPA 72, National Fire Alarm Code® - 2012 Edition
¼ NFPA 45 - Fire Protection for Laboratories Using Chemicals – 2004 Edition
½ NFPA 101, Life Safety Code® - 2012 Edition

D. Listing Laboratory: Underwriters Laboratories (UL) Equipment List – Latest Edition

E. Insurance Underwriter: FM Global Requirements and Approval Guide – Latest Edition

PART 2 - PRODUCTS

2.01 GENERAL

A. All products specified in Part 2 shall be UL listed and FM approved based on the current FM Approval Guide, for fire protection service.

2.02 PIPE HANGERS AND SUPPORTS

A. Provide pipe hangers and supports in accordance with the Regulatory Agencies, Codes and Standards.

2.03 FIRE PUMPS

A. Provide split case fire pump, including pump drive, controller and accessories. The fire pump shall deliver 500 GPM at 70 psi boost (3560 RPM).

B. Mount fire pump and pump drive as a factory packaged unit on a common steel base plate, and connect to each other with a flexible shaft coupling equipped with a coupling guard. Provide a concrete housekeeping pad, minimum of 6 inches thick and 4 inches wider on all sides than the fire pump base plate.

C. Pump shall be capable of delivering not less than 150% of rated flow at 65% rated pressure.

D. Pump shutoff pressure shall not exceed 120% rated pressure.

E. If required, provide eccentric reducer on the suction side of pump and a concentric increaser on the discharge side of pump.

F. Provide an automatic 3/4-inch circulation relief valve set at slightly lower than shutoff pressure, pipe discharge to an open funnel drain. Circulation relief valve to discharge 3-5% at pump churn pressure.

G. Provide pump suction and discharge gauges each with 3-1/2 inch dials reading in psig and having a range equal to twice the rated discharge pressure of the pump, or 300 psig whichever is greater.

2.04 FIRE PUMP DRIVE

A. Provide a 50 HP electric motor fire pump drive rated for 460 volts/3 phase/60 Hertz at 3560 rpm.

2.05 FIRE PUMP CONTROLLERS

A. Provide factory assembled, pre-wired and tested automatic controllers for electric motor driven fire pumps.

B. Locked rotor KVA code letter G.

C. NEMA design letter B.

D. The controller shall be built in accordance with NFPA 20.

E. The controller shall automatically start the fire pump when water pressure switch senses a preset pressure drop in the sprinkler standpipe system.

F. Provide a reduced voltage, wye-delta, closed transition type electric controller consisting of:

1. Magnetic motor contactor.
2. Circuit breaker.
3. Water pressure switch and necessary circuitry.
4. Control transformer.
5. Current sensors for locked rotor protection.
6. Running period timer and pilot light.
7. Isolation switch.
8. "Hand"-"Off"-"Automatic" selector switch.
9. Starting relays and all required alarm, protective, control, monitoring and indicating devices.
10. Auxiliary contacts for remote alarm and monitoring.
11. Floor mounted NEMA 2 enclosure with hinged door.
12. Automatic Transfer Switch.

G. Controller Performance

1. Manual start for test or emergency shall be done electrically from the "start" push-button on the front of the fire pump controller. The motor shall continue running until stopped by the "stop" push-button on the controller.

2. Provide a pilot light to give visual indication of power availability.

3. Automatic start shall be initiated by an integral pressure-sensitive switch responsive to a field-set drop in system pressure. The pressure switch shall have a calibrated dial and independent setting adjustments.

4. To prevent cycling, provide a running timer which shall be adjustable for a minimum of one minute for each ten horsepower, maximum need not exceed 7 minutes, regardless of horsepower. The running period timer shall provide an automatic stop.

5. The magnetic motor contactor shall be operated at line voltage, while the associated control circuitry, relays and push buttons shall operate on 115 volts from a control transformer.

6. Power availability relays shall monitor line power and also assure that the isolating switch and circuit breaker are closed. Provide contacts on these relays to discretely operate remote alarm devices from a separately supplied reliable power source in the event of:

a. Loss of line power on line side of motor starter in any phase.
b. Failure or disconnection of the control transformer.
c. Phase reversal on line side of motor starter.
d. Pump on emergency power.

H. Provide contacts on the motor contactor to signal remotely that the controller is in the "pump

running" condition.

I. Provide contacts to signal remotely in the event the controller is in a trouble condition, including controller in the "OFF" position.

2.06 FIRE PUMP TEST HEADER

A. Provide a fire pump test header where shown on the drawings.

B. Test header will consist of Three 2-1/2 inch fire hose outlet connections and a 6-inch flanged inlet connection.

C. The wall plate shall be lettered FIRE PUMP TEST header and all exposed parts shall be polished chrome.

D. The fire pump test header shall be flat plate concealed type.

2.07 FIRE PUMP PRESSURE RECORDER

A. Provide a 10" dia. pressure recorder, integral with the controller or wall mounted, which shall supply accurate, reliable time, and pressure checks on the wet pipe sprinkler system pump discharge piping.

B. The recorder shall have a reserve spring capacity of 48 hours.

C. The recorder shall be rated for 115 volts ac.

D. Connect pressure recorder to 1/4" copper piping to fire pump controller.

2.08 JOCKEY PUMPS

A. Provide a centrifugal jockey pump complete with electric pump drive, controller, and pressure switch. Pump capacity to be 5 gpm vs. 125 psi. The basis for design is an Aurora #JP-277-5

B. Provide an electric pump drive motor 2 1/2 HP rated for 460 volts/3 phase/60 Hertz at 3500 rpm.

C. When water pressure in the sprinkler standpipe system drops below a pre-set level (approximately 5 psig higher than the pressure switch for the main pump controller), a pressure switch shall energize a starter which activates the jockey pump.

D. Provide jockey pump with pressure relief valve.

E. Provide factory assembled, pre-wired, and tested automatic jockey pump controller of the same manufacturer as the fire pump controller and including:

1. "Hand"-"Off"-"Automatic" selector switch located on the front of the controller door.
2. Fusible 3- pole disconnect switch.
3. Magnetic motor contactor
4. Control transformer
5. Three thermal overload relays with external reset button.
6. Pressure switch and necessary circuitry.
7. Running period timer and pilot light.
8. All required alarm, protective, control, monitoring and indicating devices.
9. NEMA 2 enclosure with hinged door, suitable for wall mounting.

2.09 WIRE AND CONDUIT

A. Wiring and conduit shall be in accordance with the manufacturer's Specification and NFPA 70.

2.10 MANUFACTURER

A. The following manufacturer's equipment would be acceptable, are approved for use on this project,

however, product data submission shall still be required as described in paragraph 1.3.

1. Patterson Fire Pumps and Jockey Pumps
2. Aurora Pump Unit General Signal Corp.
3. Fairbanks Morse Pump Div. Colt Ind. Operating Corp.
4. Peerless Pump Sterling Co.

B. Fire Pump and Jockey Pump Controllers

1. Joslyn Clark Controls, Inc.
2. Firetrol Inc.
3. Lexington Switch & Controls Unit Electro Switch Corp.

C. Fire Pump Pressure Recorder

1. The Dickson Company

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install all products in accordance with manufacturer's instructions, approved submittals, NFPA 20 requirements, the Owner's fire insurance carrier, authorities having jurisdiction and referenced sections of the specifications.

B. It shall be the responsibility of the installing contractor to coordinate with all other trades, pipe runs, space allocations, clearances, penetrations, etc. prior to installation.

C. Install wiring and conduit in accordance with the manufacturer's Specification.

3.02 FLUSHING AND CLEANING

A. Flush underground mains and lead in connections to the fire pump in accordance with the approved procedures before connections are made.

B. Provide drainage plugs, taps and valves where required to conduct the flushing operation.

C. Provide for the disposal of flushing water discharged from test outlets such to avoid damage to the Owner's property. Obtain owner's approval of locations where flushing water shall be drained.

D. Repair all damage caused by leaks, flooding or draining during flushing work.

E. Give the authority having jurisdiction and the Owner's Representative two weeks written advance notification of the date and time flushing will be conducted.

F. Complete and forward the Contractor's NFPA Material and Test Certificate to the authority having jurisdiction.

3.03 TESTING AND ADJUSTING

A. General Requirements

1. Test underground fire main in accordance with approved procedures.
2. Should leaks occur during testing, stop the test, repair the leaks and repeat the entire test from the beginning.
3. Repair damage caused by leaks, flooding or draining during testing.
4. Tests shall be witnessed by the authority having jurisdiction and the Owner's Representative. Give the authority having jurisdiction and the Owner's Representative two weeks written advance notification of the date and time testing will be conducted.
5. Complete and forward the Contractors' NFPA Material and Test Certificate to the authority having jurisdiction.

3.04 FIRE PUMP INSTALLATION

A. Mount and bolt fire pump and pump drive packaged unit on concrete pad.

B. Connect fire pump to water supply as shown.

C. Install pressure relief valves and pipe discharge to drain.

D. Install control wiring between the fire pump and the fire pump controller in accordance with the National Electrical Code and the requirements of Division 16.

E. Install 1/4" copper piping from system piping to pressure switch in the fire pump controller.

3.05 JOCKEY PUMP INSTALLATION

A. Mount and bolt jockey pump and pump drive packaged unit on concrete pad where shown on the drawings.

B. Connect jockey pump to water supply as shown.

C. Install pressure relief valve, and pipe vent line to nearest drain.

D. Install control wiring between the jockey pump and the jockey pump controller in accordance with the National Electrical Code and the requirements of Division 16.

E. Install 1/4" copper piping from system piping to the pressure switch in the jockey pump controller.

3.06 FACTORY TESTING

A. Conduct factory performance test on each pump.

B. Submit certified pump test report showing the test procedures and results.

3.07 MANUFACTURER'S SERVICES

A. Provide manufacturer's services to check pumps, conduct field tests and certify that the pumps function properly.

B. Provide training to Owner's personnel in the operation of the pumps.

C. Submit a service contract to the Owner to inspect and service the fire and jockey pumps semi-annually.

3.08 TRAINING

A. Prior to final acceptance, provide operation training to each shift of the Owner's personnel. Each session shall include a complete demonstration of the pumps.

B. Coordinate the dates and times of the training periods with the Owner at least two weeks prior to the training session. Conduct at least three training sessions, one per shift.

3.09 MAINTENANCE

A. Maintain fire pump and jockey pumps, and certify they are fully operational and ready for use when Project is officially turned over to the Owner.

B. Contractor to submit complete maintenance manuals for the fire pump, jockey pump, controllers, and appurtenances (i.e. pressure relief valve). Manuals shall provide detailed information on testing, service, trouble shooting, etc.

+ + END OF SECTION + +

SECTION 15400 - PLUMBING

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes:

1. Sanitary Drainage System.

2. Storm Water Drainage System.

3. Cold Water Distribution.

4. Hot Water Generation and Distribution.

5. Hot Water Recirculating System.

6. Freeze Protection.

1.02 SUBMITTALS

A. Submit for Review:

1. Product Data and installation instruction for cleanouts, plumbing specialties, mixing valves, fixture supports, drainage specialties, water heaters, piping freeze protection, and automatic water softeners.

2. Product Data that includes manufacturer brochures, diagrams, standard schedules, performance and design data, instruction that illustrate physical size, appearance capacity and other characteristics of materials and equipment.

3. Clearly mark each copy to show applicable choices and options.

4. Clearly identified products, equipment and material submitted by detailed number.

5. Highlight or otherwise indicate deviations from Contract Documents.

1.03 CODES, PERMITS AND INSPECTIONS

A. All work shall meet or exceed the latest requirements of all national, state, county, municipal and other authorities exercising jurisdiction over construction work at the project.

B. Installation procedures, methods, and conditions shall comply with the latest requirements of the Federal Occupational Safety and Health Act (OSHA).

C. The Contractor shall be responsible for the installation and filing until the installation has been approved by the authorities having such jurisdiction.

D. Certification shall be submitted attesting that specified performance criteria have been met by all sections of the plumbing systems and equipment.

1.04 TEMPORARY WATER

A. The Contractor shall provide and maintain a temporary Water Distribution System for the use of the various trades and for a temporary Fire Protection System. All temporary materials and equipment, required to furnish temporary water for construction and fire protection purposes, are the responsibility of this Contractor.

B. The Contractor shall keep the temporary water system operational during working hours as may be established for any trade on the project, until no longer required as determined by the General Contractor.

C. Temporary construction water system will consist of a number of 3/4" hose bibs arranged in pairs at the locations as directed by General Contractor.

D. Trade contractor is responsible for providing any hoses required to bring water from hose bibs to their work areas or to otherwise fulfill their needs.

E. Water will be provided to all contractors without cost. Contractor reserves the right to assess any subcontractor that is wasteful in its use.

F. When no longer required, as determined by the General Contractor, the temporary systems shall be dismantled and removed by the contractor.

1.05 EQUIPMENT NOT IN CONTRACT

A. All equipment shown on schedule shall be provided and installed by others.

B. All pantry and lab room fixtures, equipment, sinks and all related faucets, tail-pieces, etc. shall be provided and installed by contractor.

C. After lab and pantry equipment is installed, this Contractor shall provide and install all traps and service piping and make final connections.

D. All floor drains and trap primer connections indicated on plans shall be provided and installed by this Contractor.

PART 2 - PRODUCTS

2.01 GENERAL

A. Unless otherwise specified, all items not furnished as an integral part of a piece of equipment shall be of one manufacturer and shall be as herein specified.

B. Provide equipment and materials as manufactured by the following:

1. Valves - See Section 15101

2. Gauges and Thermometers - See Section 15071

3. Insulation - See Section 15251

4. Plumbing Fixtures - See Section 15450

5. Toilet Seats - See Section 15450: Centoco-1500 STSCC, Beneke 523, Church - 9400C, Olsonite - 95CC/1050.

6. Faucets - Commercial Type: American Standard, Chicago Faucet Co., T & S Brass Inc., Speakman Co.

7. Fixture Supports: Jay R. Smith, Josam, Zurn, Wade, Ancon.

8. Flush Valves - See Section 15450: Sloan, Delany.

9. Bronze Fittings - See Section 15061: Flagg Co., Walworth Co., N.Y. Brass Foundry.

10. Pipe Supports and Hangers - See Section 15141

2.02 TRAPS

A. Traps in Sanitary Drainage Systems: Cast brass 17 gauge "P" traps above ground and cast iron underground with 2" minimum trap seal with gasketed cleanout plugs made of machined bar stock. Locate traps per code requirements.

2.03 CLEANOUT

A. Cast Iron Pipe Cleanouts: Tapped extra heavy cast iron ferrule, caulked into cast iron fittings, and extra heavy lead seal plug with solid hexagonal nut or countersunk plug to suit.

B. No-hub Cast Iron Pipe Cleanouts: No-hub cleanout plug or extra heavy brass screw plug in tapped cast iron fittings, with solid hexagonal nut or countersunk plug to suit.

C. Steel Pipe Cleanouts: Extra heavy brass screw plug in drainage fitting.

D. Cleanout Plugs: Comply with the Plumbing Code; American Standard pipe threads with "Permacel" or approved teflon tape applied to the male threads.

E. Extend cleanouts to walls and floor with long sweep ells or "y" or 1/8 bends with plugs and face or deck plates to conform to the architectural finish in the room. Where no definite finish is indicated on the architectural and/or mechanical drawings, use stainless steel wall plates and floor plates of nickel bronze.

F. Cleanouts and Plates: J. R. Smith models as indicated below.

1. Finished Floor: J. R. Smith 4028, duco cast iron body and frame, with round adjustable scoriated secured nickel bronze top, taper thread bronze plug.

2. Finished Floor: (Composition or Ceramic Tile and Terrazzo): J. R. Smith 4188, cast iron body and frame, with round adjustable recessed (for floor material), nickel bronze top, taper thread bronze plug.

3. Finished Floor (Carpeting): J. R. Smith 4025-Y, cast iron body with round adjustable nickel bronze top taper thread bronze plug and carpet cleanout marker.

4. Concrete Floor: J. R. Smith 4228, duco cast iron body and frame, with round adjustable scoriated secured cast iron top, taper thread bronze plug.

5. Outside Cleanout: J. R. Smith 4258, duco cast iron body and double flanged housing, with double extra heavy duty secured scoriated cast iron cover, with lifting device, taper thread bronze plug.

6. Finished Walls: J. R. Smith 4533 or 4558 cast iron cleanout tee with taper thread bronze plug, and square chrome plate frame and cover.

7. Exposed Piping in Unfinished Areas: J. R. Smith 4512 cast iron cleanout tee, taper thread bronze plug.

2.04 PLUMBING SPECIALTIES

A. Approved Manufacturers: J. R. Smith, Josam, Wade, Zurn, Ancon.

1. Hose Bibb Mark H.B. (for finished areas): Nibco Fib. No. 63-VB chrome plated sillcork with wall flange, 1/2" dia inlet and 3/4" threaded garden hose connection with integral vacuum breaker and wheel handle.

3. Hose Bibb Mark H.B. (for unfinished areas): Nibco Fig. No. 74-VB rough bronze sillcock, 1/2" inlet and 3/4" threaded garden hose outlet with integral vacuum breaker and wheel handle.

4. Backflow preventer (RZBP-1) (on domestic water lines) shall be similar to WATTS Series 909, reduced pressure principle backflow preventer, all bronze construction, with stainless steel trim, for size up to 2 (two) inches and epoxy coated cast iron body with bronze seats and stainless steel trim for 2-1/2 inches and larger, with epoxy coated FDA approved strainer and epoxy coated shut-off valves (ball type for up to 3" dia. and O.S.& Y. Type for 4" dia. and larger).

5. Shock Absorbers – (SA): J. R. Smith No. 5000 Series all stainless steel designed to last life of piping. Type A - No. 5005, Type B - No. 5010, Type C - No. 5020, Type D - No. 5030; or Precision Plumbing Products Inc., "SC" series, piston operated, Type K copper barrel with brass threaded adaptor designed to last life of piping. Type A - SC-500, Type B - SC-750, Type C - SC-100, Type D - SC-1200.

6. Trap Primers:

   a. Trap Primer "A": J. R. Smith “Primeze” fixture trap type primer.
   b. Trap Primer "B": Precision Plumbing Product, Inc. Model PT-4 or PT-6 as required. Automatic, electronic trap primer with four or six primer connections, 120 V solenoid valve, vacuum breaker and shock absorber, all in 16 gauge steel, recessed cabinet with prime coated access door.

2.05 PRESSURE REDUCING VALVES

A. Approved Manufacturers: Watts, Spence, Lawler.

B. For Cold and Hot Water: Pressure reducing valves to be fluid activated and have a single moving assembly. F.D.A. approved nylon fabric reinforced synthetic elastomer diaphragm shall be integral with assembly. Valve body and cover to be cast iron with epoxy coating on the internal and external exposed surfaces. All internal valve components shall be removable for repair without removing valve. Valves up to 3 inches shall be provided with strainer mounted on inlet side. Valves 4 inches and over shall have externally mounted strainers. Valves shall be Watts ACV Figure 115 globe type or Figure 1115 angle type.

C. For Cold Water: Pressure reducing valves to be of cast iron body, Hycar diaphragm, Hycar composition disc, tempered steel spring, bronze trim, as manufactured by Spence Engineering Co., Type D34.

D. For Hot Water: Bronze body, spring chamber, cap and trim. Stainless steel seat ring, spring, adjustable screw and fasteners. Hycar rubber disc and diaphragm as manufactured by Spence Engineering Co., Type D-35.

E. Sizes and capacities as shown on drawings.

2.06 MIXING VALVES

A. Approved Manufacturers: Leonard, Powers.

1. Mixing Valve - for Emergency Shower and eyewashes: Leonard TM-850 thermostatic mixing valve assembly with cold water by-pass, 1-1/4" inlets and outlet. Exposed or in recessed steel cabinet as shown on drawings.

2.07 FIXTURE SUPPORTS

A. Approved Manufacturers: J. R. Smith, Josam, Zurn, Wade, Ancon.

1. Lavatory supports - Floor mounted, single or back-to-back type with concealed, adjustable arms with locking device. Uprights to be high strength steel with welded bases.

2. Urinal supports - Floor mounted single fixture carrier with hanger plate, bearing plate and adjustable supporting rods. Uprights of the carrier to be high strength steel with welded bases.

3. Water closet supports - Commercial type, floor mounted carrier with 4" fixture connection and 2" dia vent connection. Vertical or horizontal, single or back-to-back type as required; with adjustable heights and extensions to suit conditions of the toilet room.

2.08 PIPING FREEZE PROTECTION

A. Provide electric heat tracing capable of maintaining a minimum water temperature of 40 deg. F. at an ambient air temperature of -10 deg. F. Provide cable length to cover pipe to 2 feet inside of building wall.

B. The electric heat tracing shall be a self-regulating "Auto-Trace" heater as manufactured by Raychem Corporation 5XL2-277 volts, and shall respond to varying localized temperature conditions along the pipe by self-regulating its heat output a each point along its length without reliance on thermostat controls. A constant wattage heater will not be acceptable.

C. The self-regulating feature shall automatically control heat output proportional to the heat requirements. The absolute heater temperature limit shall be furnished without reliance on thermostats.

D. The electrical heat tracing shall consist of UL approved, flat, flexible, low heat density strip comprising parallel circuit construction with continuous inner core of self-regulating conducive material, insulated with a polyolefin or fluoropolymer jacket and protected with a flexible metallic over-shield over the entire length of cable. Output rating as required by pipe size, materials conveyed, and by pipe and temperature limits. Voltage rating: Refer to Electrical Drawings. Cable shall be self-limiting, capable of being cut to desired length infield. Raychem components shall be used for all power connection points, heat tracing tees and end seal terminations.

E. The heating cable shall be sized in accordance with table below:

Up to 4" dia. pipe with 1" insulation	5 watts
5" & 6" dia. pipe with 1-1/2" insulation	8 watts
8" dia. pipe with 1-1/2" insulation	2 strips of 5 watts
10" & 12" dia. pipe with 1-1/2" insulation	2 strips of 8 watts

F. The systems shall be controlled by an ambient sensing thermostats AMC-F5 set at 40 deg. F.

G. Electric power for each heat tracing circuit shall be routed as shown on the Electrical Contract Drawings.

H. Refer to Section 15251 for insulation of heat traced piping.

I. Installation:

1. System must be installed per manufacturer's recommendations.

2. Apply the heating cable linearly on the pipe after piping has been successfully pressure-tested. Secure the heating cable to piping with cable ties or fiberglass tape.

3. Apply "Electric Traced" labels to the outside of the thermal insulation.

J. Tests: After installation and before and after installing the thermal insulation, subject heating cable to testing using a 2500-Vdc Megger. Minimum insulation resistance shall be 20 megohms or greater.

PART 3 - EXECUTION

3.01 SHOCK ABSORBERS

A. Shock absorbers shall conform to and shall be sized in accordance with PDI WH201.

3.02 CLEANOUTS

A. Provide cleanouts on all drainage piping at 50 ft. intervals on lines up to 4" and 100" apart on lines over 4" in diameter at each change in direction of 45 degrees or more, at each additional location shown on the drawings; cleanouts shall be full size for pipes up to 4" and not less than 4" for larger pipes.

3.03 COPPER PANS

A. Provide copper pans for shower floors, janitor's floor sinks, and other designated areas having floor drains above ground. Clamp copper pan to floor drain, turn pan up into walls and thresholds as indicated in details on the drawings.

3.04 VENTS THROUGH ROOF

A. All vents passing through roof shall be terminated 24 inches above roof.

3.05 ROOF DRAIN INSTALLATION

A. All roof drains shall be provided and installed by this contractor. Special underdeck flange and all flashing shall be provided and installed by General Contractor as indicated on Architectural Detail.

3.06 HOT WATER CIRCULATING PUMP

A. Provide approved steel support for the recirculating pump, which shall be fastened to building construction.

B. Provide aquastat in the hot water return piping ahead of the circulator for controlling the operation of circulator.

C. Arrange aquastat to start the circulator when the temperature of the return hot water is 110 deg. F. or lower, and to stop the circulator when the return hot water temperature is 120 deg. F. or higher. Provide control wiring between aquastat and pump motor starter. Do not insulate for three feet on either side of aquastat.

+ + END OF SECTION + +

SECTION 15450 - PLUMBING FIXTURES

PART 1 - GENERAL

1.01 PRINCIPAL WORK IN THIS SECTION

A. This section describes plumbing fixtures, fittings, carriers and associated accessories.

1.02 SUBMITTALS

A. Submit for Review:

1. Product Data and installation instruction for cleanouts, plumbing specialties, mixing valves, fixture supports, drainage specialties, water heaters, piping freeze protection, and automatic water softeners.

2. Product Data that includes manufacturer brochures, diagrams, standard schedules, performance and design data, instruction that illustrate physical size, appearance capacity and other characteristics of materials and equipment.

3. Clearly mark each copy to show applicable choices and options.

4. Clearly identified products, equipment and material submitted by detailed number.

5. Highlight or otherwise indicate deviations from Contract Documents.

PART 2 - PRODUCTS

2.01 PLUMBING FIXTURES

A. General: All fixtures shall be White unless noted otherwise. Exposed metal shall be chromium-plated over nickel plating on copper or brass. White metal trim will not be accepted.

2.02 MOUNTING HEIGHTS OF FIXTURES

A. Water Closet - 15" to top of rim from finished floor (18" to top of seat for handicapped).

B. Urinal: 24" to lip of urinal up from finished floor (16" for handicapped).

C. Lavatory: 31" to top of rim to finished floor (34" for handicapped).

D. Electric Water Cooler: 40" to top edge from finished floor (33" for handicapped).

2.03 PLUMBING FIXTURES

A. Manufacturers: American Standard, Elger, Kohler, Crane or as approved equal.

2.04 ELECTRIC WATER COOLERS

A. Manufacturers: Elkay, Halsey/Taylor, Sunroc, Oasis, Filtrine.

2.05 STAINLESS STEEL FIXTURES

A. Approved Manufacturers: Elkay, Just.

PART 3 - EXECUTION

3.01 GENERAL

A. Fixtures shall be free from imperfections, true as to line, angles, curves, and color; smooth, watertight, and practically noiseless in operation.

3.02 METHODS AND REQUIREMENTS

A. All fittings, escutcheons, faucets, traps, exposed piping, etc., shall be brass, chrome plated over nickel plate with satin finish. Any hanger nuts visible shall likewise be chrome plated over nickel plate.

B. Before roughing work is started, submit to the Architect complete figured drawings and cuts of each and all of the plumbing fixtures, fittings, trimmings, etc., and secure approval before proceeding with the installation of any work.

C. Provide all hangers, supports, brackets, etc., for the proper installation of all fixtures requiring support. Such supports shall be in accordance with the recommendations of the manufacturers of the fixtures, and if built into partitions or wall shall be set as the wall progresses.

D. All fixtures specified to be of vitreous ware shall be fired vitreous china ware of the best quality, non-absorbent and burned so that the whole mass is thoroughly fused and vitrified, producing a material white in color (unless indicated otherwise), which when fractured will show a homogenous mass; close grained and free from pores. The glaze and vitreous china fixtures shall be white, thoroughly fused and united to the body, without discoloration chips, or flaws and shall be free from craze. Warped or otherwise imperfect fixtures will not be accepted.

E. All fixtures shall have the standard recommended mounting heights indicated by the fixture manufacturer or as required by the Architectural plans and details.

+ + END OF SECTION + +

SECTION 15541 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Furnish services of a water treatment contractor to provide water treatment service, including furnishing and application of chemicals, one visit to collect samples for chemical analysis at water treatment company's laboratory, and necessary inspection, adjustment, and maintenance of chemical treating devices for period of one year.

B. Provide water treatment service to minimize corrosion, scale formation and organic growth in the following systems:

1. Closed-circuit glycol/water.

2. Heating hot water.

3. Chilled water.

1.02 REFERENCE CODES AND STANDARDS

A. Comply with the following:

1. State of Delaware Water Pollution Control Code.

2. United States Environmental Protection Agency regulations.

3. 2009 Plumbing Code.

4. National Fire Protection Association (NFPA): 70 National Electric Code

1.03 WATER CHEMISTRY PARAMETERS

A. Maintain the following conditions in each system:

SYSTEM	Ph	Inhibitor for Scale & Corrosion*	Cycles*	Organic Growths (Maximum)
Chilled Water, Closed-Circuit Glycol/Water	7.0 to 9.0	50 - 100 ppm	---	1,000 ml
Heating Hot Water	7.0 to 9.0	100 - 150 ppm	---	1,000 ml

* Determine actual cycles of concentration from analysis of make-up water using the Langelier Index.

1.04 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including hot-water heating chilled water and glycol cooling, shall have the following water qualities:

1. pH: Maintain a value within 9.0 to 10.5.

2. "P" Alkalinity: Maintain a value within 100 to 500,ppm.

3. Boron: Maintain a value within 100 to 200 ppm**.**

4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.

5. Soluble Copper: Maintain a maximum value of 0.20 ppm.

6. TDS: Maintain a maximum value of 10 ppm.

7. Ammonia: Maintain a maximum value of 20 ppm.

8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.

9. Microbiological Limits:

   a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
   b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.
   c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
   d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
   e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.

1.05 SUBMITTALS

A. Submit the following to the Architect for review.

1. Product Data: Manufacturer's published product data for components provided as part of the work of this Section.

   a. Specifications for chemicals provided.

2. Shop Drawings: Include system layout and sizes, and maintenance space required.

3. Field Quality Control Test Reports: Submit reports of chemical analysis of water samples as indicated.

   a. Untreated site domestic water.
   b. Discharge and blowdown samples from each system receiving treatment as part of the work of this Section.

4. Other Informational Submittals:

   a. Water-Treatment Program: Written sequence of operation on annual basis for application equipment required to achieve water quality defined in Article "Performance Requirements."
   b. Water Analysis: Illustrate water quality available at Project site.

1.06 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. The water treatment company shall:

1. Obtain water samples from the site and furnish a laboratory analysis of the water supply.

2. Review the specified requirements to ensure compatibility with the water treatment program.

3. Propose water treatment methods and appropriate chemicals required for the cleaning, removal and dissolving of foreign substances from each of the treated systems,

D. Methods and chemicals selected shall comply with the requirements of the American Public Health Association (APHA), the Environmental Protection Agency (EPA) and Occupational Health and Safety Administration (OSHA).

E. Analyze discharge to surface drainage or sanitary sewer from automatic blowdown devices in a laboratory for parameters listed in this section. Upon acceptance of the systems, submit laboratory analysis of discharge to assure compliance with regulatory requirements.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Engage a water treatment company that regularly services the University. Other service companies will be subject to Engineer approval.

2.02 FREQUENCY OF SERVICE

A. The water treatment company shall provide chemical treatment service for a period of one (1) year from the date of startup and acceptance. Frequency of chemical treatment service shall be every 3 months for closed systems.

2.03 WATER TREATMENT CHEMICALS

A. Biological Control

1. A biocide treatment program specifically designed to address biological control shall be initiated when the cooling tower system is first filled with water and shall be administered on a regular basis thereafter.

2. Perform monthly tests of each cooling tower for Legionella Pneumophilia. Submit reports stating bacteria counter per milliliter and the results from the previous month's tests. Submit report to the Owner.

B. Do not furnish or install water treatment chemicals containing chromates, phosphates, or zinc.

C. Chemicals shall be non-toxic to humans and animals for the intended use and for general storage and handling as required by the application.

2.04 FOR HEATING HOT WATER, CHILLED WATER, CLOSED CIRCUIT GLYCOL

A. Provide following equipment for each system:

1. Sidestream Bypass Feeders

a. 5-gallon capacity with bag filter.
b. Acceptable Manufacturer, subject to compliance with requirements: Neptune FTF-5.

2. One (1) corrosion coupon rack with three holders for carbon steel, galvanized steel and copper coupons sufficient for one-year's testing at 90 day intervals.

2.05 CLEANING AND FLUSHING OF PIPE

A. Thoroughly flush each piping system with precleaning chemicals, furnished by the chemical treatment company, designed to remove deposition and foreign materials. Recommended dosages of precleaned chemical products shall be added and circulated throughout each system. The system shall then be drained, refilled and flushed thoroughly until no foreign matter is observed and total alkalinity of the rinse water is equal to that of the makeup water.

B. Refer to Section 15181 for additional requirements.

2.06 GLYCOL SYSTEM

A. Acceptable Manufacturers: Subject to compliance with requirements, provide products by Dow Chemical Co., Monsanto, Union Carbide.

B. Glycol system solution shall be inhibited propylene glycol. Provide a complete glycol charge to a 3 percent concentration.

C. Provide glycol solution feed system consisting of:

1. 50-gallon polyethylene chemical solution tank with a hinged cover.

2. Primed and finish-painted steel tank-and-motor support frame.

3. Rotary gear pump mounted below tank, rated for 1.3 gallons per minute at 100 psig

a. Acceptable Manufacturer: Subject to compliance with requirements, provide products by Neptune Chemical Pump Company, model AG50-1.
b. Provide pump suction piping with shut-off valve and strainer.
c. Pump motor shall be suitable for plugging into single-phase 15-ampere wall receptacle, and shall be manually switched on and off.
d. At the pump discharge, provide pressure gage and relief valve with the discharge piped to fill tank.

2.07 TESTING EQUIPMENT

A. Furnish water testing equipment, including carrying case and spare reagents, for maintaining control of program standards in the steam boiler system. Testing equipment shall consist of the following:

1. Reagents and apparatus for determination of phosphate and sulfite levels in the boiler water.

2. Reagents and apparatus for determination of pH, P and M alkalinity, and chlorides.

3. Reagents and apparatus for determination of neutralizing amine level in the steam and condensate return lines.

4. One (1) conductivity meter with temperature compensation and multiple measurements ranges of 0-10, 0-100, and 0-10,000 micromhos.

B. Furnish one test cabinet, suitable for wall mounting, for storage of testing glassware and reagents. The cabinet shall have one shelf, keylock door and fluorescent light. Cabinet shall be constructed of No. 18 gauge, cold-rolled steel, primed and painted with white, polyurethane enamel paint for corrosion protection.

C. Furnish prefabricated steel corrosion nipple bypass assembly to monitor program effectiveness. This prefabricated assembly shall include:

1. Inlet and outlet shut-off valves.
2. Wye strainer.
3. Two corrosion nipples.

D. Furnish sample coolers, including one for each boiler, one for condensate, and one for feedwater.

PART 3 - EXECUTION

3.01 GENERAL

A. Provide necessary taps in piping for operation of water treatment systems.

B. Install control panel, and provide control and power wiring necessary to implement the water treatment program indicated, including power wiring to blowdown solenoid valves.

C. Install chemical feed pumps, corporation stop and nozzle assemblies, and feed tubing.

D. Provide chemicals for initial cleaning, startup and those required during the service period.

E. Furnish the Owner with a portable water test kit with suitable equipment and chemicals for testing the water quality of the hydronic systems.

1. Equipment and chemicals shall be stored in a heavy-duty plastic carrying case.

2. Owner will use the test kits to monitor the water quality and maintain records of water quality between visits by the water treatment company.

F. Remove and analyze boiler corrosion coupons every 60 days.

G. Provide consulting services for a period of one (1) year from startup of each water system which shall include:

1. Installation and system startup procedure recommendations.

2. Pre-operation system cleanout procedure supervision.

3. Training of operating personnel on feeding and control techniques.

4. Monthly field service and consultation meetings.

5. Necessary log sheets and record forms.

6. Required laboratory and technical assistance.

3.02 CHEMICAL CLEANING OF NEW BOILERS

A. New boilers shall be cleaned and flushed as approved by the boiler manufacturer to remove grease, oil, mill scale and other foreign matter.

B. After cleaning and flushing, drain and refill boiler with fresh water in accordance with the chemical treatment manufacturer’s recommendations.

+ + END OF SECTION + +

SECTION 15559 - BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes packaged, factory-fabricated and - assembled, gas-fired condensing boilers, trim, and accessories for generating hot water.

1.2 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

1. Prior to flue vent installation, engineered calculations and drawings must be submitted to Architect/Engineer to thoroughly demonstrate that size and configuration conform to recommended size, length and footprint for each submitted boiler.

B. Efficiency Curves: At a minimum, submit efficiency curves for 100%, 50%, and 20% input firing rates at incoming water temperatures ranging from 60°F to 160°F. Test protocols shall conform to AERCO's AE-1 standards and shall be witnessed and reviewed by an independent, third-party group.

C. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other Work.

1. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

2. Wiring Diagrams: Detail power, signal, and control wiring.

D. Source quality-control test reports.

E. ASME "A" Stamp Certification and Report: Submit "A" stamp certificate of authorization, and document hydrostatic testing of piping external to boiler.

F. Startup service reports.

G. Operation and Maintenance Data: For condensing boilers to include in emergency, operation, and maintenance manuals.

H. Warranties: Special warranties specified in this Section.

1.3 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of condensing boilers and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. ASME Compliance: Fabricate and label condensing boilers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. ASHRAE/IESNA 90.1 (2004) Compliance: Condensing boilers shall have minimum efficiency according to Table 7-8.

E. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."

F. UL Compliance: Test condensing boilers to comply with UL 795, "Commercial-Industrial Gas Heating Equipment."

1.4 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing boilers that fail in materials or workmanship within specified warranty period.

B. Warranty Period for Condensing Boilers:

1. Leakage and Materials: 10 years from date of Substantial Completion.

2. Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated for seven years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply for product selection:

1. Acceptable Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 CONDENSING BOILERS

A. Acceptable Manufacturers:

1. AERCO International

2. Fulton

3. Patterson-Kelley

4. Viessmann Manufacturing Co.

5. Cleaver-Brooks

6. Bosch

B. Description: Factory-fabricated, -assembled, and -tested condensing boiler with heat exchanger sealed pressure-tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.

1. Thermal efficiency shall increase as firing rate decreases.

C. Fabricate base and attachment to pressure vessel with reinforcement strong enough to resist boiler movement during a seismic event when boiler base is anchored to building structure.

D. Boiler Characteristics and Capacities:

1. Heating Medium: Hot water.

2. Maximum Design Pressure Rating: 150 psig.

3. Minimum Entering-Water Temperature: 50 deg F.

4. Maximum Leaving-Water Temperature: 200 deg F.

5. Water Flow Rate: 35 gpm minimum to 350 gpm maximum.

6. Minimum Full-Load Efficiency: 88% AFUE.

7. Boiler shall have a noise level of less than 65 dba when measured within five feet of the respective boiler's front, back, left and right sides and within three feet of the intake and exhaust connections. Sound levels are based on assumed environmental noise conditions.

E. Boiler Components:

1. Heat Exchanger: Nonferrous, corrosion-resistant sealed combustion chamber with 316L stainless steel tubes and tube sheets with a one-pass combustion gas flow design.

2. ASME Stamped Pressure Vessel: Carbon steel with welded heads and tube connections.

3. External convection and radiation heat losses to the boiler room from the boiler shall be less than 0.5% of the rated boiler input. The boiler shall not contain any refractory, refractory lining or ceramic in the furnace or firebox.

4. The boiler shall be designed for operation in a condensing mode, in order to extract the latent heat from the combustion products. The boiler shall have a minimum acceptable fuel-to-water efficiency of 91% at a return water temperature of 80°F.

5. The boiler shall have no minimum return water temperature requirements.

6. The boiler shall have a minimum flow rate less than 20% of the design flow rate.

7. Burner: Natural gas, modulating forced draft power burner capable of a 5:1 turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves.

   a. Cast stainless steel head.
   b. All material exposed to combustion zone of stainless steel construction.

8. Exhaust Manifold: Corrosion-resistant porcelainized cast iron with collecting reservoir and gravity drain for elimination of condensate.

9. Gas Train: UL/FM Listed, combination gas valve with manual shutoff and pressure regulator designed to reduce service pressure of 14 to pressure required by boilers. Include 100 percent safety shutoff with electronic flame supervision.

10. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

11. Casing:

    a. Jacket: Sheet metal with snap-in or interlocking closures.
    b. Control Compartment Enclosures: NEMA 250, Type 1A.
    c. Finish: Baked-enamel protective finish.
    d. Insulation: Minimum 2-inch thick fiberglass insulation surrounding the heat exchanger.
    e. Combustion-Air Connections: Combustion-Air inlet and exhaust vent duct collars.

12. Mounting base to secure boiler to concrete base.

13. Condensate drainer(s) as required for the boiler plant.

2.3 HOT-WATER BOILER TRIM

A. Include devices sized to comply with ANSI B31.9, "Building Services Piping."

B. Aquastat Controllers: Operating firing rate and high limit.

C. Safety Relief Valve: ASME rated. 125 psig.

D. Altitude and Temperature Gage: Minimum 3-1/2-inch diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is at approximately 50 percent of full range.

E. Boiler Combustion Air Vent: Direct vent to outside (sealed combustion).

F. Drain Valve: Minimum NPS 3/4 hose-end ball valve.

2.4 CONTROLS

A. Refer to Division 17

B. The boiler control system shall be segregated into three components: Control Panel, Power Box and Input/Output Connection Box. The entire system shall be Underwriters Laboratories recognized.

C. The combustion safeguard/flame monitoring system shall use spark ignition and a rectification-type flame sensor.

D. The control panel hardware shall support both RS-232 and RS-485 remote communications.

E. The controls shall annunciate boiler and sensor status and include extensive self-diagnostic capabilities.

F. The control panel shall incorporate three self-governing features designed to enhance operation in modes where it receives an external control signal by eliminating nuisance faults due to over-temperature, improper external signal or loss of external signal. These features include:

1. Setpoint High Limit: Setpoint high limit allows for a selectable maximum boiler outlet temperature and acts as temperature limiting governor. Setpoint limit is based on a PID function that automatically limits firing rate to maintain outlet temperature within a 0 to 10 degree selectable band from the desired maximum boiler outlet temperature.

2. Setpoint Low Limit: Setpoint low limit allows for a selectable minimum operating temperature.

3. Failsafe Mode: Failsafe mode allows the boiler to switch its mode to operate from an internal setpoint if its external control signal is lost, rather than shut off. This is a selectable mode, enabling the control can to shut off the unit upon loss of external signal, if so desired.

G. The boiler control system shall incorporate additional features for enhanced external system interface listed in Div 17.

H. Each boiler shall include an electric, single-seated combination safety shutoff valve/regulator with proof of closure switch in its gas train. Each boiler shall incorporate dual over-temperature protection with manual reset, in accordance with ASME Section IV and CSD-1.

I. Each boiler shall have an oxygen monitoring system that will measure the oxygen content of the exhaust gasses in real-time. Output of information shall be displayed on the control panel.

J. The Boiler Manufacturer shall supply as part of the boiler package a completely integrated Control System to control all operation and energy input of the multiple boiler heating plant. It shall be comprised of a microprocessor based control utilizing the MODBUS protocol to communicate with the Boilers via the RS-485 port. One controller shall have the ability to operate up to 4 boilers.

K. The controller shall have the ability to vary the firing rate and energy input of each individual boiler throughout its full modulating range to maximize the condensing capability and thermal efficiency output of the entire heating plant. It shall control the boiler outlet header temperature within ±2ºF. The controller shall be a PID type controller and uses Ramp Up/Ramp Down control algorithm for accurate temperature control with excellent variable load response. The controller shall provide contact closure for auxiliary equipment such as system pumps and combustion air inlet dampers based upon outdoor air temperature.

L. The ACS shall have the following anti-cycling features:

M. Manual designation of lead boiler and last boiler.

N. Lead boiler rotation at user-specified time interval.

O. Delay the firing/shutting down of boilers when header temperature within a predefined dead band.

P. When set on Internal Setpoint Mode, temperature control setpoint shall be fully field adjustable from 50ºF to 190ºF in operation. When set on Indoor/Outdoor Reset Mode, the ACS will operate on an adjustable inverse ratio in response to outdoor temperature to control the main header temperature. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation. When set on 4ma to 20ma Temperature Control Mode, the ACS will operate the plant to vary header temperature setpoint linearly as an externally applied 4-20 ma signal is supplied.

Q. When set on MODBUS Temperature Control Mode, the ACS will operate the plant to vary header temperature setpoint as an external communication utilizing the MODBUS protocol is supplied via the RS-232 port. The ACS controller shall have a vacuum fluorescent display for monitoring of all sensors and interlocks. Non-volatile memory backup of all control parameters shall be internally provided as standard. The controller will automatically balance the sequence of operating time on each boiler by a first-on first-off mode and provide for setback and remote alarm contacts. Connection between central ACS system and individual boilers shall be twisted pair low voltage wiring, with the boilers ‘daisy-chained’ for ease of installation.

2.5 VENTING

A. The exhaust vent must be UL Listed for use with Category II, III and IV appliances and compatible with operating temperatures up to 230°F, positive pressure, condensing flue gas service. UL-listed vents are PVC, CPVC, Polypropylene and AL 29-4C stainless steel. Basis of design is Polypropylene, coordinate alternates as required.

B. The minimum exhaust vent duct size for each boiler is six-inch diameter.

C. Combustion-Air Intake: Boilers shall be capable of drawing combustion air from the outdoors via a metal or PVC duct connected between the boiler and the outdoors.

D. The minimum sealed combustion air duct size for each boiler is six-inch diameter.

E. Follow guidelines specified in manufacturer’s venting guide.

2.6 SOURCE QUALITY CONTROL

A. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code: Section IV, for low-pressure boilers.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

2. Provide manufacturer's recommended service clearances.

B. Examine mechanical spaces for suitable conditions where boilers will be installed. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Install boilers level on concrete housekeeping pads. Concrete housekeeping pads are specified in Div 03

B. Vibration Isolation: Vibration isolation devices and installation requirements are specified in Div 15.

C. Install gas-fired boilers according to NFPA 54.

D. Assemble and install boiler trim.

E. Install electrical devices furnished with boiler but not specified to be factory mounted.

3.3 CONNECTIONS

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

B. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Div 15.

C. Connect gas piping full size to boiler gas-train inlet with union.

D. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve at inlet and combination shutoff, metering and balancing valve at outlet, and union or flange at each connection.

E. Install piping from safety relief valves to nearest floor drain.

F. Install relief piping from gas train to outside according to manufacturer's recommendations.

G. Connect exhaust vent full size to boiler outlet. Boiler manufacturer shall review chimney provisions as shown on drawings for adequacy and provide recommendations to mechanical contractor, where necessary before chimney manufacturer issues final shop drawings for review.

H. Connect combustion air duct to boiler. Boiler manufacturer shall review combustion duct provisions as shown on drawings for adequacy and provide recommendations to mechanical contractor, where necessary before sheet metal shop drawings are produced.

I. Install piping adjacent to boiler to allow service and maintenance.

J. Ground equipment according to Division 16.

K. Connect wiring according to Division 16.

L. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 MANUFACTURER’S STARTUP SERVICE

A. Engage a factory-authorized service representative to test, inspect, and adjust boiler components and equipment installation and to perform startup service for one business day (8 hours).

B. Perform installation and startup checks according to manufacturer's written instructions.

C. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.

D. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.

E. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Adjust initial temperature set points.

G. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

H. The service engineer shall instruct Owner's operating personnel in operation and maintenance procedures of the boilers for a minimum of 4 working hours.

I. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

J. Prepare written report that documents testing procedures and results.

+ + END OF SECTION + +

SECTION 15680 - WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. This section describes water chillers.

1.2 REFERENCE CODES AND STANDARDS

A. Comply with the following:

1. American National Standards Institute/American Society of Heating, Refrigerating and Air-Conditioning Engineers (ANSI/ASHRAE)

a. 15 Safety Code for Mechanical Refrigeration

2. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME)

a. B31.5 Refrigeration Piping
b. Boiler and Pressure Vessel Code, Section VIII - Pressure Vessels

3. Air-Conditioning and Refrigeration Institute (ARI)

a. 550/590 Standard for Water-Chilling Packages Using the Vapor Compression Cycle
b. 575 Methods of Measuring Machinery Sound Within Equipment Rooms

1.3 SUBMITTALS

A. Submit for review:

1. Description of all refrigeration, electrical and control components.

2. Power consumption per ton and sound power level data at design point, and 75 percent, 50 percent and 25 percent of design point (for part loads, the condenser inlet temperature shall be according to conditions listed in ARI 550/590).

3. Certified water velocity and friction loss through evaporator and condenser at design lows. Show pass arrangement.

4. Certified evaporator temperatures and pressures, condenser temperatures and pressures, and refrigerant type and quantity.

5. Certified full-load current, locked-rotor current, and power factor at full and part loads (25 percent, 50 percent and 75 percent).

6. Composite field wiring diagram showing all interconnecting power and control wiring between starter, chiller, primary chilled water field equipment panel, and auxiliaries, ndependent power sources, and field-supplied components necessary to accomplish control sequence.

7. Field piping diagram indicating makeup water, compressed air, drains, vents, etc.

8. Overall dimensions and weights of the equipment, and all auxiliary devices.

9. Foundation drawings and data required to completely design the foundations for the equipment package, including anchor bolt layout.

10. Control panel front views, internal layout and wiring diagrams.

11. Submit minimum chilled water piping system volume needed for stable chiller operation.

1.4 QUALITY ASSURANCE

A. Chillers shall bear a U.L. label, and shall be ARI 550 certified.

B. See PART 3 for FACTORY PERFORMANCE TESTING.

1.5 WARRANTY

A. Warranty period for the chiller shall be for a period of two (2) years commencing with either substantial completion or with the completion, Owner sign-off of a successful field performance test.

1. Chiller manufacturer shall provide Owner a quotation for the performance of preventive maintenance to the a) chiller and b) chiller control system for the equipment during the warranty period.

1.6 COMMISSIONING

A. Selected equipment shall be commissioned according to Commissioning Spec Section. The Contractor, Subcontractors, and their vendors shall be responsible for all content described in this section.

B. Equipment to be Commissioned:

1. Air cooled chiller.

2. Chiller instrumentation and controls

PART 2 - PRODUCTS

2.1 GENERAL

A. Approved Manufacturers: Trane, Multistack, Artic Chill & Smardt

B. General

1. Each refrigeration system shall use refrigerant 134A.

2. Each system shall be complete, including compressors, motors, motor starters, cooler, condenser, refrigerant flow control device, purge unit (if required) and central control center with all related system-mounted controls and related starters. Provide integral motor overload heaters and fuses.

3. Factory-assemble each chiller; insulate, pipe, wire, leak test, evacuate to an absolute pressure of 0.20 inch of mercury, and charge with refrigerant and oil. Shipment with a holding charge is permissible if the chillers are field charged by the chiller manufacturer's field service personnel with refrigerant furnished by the chiller manufacturer.

4. Select and guarantee chillers on the basis of manufacturer's ratings, with a fouling factor of 0.00025 (hour) (square foot) (degree F) /(BTU) in the cooler and condenser.

5. Under design performance conditions, the minimum evaporator temperature of the low temperature system shall be 33 degrees F.

6. Factory-test and ASME-stamp vessels whose total refrigerant or waterside volumes or pressures fall within the ranges governed by the ASME Boiler and Pressure Vessel Code to the pressure designated by the ANSI/ASME Code. Ship each system charged with inert gas or under vacuum after completion of factory tests.

7. Include and ship separately chilled water and condenser water differential pressure switches (2 switches per machine) for field installation.

8. Refrigerant and oil shall be included and may be shipped separately in containers for field installation.

C. Chiller Starters (208 to 480 volts)

1. Furnish with a NEMA 4X1 enclosure with front accessibility and a hinged door with lock and key. Starter shall be mounted on the chiller. Verify type and size of lugs and/or connections, line and load side of starters and motors. Starter shall contain:

a. Combination-type compressor motor starter with protected load-break disconnect switch suitable for 700 amperes symmetrical interrupting capacity.
b. One three-pole ac running contactor with auxiliary relays and interlocks as required.
c. Load signal resistor.
d. Set of line, load and control terminals with lugs permanently marked in accordance with the chiller manufacturer's diagram for interconnection.
e. Green indicating pilot light for "starter energized" indication. Locate in the door or front panel.
f. Power transformer and fused switch sized to handle all auxiliaries. Power the transformer from the load side of the incoming power disconnect for operation when compressor motor main contactor is off.
g. 120 V/1 phase/60 Hz fused control circuit transformer sized to handle starter controls, chiller controls and all auxiliaries.
h. Low voltage protection.
i. Anti-reverse cycling protection.
j. Automatic start control that allows chiller to start and stop automatically through a set of contacts which can be wired to the building automation system.
k. Automatic restart after power failure.
l. Start-to-start anti-recycling control that allows each chiller to start automatically within 2 minutes of nuisance tripout of power failure if it has been running a minimum of 20 minutes prior to shutdown or is on active standby. Stagger the restart of all chillers that were in operation before a power failure.
m. Combination circuit breaker/magnetic starter (120 V) for purge compressor motor, transfer unit motor, and oil pump auxiliaries. Power auxiliaries from the power transformer. Locate in low-voltage compartment, integrally mounted and wired within the main compressor starter enclosure.
n. Oil heater contactor and circuit breaker mounted in low-voltage compartment.
o. Phase rotation protection of compressor motor starter.
p. Single-phase failure protection circuit of compressor motor starter.
q. "KVAR" meter in starter panel.
r. Power-factor correction capacitors to obtain 95 percent power factor at full load. Mount in chiller starter or attach to the compressor motor starter. Power factor meter, door or panel mounted, to monitor power factor on line side of the starter.
s. Ground fault protection controls.
t. Electronic motor protection system that is an integral part of the starter to monitor and protect the motor against the following conditions:

1) Three-phase overload;
2) Overload during start-up;
3) Phase unbalance;

u. Power all auxiliaries internally from the power transformer. Auxiliaries requiring starters shall have starters integrally mounted and wired within the main compressor starter enclosure.

v. Elapsed run-time hour indicator (totalizer).

2. Starter shall be reduced voltage (wye-delta) closed transition combination type with fused load-break disconnect switch suitable for mounting in chiller starter enclosure. In addition to the components listed above, the compressor motor starter shall include:

a. One three-pole starting and running contactor with auxiliary relays and interlocks as required.
b. One two-pole transition starting contactor with auxiliary relays and interlocks as required.
c. One timing relay to transfer from start to run.
d. One auxiliary contact in the run position.
e. Two normally-closed and two normally-open auxiliary contacts.

3. Provide the chiller starters with ventilation louvers or mechanical ventilation to suit internal equipment heat-generation loads.

4. Provide a stop button in the starter door or at the control panel of each chiller.

2.2 ROTARY SCREW WATER CONDENSING UNIT

A. Compressor

1. Compressor: Rotary screw type.

2. Compressor Housing: Cast iron, precision machined to provide minimal clearance for the rotors. Provide a rupture disc or safety relief valve to meet the requirements of the referenced ASHRAE Standard 15.

3. Manufacture the rotors from forged steel and using asymmetrical profiles.

4. The compressor shall incorporate a complete anti-friction bearing design for reduced power and increased reliability. Provide four (4) separate cylindrical roller bearings to handle radial loads. Provide two (2) 4-point angular contact ball bearings to handle axial loads.

B. Motor

1. Provide an open drip proof, squirrel cage, induction type hermetic or open motor. Provide No. 14 gauge steel terminal box with gasketed front access cover for field-connected conduit.

2. Motor shall be air, or liquid refrigerant cooled. Locate solid-state high-temperature sensors in each phase of the motor windings.

3. Motor full-load ampere (FLA) draw at design conditions shall not exceed motor nameplate FLA.

4. Design motor and terminals to permit connection to the type of starter specified. Provide motor for the voltage and phase scheduled.

5. Directly connect the motor drive shaft to the compressor shaft with a flexible disc coupling. Design the coupling to accommodate slight shaft misalignments. Provide all-metal construction with no wearing parts and no lubrication requirement. Provide steel coupling guard.

6. Mount the driveline on a fabricated structural steel base. Mount the base on top of the evaporator sheet, isolated from the sheet by rubber mounts.

C. Evaporators and Condensers

1. Fabricate evaporator, subcooler, and oil separator shells from rolled carbon steel plate with fusion-welded seams. Carbon steel tube sheets, drilled and reamed to accommodate the tubes, shall be welded to the end of each shell. Intermediate tube supports shall be fabricated from carbon steel plate, spaced a maximum of 4 feet apart.

2. Design, test and stamp the refrigerant side of each shell in accordance with the ANSI/ASME Boiler and Pressure Vessel Code, Section VIII - Division 1.

3. Tubes shall be high-efficiency, internally-enhanced type to provide optimum performance. Each tube shall be roller expanded into the tube sheets, and shall be individually replaceable. Tubes shall be 3/4 inch O.D. copper alloy.

4. Evaporator: Shell and tube, flooded type, designed for 225 psig design working pressure on the refrigerant side and tested at 338 psig. Distribution trough shall provide uniform distribution of refrigerant over the shell length. Locate a 4 inch liquid level sight glass on the side of the shell. Provide a 3/4 inch refrigerant charging valve.

5. Condenser: Seamless copper tubes mechanically bonded into aluminum fins.

6. Condenser Fans: Propeller type, approved for vertical air discharge and individually driven by direct drive fan motors. Fan motors shall be weather protected, totally enclosed fan cooled type.

7. Locate a dual refrigerant relief device set at 300 psig at the top of the shell, in accordance with local codes and the referenced ASHRAE Standard 15.

8. Locate a subcooler in the bottom of the condenser section.

9. Evaporator flanged water connections.

10. Water boxes shall be designed for 150 psig design working pressure and tested at 225 psig.

11. Factory attach 3/4 inch thick elastomeric insulation, with vapor-proof cement to the cooler shell, flow chamber, tubesheets, suction connection and as necessary to the auxiliary tubing, and all other surfaces subject to sweating.

D. Waterside Economizer Option (WSE)

1. The air-cooled chiller shall include an integral waterside economizer (WSE) option designed, fabricated, and installed by the chiller manufacturer. This option shall carry the same manufacturer's warranty as the air-cooled chiller. The integral WSE option shall be fully assembled on the air-cooled chiller and shall include all controls and operating components – no field-installed components shall be required. The factory-installed controls shall automatically switch the chiller between mechanical-cooling mode and free-cooling mode when ambient temperature allows. No manual intervention shall be required.

2. The integral WSE chilled water return piping shall include e a 3-way diverting valve that will, on a signal from the factory-provided controller, divert the return water to the economizer coils that shall produce partial free-cooling anytime the ambient temperature is lower than the building return water temperature. The water from the economizer coils shall return back to the system chilled water return piping downstream of the 3-way valve and before the evaporator barrel so additional mechanical cooling by the chiller can be provided, if needed. When 100% of scheduled cooling capacity is achieved in a free-cooling mode, typically between 15F and 25 F depending on coil design, the compressors shall be disabled and the cooling load shall be achieved by free-cooling only. (See Chiller schedule for specific performance requirements)

3. The additional pressure drop of the WSE coils shall be clearly indicated. The system pump shall be provided with a variable speed drive that will maximize the energy savings

by allowing the pump to operate at a lower system pressure drop when the WSE coils are bypassed in full mechanical cooling mode. Balancing valves that add pressure drop to the mechanical cooling side, to compensate for coil pressure drops, are not acceptable.

4. A flow switch on the discharge of the evaporator barrel shall be factory wired into the chiller controls as a safety interlock. It shall be set at the minimum flow for the evaporator barrel.

5. Economizer Coils: Coils will be designed with aluminum flat/corrugated fins and copper/copper alloy tubes. The copper tubes have a minimum wall thickness of 0.020" and an outside diameter of 0.50". Plastic, Rubber, or PVC connections are not acceptable. The coils shall have headers of type L copper with vents and drains. The coil connections are copper O.D. sweat connections. Coil casings are manufactured with 14 gauge galvanized steel. Each individual WSE coil shall have a shut off valve on inlet and a circuit balancing valve on the outlet. Main headers shall be welded schedule 40 black pipe painted to match the chiller cabinet. Individual coils shall be piped with type L hard copper. Grooved Victaulic connections are not acceptable. Headers under All waterside coils and piping shall be hydrostatically tested to 80 psi, held under pressure for at least 2 hours, and all joints bubble tested. Each WSE system shall be piped to the edge of the chiller frame (or location specified by customer) and a shut off valve shall be provided at the main inlet and outlet connections.

6. Service Access: WSE coils shall not block any service access to compressors or other components needing inspection or maintenance. Removing, draining, replacing, and refilling coils in order to service any components under the condenser coils is not acceptable. WSE coils can incorporate architectural louvers over the coil sections, with options for full louvers where appearance dictates. All coil guard louvers are easily removable for service and maintenance. Wide spaced wire mesh coil guards are not acceptable for coil protection.

7. Isolation: Neoprene isolators properly sized for the revised weight of the chiller shall be provided by chiller manufacturer.

8. Brief Control Sequence: Anytime the Ambient Temp is below the Chilled Water Return Temp, the diverting valve shall open and allow water to pass through the chilled water coils. After the water has been partially cooled by the cold air, the water will pass through the evaporator where the remaining required cooling shall take place. As the Ambient Temp continues to decrease, more cooling will take place in the chilled water coils and the compressors will unload and eventually shut down.

E. Controls

1. Achieve capacity control by a slide valve which shall provide fully modulating capacity control from 100 percent to 15 percent of full load. Actuate the slide valve by oil pressure controlled by external solenoid valves via the microcomputer control center.

2. Variable Volume Ratio Control

a. The compressor shall include a movable slide valve stop which optimizes the discharge port location. Automatically change the internal compressor volume ratio to match the varying system pressure ratios at lower loads and lower entering condenser water temperatures.
b. Control the volume ratio based on system suction and discharge pressure measured via the microcomputer control center.

F. Refrigerant System

1. Control the refrigerant flow to the evaporator by a single fixed orifice or a motorized expansion valve.

2. Install a check valve in the suction line to prevent compressor rotor backspin due to system refrigerant pressure gradients during shutdown.

3. The condenser shell shall store the system refrigerant charge during servicing.

4. Locate a manually-operated isolation valve in the compressor discharge line.

5. The thermal expansion valve shall be able to be manually closed.

G. Microprocessor Control Center

1. Factory-mount, wire and test the microprocessor control center. House the control center in a steel, NEMA 1 enclosure with a hinged, gasketed front access cover having screw latches.

2. The control center shall automatically control and monitor the operation of the chillers in meeting system cooling requirements while minimizing energy usage.

3. Display all operating conditions, control setpoints, safety controls and pre-alarm messages on a backlit 320-character liquid crystal display (LCD). A time clock shall display the date and time.

4. Chiller operating parameters shall be sensed by either temperature transmitters or pressure transducers and shall be continually updated on the display. Display temperatures in degrees F and pressures in psig or inches of mercury.

5. The keyboard shall consist of thirty-two (32) membrane-type keys. A five-digit, changeable, security access code shall prevent unauthorized changing of setpoints.

6. The control center shall be able to provide either manual or automatic restart of chillers after power failure.

7. Provide the following adjustable setpoint operating controls, programmed from the keypad:

   a. Leaving chilled liquid temperature
   b. Percent full-load motor current.

8. Display the following operating data at the control center:

   a. Leaving chilled liquid temperature and setpoint
   b. Evaporator refrigerant pressure and temperature (suction)
   c. Condenser refrigerant pressure and temperature (discharge)
   d. Oil temperature and pressure
   e. Percent motor current and setpoint (including indication if loading or unloading)
   f. Percent slide valve position (including indication of manual or auto mode and, if loading, unloading or hold)
   g. Volume ratio (including indication of manual or auto mode and, if loading, unloading or hold)
   h. Subcooler refrigerant liquid level
   i. Compressor status (manual, auto or remote)

9. Display the following safety cutouts at the control center:

   a. Low chilled liquid temperature
   b. Low oil pressure
   c. High condenser pressure
   d. Low evaporator pressure
   e. Undervoltage
   f. Flow switch (evaporator and/or condenser)

g. Anti-recycle (30 minutes between restarts)h.
h. Overcurrent/motor control failure

10. Building Automation System (BAS) Interface

a. Provide the microcomputer controller with a communications terminal for remote monitoring and control.
b. Control the following remotely:

1) Chiller start and stop
2) Chilled water setpoint change

c. Monitor the following remotely:

1) Compressor status
2) Each individual (or all) temperature readings
3) Each individual (or all) pressure readings
4) Percent current information
5) Each individual (or all) display screens

H. Oil Management System

1. The oil separator shall be a horizontal design with no moving parts. Achieve effective oil separation by a combination of the following methods:

a. Gravity dropout of oil from the refrigerant gas as velocity decreases upon entering the separator.
b. Change of gas direction in the separator.
c. Dual-density mesh pads for final gas/oil separation before gas enters the condenser.

2. Provide two (2) 500-watt, 120 volt, 1 phase, 60 Hz immersion oil heaters, temperature-actuated to effectively remove refrigerant from the oil.

3. Provide an external, replaceable cartridge, 15 micron oil filter. Provide manual isolation stop valves and drain connections, for ease of servicing.

4. Provide an oil educator to automatically remove oil which may accumulate in the evaporator, and return it to the compressor.

5. Provide a water or refrigerant cooled oil cooler, with factory connected water piping with manual shut-off valves to allow isolation for service and tube cleaning.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the chillers, including all devices shipped separately for field installation, in accordance with manufacturer's instructions and under the supervision of the manufacturer's field engineer.

B. Provide all necessary piping, valves and controls for water-cooled purge units or oil coolers

C. Install and wire to the chiller manufacturer's control panel the condenser water and chilled water differential pressure (DP) switches across the condenser water and chilled water inlets and outlets of each chiller.

D. Pipe the refrigerant relief discharge of each chiller to the exterior of the building as shown on the drawings. Multiple relief devices may be piped to a common vent; however, both the vent size and

relief valve size shall be coordinated when piped to a common vent. Connect the purge unit discharge to the relief valve discharge.

E. Do not operate chillers until chemical treatment is applied to water systems and all components are working.

3.2 FACTORY TESTING

A. System Leak Test

1. Evacuate the system to a maximum absolute pressure of 1000 microns of mercury. When this condition is attained, valve the vacuum pump and the wet bulb indicator off from the system for a period of 30 minutes.

2. If, at the end of this period, the pressure loss is within 200 microns, the test is successful. If not, make corrections and repeat the test procedure until these conditions are met.

3. Perform this procedure on all chillers and document in the factory test report.

B. Insulation Resistance Test

1. Impose a potential of 500 volts dc from individual motor leads to ground to determine the insulation resistance. If a steady "megger" reading of 200 megohms cannot be maintained for at least one minute, follow manufacturer's recommendations for drying until a reading of 200 megohms is maintained or replace the motor.

C. Chiller Performance Test

1. Equip the condenser water and chilled water piping with pressure gauges and thermometers with wells at the inlet and outlet of each chiller. Each system shall have a flow meter and pressure gauges on both sides of each pump. Provide the following instrumentation:

a. Two (2) flow metering devices sized for the specified evaporator gpm. The accuracy of these devices shall be plus or minus 0.5 percent of actual flowrate.
b. Two (2) thermometers in 50 percent immersion wells installed at each temperature-sensing location. The accuracy of these thermometers shall be plus or minus 0.15 degree F and shall be readable to plus or minus 0.1 degree F. Each thermometer shall be calibrated and traceable to the National Institute of Standards and Technology (NIST). The calibration curves shall be attached to the performance test report. The readings of both thermometers shall be averaged together to minimize the effect of temperature gradients.

2. Test the chillers as follows:

a. Test readings required by ARI Standard 550 shall be taken at 100 percent capacity. Readings taken in each set should be as simultaneous as possible.

3. Conduct all factory tests for each chiller. The satisfactory results of these tests shall be certified in the factory test report.

4. The factory performance tests will not be witnessed.

3.3 START-UP/MANUFACTURER'S SERVICES AND FIELD TESTING

A. The chiller manufacturer's personnel shall supervise the initial start-up of the system, including coordination on start-up of the condenser water system and the chilled water valves and pumps.

B. Provide chiller manufacturer's personnel to supervise the operation of all equipment for a period of three 8-hour days prior to its acceptance. Before acceptance, conduct all performance tests as

required to demonstrate that equipment operates mechanically and electrically as specified, and that all operating and safety controls are correctly adjusted in accordance with the chiller manufacturer's approved field test procedures.

C. Provide chiller manufacturer's personnel to supervise the testing and adjusting of equipment. Repeat performance tests as required to demonstrate compliance with contract documents.

D. The differential pressure switches furnished by the chiller manufacturer as specified in this section shall be installed and wired by the Contractor under the chiller manufacturer's supervision. The chiller manufacturer shall be responsible for final adjustment of the differential pressure switches that he furnishes.

3.4 COORDINATION WITH DDC SYSTEM CONTRACTOR

A. Prior to the submittal of shop drawings, the chiller manufacturer's technical representative shall contact the DDC System Contractor to document the interface between the DDC System and each chiller's control panel furnished for this project. The date and results of these meeting(s) shall be submitted in detail with the chiller manufacturer's shop drawings.

B. Submit a detailed submittal showing the interface between the BAS and each chiller (including chiller interface terminal identification numbers).

C. The DDC System Contractor shall be responsible for furnishing and installing all communications wiring and conduit from the BAS to each chiller control panel, and he shall leave an extra 3 feet of wire for each circuit at each chiller control panel. These communications wires shall be properly labeled as recommended by the chiller manufacturer's technical representative.

D. The DDC System Contractor shall complete all final connections at each chiller control panel under the supervision of the chiller manufacturer's technical representative.

E. The final checkout of panel controls and chiller operations, as specified, shall be accomplished with both the chiller manufacturer's and the DDC System Contractor's technical representatives in attendance.

F. The chiller manufacturer and the DDC System Contractor shall demonstrate to the Owner's Representative that all functions in the "Chiller Operating Sequences" described in the DDC System Sequences of Operation in Division 17 have been implemented.

G. The chiller manufacturer and the DDC System Contractor shall provide, for Owner's personnel, training demonstrations of the entire chiller control system and its interfaces to the DDC System, including system performance and report generation, to the satisfaction of the Owner.

3.5 COMMUNICATION WITH BUILDING AUTOMATION SYSTEM

A. Provide and factory install a controller using one of the following protocols to communicate certain points to the building automation system:

1. BACnet: This protocol shall support transmission from each BACnet node to adjacent nodes following all requirements of ASHRAE standard 135-1995, including Addenda a, b, and c, at conformance Class 3 or higher. This interface shall be based on one of the following BACnet standard protocols:

a. MS/TP RS-485, minimum 9600 baud. Use low-capacitance shielded cable.
b. PTP RS-232, minimum 9600 baud. Use shielded serial communication cable.
c. Ethernet TCP/IP, 10 MB. Use CAT 5 cable, multimode fiber, or RG58 coax.
d. ARCNET, minimum 178 KB. Use multimode fiber or RG62 coax.

2. Lonworks: This protocol shall support transmission from each Lonworks node to any adjacent node following all requirements of the Lonworks FTT10 or RS-485 cabling specifications.

3. Modbus: This protocol shall support transmission from each Modbus node to adjacent modes following all requirements of the ISA Modbus specifications.

B. The controller shall provide points to the BAS outlined in specification Section 17500 (point list) and Section 17600 (sequence of operations).

3.6 OPERATION AND MAINTENANCE MANUALS

A. Furnish manuals as described in Division 1 possessing sufficient detail to enable the Owner's technicians to understand, operate, and maintain the system equipment, and to identify replaceable parts.

B. Divide the manuals into the following sections:

1. General description.

2. Operating instructions.

3. Routine maintenance (Parts, schedules, tests).

4. Troubleshooting (Step-by-step chart format).

5. Data (Bill of materials, schematic diagrams, layouts, exploded views, parts lists and performance characteristics).

6. Recommended spare parts stocking list, with prices for these parts.

C. Manuals shall contain address and telephone number of nearest service organization.

D. Chiller manufacturer's standard catalog or catalog data sheets will not be acceptable as a maintenance instruction manual. Catalog data sheets are acceptable only to show equipment performance characteristics. Chiller manufacturer's standard maintenance instruction manuals that apply specifically to the furnished equipment are acceptable. Modifications to standard equipment shall be incorporated.

3.7 TRAINING

A. Provide chiller manufacturer's factory-authorized representative to instruct the Owner's personnel on the operation and maintenance of the chiller systems at the site after start-up for at least one (1) continuous or intermittent working day (8 hours), at the option of the Owner.

+ + END OF SECTION + +

SECTION 15710 - HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes heat exchangers.

1.02 SUBMITTALS

A. Submit for review:

1. Product data for all items.

2. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

a. Tube-removal space.
b. Structural members to which heat exchangers will be attached.

3. ASME certification for steam-to-water heat exchangers.

4. Factory Test Report: Report of factory hydrostatic test.

1.03 QUALITY ASSURANCE

A. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

PART 2 - PRODUCTS

2.01 PLATE AND FRAME HEAT EXCHANGERS, GASKETED

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Ameridex Plate Exchangers

2. Baltimore Air Coil.

3. Bell and Gossett.

4. Paul Mueller Co.

5. Alfa-Laval.

6. Taco Inc.

7. APV Heat Transfer.

B. Exchangers: Counterflow, ASME designed, constructed, and stamped. Certified and rated in accordance with ANSI/AHRI Standard 400: Liquid to Liquid Heat Exchangers, with all Addenda.

C. Frames Tightening Bolts and Carrying Bar: Carbon steel with baked epoxy enamel paint. Provide for the ability to add 20% more plates in the future.

D. Gaskets: One piece molded nitrile rubber. Do not exceed the differential pressure/temperature limit (DPTL) of the gasket material, i.e. the maximum difference in operating pressure between the two fluid flows in the plate heat exchanger at the maximum operating temperature.

E. Plates: Type 304 stainless steel, designed for an operating pressure of 150 psig.

2.02 HIGH-PERFORMANCE SHELL-AND-TUBE HEAT EXCHANGERS

A. Provide a zero-leakage compression seal between the tubes and the tubesheet.

B. Provide flanges to allow separation of one individual shell without affecting the second shell.

C. Supply each individual circuit with connections to allow isolation of each circuit.

D. ASME Code Vessel: Design, fabricate, test and stamp the heat exchanger in accordance with Section VIII, Division 1 of the ASME Unfired Pressure Vessel Code.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

A. Install equipment in accordance with manufacturer's instructions.

3.02 INSTALLATION - HEAT EXCHANGERS

A. Mount heat exchangers on support bases on concrete housekeeping pads with vibration isolation devices as specified in Section 15070.

3.03 CONNECTIONS

A. Install shutoff valves at heat-exchanger inlet and outlet connections.

B. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.

C. Install hose end valve to drain shell.

+ + END OF SECTION + +

SECTION 15729 - CUSTOM PENTHOUSE AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section describes custom penthouse units and custom air handling units.

1.2 REFERENCE CODES AND STANDARDS

A. Comply with the following in accordance with Division 1:

1. Air Movement and Control Association (AMCA):

a. 210 Laboratory Methods of Testing Fans for Rating
b. 211 Certified Ratings Program - Air Performance.
c. 300 Reverberant Room Method for Sound Testing of Fans
d. 500 Test Methods for Louvers, Dampers and Shutters

2. Air-Conditioning and Refrigeration Institute (ARI):

a. 430 Central-Station Air Handling Units

3. American Society for Testing and Materials (ASTM):

a. A 366 Specification for Steel, Carbon, Cold-Rolled Sheet, Commercial Quality
b. A 480 Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
c. A 527 Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality
d. A 700 Practice for Packing, Marking, and Loading Methods for Steel Products for Domestic Shipment
e. B 117 Standard Test Method of Salt Spray (Fog) Testing
f. B 209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate
g. B 632 Specification for Aluminum-Alloy Rolled Tread Plate
h. C 423 Standard Test Method for Sound Absorption and Sound Coefficients by the Reverberation Room Method
i. C 920 Specification for Elastomeric Joint Sealants
j. D 1735 Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus
k. E 90 Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Components
l. E283 Rate of Air Leakage through Exterior Windows, Curtain Walls and Doors

4. American Welding Society (AWS):

a. D9.1 Sheet Metal Welding Code

5. Federal Specifications (FS):

a. TT-S-001657 Sealing Compound, Single Component Butyl Rubber Based, Solvent Release Type (For Buildings and Other Types of Construction)

6. National Fire Protection Association (NFPA):

a. 70 National Electrical Code
b. 90A Installation of Air Conditioning and Ventilating Systems

7. Sheet Metal and Air Conditioning Contractors Association, Inc (SMACNA):

a. -- HVAC Air Duct Leakage Test Manual
b. -- HVAC Systems Design Manual

8. 2009 International Mechanical Code.

9. 2009 International Building Code.

10. 2009 International Energy Conservation Code.

1.3 SUBMITTALS

A. Product Data:

1. Submit literature that indicates dimensions, weights, capacities, ratings, fan performance, gauges and finishes of materials, and electrical characteristics and connection requirements.

2. Submit data on filter media, filter performance, filter assembly, and filter frames.

3. Submit computer generated fan curves with specified operating point clearly plotted.

4. Submit computer generated psychrometric chart for each cooling coil with design points and final operating point clearly noted.

5. Calculated airflow pressure losses, fan, filter and coil performance data.

6. Value of differential pressure across housing and other loads used for strength calculations, and maximum deflection of housing permitted under these loads.

7. Application, installation and start up instructions for all components that make up the air handler. Submit within 30 days of shop drawing approval to facilitate the commissioning process.

8. Coordinate with Commissioning procedures to refine start up, check out and testing procedures for the air handling units.

B. Shop Drawings

1. Complete assembly shop drawings, schematic electrical drawings of electric service panels and details of electric components, lighting details, and point-to-point wiring diagrams.

2. Construction details, including methods of fastening panels, assembling sections, thermal and galvanic break techniques, and materials of construction.

C. Field quality control test reports.

D. Operation and maintenance data.

E. Warranty: Warranty period for the air handling units shall be for a period of two (2) years commencing with either substantial completion, or with the completion and Owner sign-off of a successful field test.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver all equipment to the job site packaged and protected for overland trucking and for storing the equipment outside exposed to the weather. Cover duct connection openings with plywood or sheet metal caps.

1.5 RELATED SECTIONS

A. Section 15055 - Motors

B. Section 15070 - Vibration Isolation - HVAC

C. Section 15075 - Piping and Equipment Identification

D. Section 15080 - Thermal Insulation – HVAC

E. Section 15110 - Valves - HVAC

F. Section 15180 - Pipe and Pipe Fittings - HVAC Systems

G. Section 15760 - Heating and Cooling Coils

H. Section 15785 - Energy Recovery Wheels

I. Section 15820 - Sheet Metal Accessories

J. Section 15837 - Centrifugal HVAC Fans

1.6 COMMISSIONING

A. Refer to General Commissioning Requirements for additional submittal, quality assurance, and product requirements. Coordinate startup, checkout, and testing procedures with the aforementioned specification. Operation and Maintenance (O&M) Manuals and training is to be provided as specified in this section and as in the Commissioning Requirements. Contractors, subcontractors, and manufacturers are responsible for reviewing Commissioning Requirements and adhering to content described within.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Acceptable Manufacturers, subject to compliance with requirements, provide products from one of the following:

1. Air Enterprises
2. Ingenia
3. Ventrol
4. TMi
5. Buffalo
6. Manfa Air Technologies
7. Haakon

B. Units shall be the factory-fabricated, custom type, factory prewired for field power connection as documented on Electrical Contract Drawings and Specifications, and prepared for field furnished and wired controls.

1. Provide all electrical wiring, devices and equipment as documented and specified by

Divisions 15 and 16.

C. When shipped in sections, ship each section complete with all interconnecting wiring and accessories required for installation.

D. Custom penthouse units and custom air handling units, consisting of all sections equipment, ladders, stairs and flooring shown on the drawings and specified in this Section shall have a total unit leakage (infiltration cfm plus exfiltration cfm) of 1/2 percent of design cfm airflow at design static pressure.

2.2 UNIT BASE

A. Construct each section on a minimum 8 inch high aluminum or G90 galvanized steel powder-coated with ProTechPT311H30 structural steel base, floor plate material shall be aluminum checker plate, consisting of electrically welded wide-flange ASTM structural members.

B. For steel bases, clean shot or sandblast the base, prime with rust-inhibiting primer, and finish with exterior enamel paint or epoxy mastic.

C. The base of each shipping section shall have removable lifting lugs. Indicate balance point on section bases.

2.3 DOUBLE-WALL INSULATED HOUSING (WALL, ROOF AND PARTITION)

A. Exterior Sheets: 12 gauge textured aluminum or 20 gauge G90 galvanized steel powder-coated with ProTechPT3, for poured-in-place foam panel units.

1. The minimum panel thickness shall be 2" thick with 3.0 pcf high density polyurethane foam insulation.

B. Interior Sheets: Solid, except perforated with 23 percent free area where noted. Construct sheets from 14-gauge galvanized steel or aluminum, or 20 gauge G90 galvanized steel painted with white ProTech Chemicals PS241W460AM anti-microbial powder coating, except 12 inches upstream and 30 inches downstream from cooling coil, where material shall be 18-gauge Type 304 stainless steel. Unit shall be perforated in the supply fan section.

C. Insulation Barrier Material for Fibrous Insulation

1. Supply Air: Provide a mylar sheet between the fibrous insulation and the perforated interior sheets.

2. Exhaust Air: Provide tight woven glass fiber cloth between the fibrous insulation and the perforated interior sheets.

D. Housing Framing Type: Support interior and exterior sheets by continuous galvanized steel or aluminum or G90 galvanized steel powder-coated, extended internal members spanning between the floor and the roof, spanning across roof, and spaced to limit sheet deflections to 1/200th of span at design differential pressure across the housing.

1. Panel and framing design, by using "no thru-metal" type construction, shall not permit exterior surface temperature to fall below dew point of 72 deg F at design ambient conditions of 95 deg F DB/78 deg F WB, when air within unit is 50 deg F.

E. Galvanizing: Hot-dipped, zinc coating designation G90, conforming to ASTM A 527/A 527M.

F. Housing Assembly: Fasten sheets to internal support members with stainless steel sheet metal screws or by spot-welding not to exceed 9 inches on centers.

G. Electrostatically and thermally isolate dissimilar metals.

H. Seal wall piping and conduit penetrations using a cast packing gland, such that a compression seal within the gland provides a removable-airtight seal around the pipe-conduit.

I. Coordinate with Division 15 Mechanical, Division 16 Electrical and Division 25 Building Automation Systems Contractors the exact location of ductwork, piping, electrical conduit and control wiring entering and exiting the custom penthouse unit.

J. Provide flanged openings for airtight attachment of field ductwork.

2.4 INSULATION

A. Install insulation to completely fill space between exterior and interior sheets and within all framing members, such that the entire wall surface is totally insulated without any voids.

B. Insulation Thickness and Type:

1. Roof: 2" thick polyurethane foam, as specified in Section 15080.

2. Walls and Plenum Roof Curb Walls, Exterior-to-Outside: 2" thick polyurethane foam, as specified in Section 15080.

3. Partitions and Floor between Supply Air, Outdoor Air and Exhaust Air: 2" thick polyurethane foam, as specified in Section 15080.

4. Bottom of Plenum Curb Handling Supply Air: 2" thick polyurethane foam.

2.5 FLASHINGS AND CLOSURES

A. Provide flashings, corner moldings and metal closures to weatherproof the unit. Material and finish shall be same as adjacent sheets.

2.6 FASTENERS

A. Manufacture fasteners from Type 304 stainless steel. Sheet metal screws shall not penetrate the casing in a manner that could allow air or water leakage over the life of the unit.

2.7 PLENUM SECTIONS

A. Discharge plenum sections shall be as shown on drawings. Provide duct collars of sizes to match the connecting duct sizes indicated on drawings. Construct discharge plenums as described above for housings. Provide access doors where shown on drawings.

B. Plenum sections (without access doors) shall be suitable for installation between any two unit components. Width shall be as indicated on drawings. Where no width is indicated, width shall be 18 inches. Use shorter sections as required to connect unit components with minor size differences. Construct plenum sections as described above for housings.

C. In order to reduce airflow pressure losses, provide 45 deg. multi-sided flare outs, minimum 6” deep, for all entry and exit openings into and from plenums and ductwork.

2.8 ACCESS SECTIONS

A. Access sections shall be suitable for installation between any two unit components and shall be at least 30 inches wide. Construct access sections as described above for housings. Provide access doors as shown on drawings. Construct access doors as described below.

2.9 ACCESS PANELS

A. Provide removable, bolted, gasketed access panels where shown on drawings and as required for removal of equipment. Size and locate panels for removal of largest piece of equipment in section which panel serves.

1. Provide panels with lifting lugs and handles.

2.10 ACCESS DOORS

A. Provide access doors where shown on drawings, and for sections which require regular inspection or maintenance, and for service compartments or closets. Doors to be 24" minimum unless noted otherwise on drawings.

B. Doors shall be of the same construction as the housing. Door and frame assembly shall utilize a true "no thru metal" construction, and shall not allow condensation on exterior surfaces at design operating conditions.

C. Doors shall have corrosion resistance continuous piano hinge for the full height of the door, an extruded aluminum door frame and shall seal against 2 separate but continuous surfaces (double-gasketed) using a adhesive backed closed cell foam gasket. Provide doors accessing sections containing rotating equipment, or containing fume-laden or contaminated air, with special tool or common key for locking. Arrange door swing so that differential pressure across door shall assist in compress the gasket on two surfaces.

D. Doors shall be 72 inches high. If the unit height is smaller than 72 inches, doors shall be equal to the unit height. Minimum door clear-openings width shall be 20-inches. For fan sections, the door width shall be at least 4-inches wider than the width of the fan motor.

E. Each door shall have a 12" x 12" view port, of double-layered, tempered or wire-reinforced glass mounted in a gasketed aluminum frame. Place a desiccant sachet in the cavity between glass layers. All viewports downstream of the cooling coil shall be the thermopane type. Each door shall also have air test port.

F. Access doors shall have been tested in an independent laboratory in accordance with the referenced ASTM standard E283. A 24" wide by 60" high assembly shall withstand 25" of water column test chamber pressure. Air infiltration shall not exceed .41 CFM/lineal foot of panel frame opening at 11" water column.

2.11 SOUND ATTENUATORS

A. Provide unit-mounted sound attenuators as specified in Section 15070, arranged as shown on drawings and with performance scheduled on drawings. For aluminum panel type units, attenuators shall be of aluminum construction.

2.12 FILTER SECTIONS

A. Provide filters as specified in Section 15861, arranged as shown on drawings and with performance scheduled on drawings.

B. Provide air filter gauges for each bank of filters. The filter gauge shall be a diaphragm actuated, dial type gauge with zero adjustment, 3-way vent valves, static pressure tips, integral compression fittings on both valves and tips, and aluminum surface mounting bracket with screws.

1. Approved Manufacturer: Dwyer Series 2000 Magnehelic.

C. For all types of air filters, filters gauge range shall be 0-3" w.g.

2.13 AUTOMATIC CONTROL DAMPERS

A. General:

1. Damper construction specifications herein are minimum. In all cases, damper static pressure ratings shall meet or exceed the rating of the ductwork or system in which they are installed.

2. Dampers for modulating service shall be opposed blade design. Dampers for two-position service shall be parallel blade design. Dampers for Air Handling Unit mixing box applications shall be parallel blade design.

3. The BAS Contractor shall field furnish and install electronic damper operators, as specified elsewhere of sufficient capacity to ensure smooth operation under all design loading conditions. Operators shall be capable of providing 125% of the required maximum opening torque.

a. Provide hardware for mounting of all operators.

B. Control Dampers - 2" to 6" W.C. Service

1. Damper construction shall meet the following minimum criteria:

a. Blades: 16 gage aluminum airfoil type double skinned, maximum length 48 inches, maximum width 6 inches. Axles shall be 1/2" diameter plated steel.
b. Blade edge seals: extruded vinyl or neoprene.
c. Bearings: oil impregnated bronze.
d. Frame: 12 gage aluminum high hat channel.
e. Jamb seals: stainless steel compression type.

2. Leakage rate shall not exceed 3% of maximum flow or 12 cfm, whichever is less, at 6" W.C. differential.

3. Operating temperature limits shall be -10° F. to +150° F. minimum.

4. Dampers shall be Ruskin CD-50 or approved equivalent, subject to compliance with requirements.

C. Dampers shall utilize linkages concealed in the frame such that no blade linkages or connecting rods are located in the airstream. Coordinate damper installation such that all bearings and linkages are accessible for maintenance. Do not use concealed frame linkages when more than two (2) sections are required.

D. Automatic damper assemblies, consisting of multiple automatic damper sections, shall be sized (maximum blade width) to meet the maximum duct velocity in which the individual automatic damper assembly is to be installed, and under no circumstances shall the maximum individual automatic damper blade length (maximum damper section width) exceed 60".

1. Dampers shall be capable of withstanding up to 6000fpm with a 12" damper blade width.

E. Louvers: Provide outside air openings with stormproof louvers and birdscreens. Louver face velocities not to exceed 375 fpm.

2.14 SMOKE DAMPERS

A. Provide factory installed, internally mounted smoke dampers where shown on drawings. Construct dampers as specified in Section 15820.

2.15 FAN SECTION

A. Provide fans of type and with performance scheduled on drawings and as specified in Section 15837, and arranged as shown on drawings.

1. Plenum Fans: Center fans in the vertical plane within the unit.

B. Provide vibration isolation devices as specified in Section 15070. Isolate fan discharge by a flexible duct connection as specified in Section 15820 and thrust restraints as specified in Section 15070. Statically and dynamically balance fans after installation in fan section.

C. Motor and motor drives shall comply with Section 15035.

D. Provide an automatic grease dispensing unit with all required accessories for bearing lubrication. Acceptable Manufacturers, subject to compliance with requirements:

1. TM Industries "Uniquip"

2. ATS Electrolube, Jumbo Size.

E. A two bolt adjustable NEMA motor base shall be provided to allow for easy alignment and adjustment of belt tension. The frame and/or sub-base assembly shall be provided by the unit manufacturer.

F. Arrange the fan compartment so that the space between the fan inlets and the housing is a minimum of 75% of one fan diameter.

G. The roof system over each fan shall incorporate a monorail system to allow for removal of fans or motors. Unit roof construction and supports shall allow for movement of fan and motor via a rolling trolley on the monorail.

H. Provide with manufacturer's piezometer ring for air flow measuring.

2.16 HEATING AND COOLING COIL SECTIONS

A. Provide coils as specified in Section 15761, as arranged on drawings, and with performance scheduled on drawings.

B. Support coils on Type 304L stainless steel tracks extending continuously full width of unit to allow coils to be readily slipped in or out of unit.

C. Cooling Coil Drain Pans:

1. Where coils are stacked, provide an intermediate drain pan for each bank of coils, with factory-piped Type 304L stainless steel drain tubes at both housing ends piped to the main drain pan.

a. Intermediate drain pans shall be Type 304L stainless steel, two inches deep and shall extend 12 inches downstream and 4-inches upstream of the coil. Intermediate drain pans shall extend over entire width of coil bank including return bends and headers.

2. Main drain pan shall extend over entire width of coil section including return bends and headers, shall be 4-inches deep and shall extend full depth of coil section and downstream access section. Main drain pan shall be of double-wall insulated construction with Type 304L stainless steel liner.

3. Double-slope main and intermediate drain pans in the direction of airflow toward a drain

outlet located at lowest point of pan. For horizontal outlets, the drain invert shall be below the lowest point of pan wetted surface.

4. For units wider than 12 feet provide a quadruple-sloped drain pan (i.e., double-sloped to two sides).

D. Provide gasketed and caulked safe-off panels between coils and casing walls to prevent air bypass.

E. Coil headers shall be within coil section. Header connection piping shall extend through casing walls and be sealed airtight. Provide piping as specified in Section 15180.

F. All fasteners in coil sections shall be Type 304 stainless steel.

G. Primary and secondary pans shall extend 1" beyond headers and U-bends on each side of coils.

2.17 ENERGY RECOVERY WHEEL SECTIONS

A. Provide energy recovery wheels as specified in Section15785.

B. Provide required sheet metal safing around the wheel frame to force air through the wheel and purge eliminate airflow around the wheel and between the two air steams.

2.18 MOISTURE ELIMINATOR SECTIONS

A. If needed for carry-over, provide moisture eliminators that remove 99% of water droplets in the airstream downstream of cooling coils at 500 feet per minute. Construction: Type 304 stainless steel, 1" thick. Pipe drain outside of unit and to same side as other air handling unit drains. Maximum pressure drop: 0.08-inches water at 500 feet per minute face velocity.

B. Provide moisture eliminator sections after all spiral-fin cooling coils and after blow-through cooling coils, and at other locations where shown on drawings.

C. Approved Manufacturer: Mistop Inc.

2.19 INSTRUMENT TEST PORTS

A. Provide two instrument test ports at each access section.

B. Ports shall be PVC with a full sleeve and threaded plug. The port shall accommodate the insulation thickness of the panel in which it is installed.

2.20 ELECTRICAL

A. Mount motors internally on vibration isolation bases.

B. Wire each motor to its variable frequency drive or starter as applicable. Provide local disconnect at motor. Omit disconnect if VFD is mounted on unit.

C. Lights and Electrical Outlets:

1. Units shall have factory installed light fixtures in each compartment having an access door. These shall not obstruct filter removal. For units wider than 12 feet, provide 2 lights per compartment. These fixtures shall be pre-wired to individual switches on the outside of each section. Seal the conduit path to prevent air flow through the conduit. Independently switch each section.

2. Light fixtures shall be:

a. Four foot single tube, gasketed, outdoor grade, fluorescent with low temperature ballast. Approved Model: Lithonia DMW-140.

3. Provide one 120 volt, weather-tight, duplex GFCI electrical outlet at each access section. The outlet shall be controlled by the light switch.

4. Conduit for lights and outlets shall be electrical metallic tube (EMT). Flexible conduit connections shall be liquid tight.

5. All junction boxes shall be gasketed.

D. All wiring shall be done by the unit manufacturer at the factory. Provide junction box(es), as required, for connection of lighting power.

1. Provide a thermal break between the receptacle and the light switch compartment when they are adjacent to each other to prevent condensation in the light switch compartment.

E. All wiring shall be in compliance with Division 16 requirements.

F. Provide single point power connector for light and receptacle power.

2.21 VARIABLE FREQUENCY DRIVES (VFD)

A. Provide a variable frequency drive for each fan where shown on drawings and as specified in Section 15035.

2.22 SMOKE DETECTORS

A. Smoke detectors will be field furnished and installed.

PART 3 - EXECUTION

3.1 SUPERVISION OF UNIT ASSEMBLY AND INSTALLATION

A. Unit manufacturer shall provide field engineer for sixteen (16) normal working hours to supervise rigging, assembling and installing units.

3.2 FIELD TESTING

A. Leak test all units, after installation of all components and all external ductwork and piping connections are completed, using the criteria specified in Part 2, and the procedures and apparatus identified in Chapters 3 and 5 of the SMACNA HVAC Air Duct Leakage Test Manual.

1. Repair units leaking in excess of this limit and retest at no additional cost to the Owner.

3.3 START-UP SERVICE

A. Unit manufacturer shall provide field engineer for supervision of unit start-up, and instruction of Owner's personnel in unit operation and maintenance, for minimum of sixteen (16) normal working hours.

3.4 FACTORY PERFORMANCE TESTING

A. Each fan shall be factory run tested in accordance with Section 15837 to ensure structural integrity. Measure fan vibration in accordance with ANSI Standard S2.19, Grade G6.3. Maximum fan vibration, measured on fan bearings, shall be 0.20-inches per second.

B. All coils shall be factory pressure tested in accordance with Section 15837.

C. Factory run test unit after the entire unit has been fully assembled. The factory run test shall be conducted to examine unit operation, minimum vibration levels, external static pressure and maximum airflow as specified. Include test results in report.

1. Provide a complete static pressure profile through each entire unit for each supply and exhaust air path at design airflows. Simulate dirty “loaded” filters.

2. Modify internal unit construction, as required, to reduce unusually high airflow pressure losses due to construction, at no additional cost to the Owner.

3. The factory run test for one of the AHUs shall include exhaust fan operation.

4. Simulate the pressure drop across the heat wheel section if the wheel is not present.

D. The AHU manufacturer shall conduct a factory casing air leak test (FAT) for each unit prior to shipment. Unit sections shall be subjected to negative pressure upstream of supply fans and positive pressure downstream of the supply fans. Maximum air leakage rate shall be 0.5% of design CFM at 150% of the design static pressure or fan shutoff pressure, whichever is greater. Air leakage to be measured with a calibrated orifice plate or flow tube.

1. If a unit fails to meet the test requirements, corrections are to be made at the expense of the manufacturer, including any travel or accommodation expenses resulting from a second witness test.

a. Caulking of any interior/exterior surfaces is not an acceptable solution to fixing an air leak.

2. Additionally, if a unit fails the FAT at any point or requires modification to pass the FAT, the manufacturer shall bear the cost of mandatory field testing after the unit has been installed to prove it meets requirements.

E. Test reports shall be signed and furnished to the Owner.

F. The completed unit shall pass all test requirements and bear an ETL label.

G. Witnessed Factory Test:

1. The unit manufacturer shall notify the Owner twenty (20) working days prior to the scheduled testing date.

2. The Owner, Construction Manger, and engineer may witness the test. Cost of travel or living expenses not to be included in Bid Base Price.

3. Each fan shall be factory run tested in accordance with Section 15837 to ensure structural integrity. The factory run test shall be conducted to examine unit operation and minimum vibration levels as specified.

4. All water coils shall be factory pressure tested in accordance with Section 15761.

5. Factory run test for each unit shall be after the unit has been fully assembled.

6. Perform air leak test on all air handling units. Owner and A/E will witness test. Test to be accordance with 3.04D.

7. Fan Performance Test: Test fan performance at maximum and minimum design CFM and static pressures in accordance with submitted curves. Test as per AMCA field test

procedure acceptance criteria as per AMCA standard. Owner and A/E may choose to witness test.

8. Fan Heat Rise Test: Test temperature rise at fan section inlet and outlet during fan performance test. Owner and A/E may choose to witness test.

9. Test fans for unbalance tolerances. Owner and A/E may choose to witness test.

10. Test and rate cooling system to ARI Standard 210. Owner and A/E may choose to witness test.

11. Test cooling coils and drain pans for water leakage. No water leakage allowed. Owner and A/E may choose to witness test.

12. All travel and lodging costs for owner and A/E to witness unit testing shall not be included in the Bid Base Price.

13. Schedule all testing at least 20 days in advance to coordinate with the Owner's schedule. If all testing can not be completed within a two day period, assume multiple trips by the owner and A/E.

14. The Witnessed Factory Test may be done concurrently with the Factory Performance Testing described in paragraphs A thru D.

3.5 INSTALLATION

A. Install all equipment in accordance with the manufacturer's instructions and as shown on the drawings.

3.6 START-UP – CUSTOM AHUS

A. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

B. References: The following additional Sections shall also apply:

C. Refer to AC Motors in Section 15035.

D. Refer to Fans in this Section

1. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for procedures for air-handling-system testing, adjusting, and balancing.

2. Refer to Commissioning section for procedures for starting the controls related to the AHU.

E. Start-Up Checks: Perform the following inspections/checks before start-up:

1. Inspect the field assembly of components and installation of central-station air-handling units including piping, ductwork, and electrical connections.

2. Cleaning: Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.

3. Adjust and lubricate dampers and linkages for proper damper operation.

4. For field fabricated units, ensure the sections are properly connected within acceptable tolerances.

5. Seal the all penetrations air tight and ensure access doors seat tightly.

6. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete.

7. Verify proper thermal overload protection is installed in motors, starters, and disconnects.

8. Ensure vibration isolation integrity is maintained throughout the AHU installation and its connections.

9. Tension all belts per the drive manufacturer’s recommendations.

10. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.

11. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.

12. Comb coil fins for parallel orientation.

13. Install clean filters.

14. Ensure condensate drains properly and that trap is adequate.

15. Stroke all valves and damper to ensure free and full travel

F. Start-Up Tests: Perform the following before or during start-up:

1. Pressure test units as required in the AHU specification

G. Training: Factory-authorized representative shall train Owner's maintenance personnel including:

1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.

2. Familiarization with contents of Operating and Maintenance Manuals.

3.7 START-UP FANS

A. General: Provide the services of a factory-authorized service representative to test and inspect unit installation, provide startup service, and to demonstrate and train Owner's maintenance personnel as specified below.

B. Start-Up Checks: Perform the following inspections/checks before start-up:

1. Inspect the field assembly of components and installation of central-station air-handling units including piping, ductwork, and electrical connections.

2. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet, and coils entering air face. Ensure volatile irritants are contained and kept out of occupied spaces.

3. Adjust and lubricate dampers and linkages for proper damper operation.

4. Verify unit is secure on mountings and supporting devices and that connections for ductwork, and electrical are complete. Verify proper thermal overload protection is installed in motors, starters, and disconnects.

5. Ensure vibration isolation integrity is maintained with the fan installation and the connections to it.

6. Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.

7. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.

8. Stroke all dampers to ensure free and full travel

C. Training: Factory-authorized representative shall train Owner's maintenance personnel including:

1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and how to obtain replacement parts.

2. Familiarization with contents of Operating and Maintenance Manuals.

+ + END OF SECTION + +

SECTION 15730 - HEAT-WHEEL AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.01 SUMMARY

A. Energy recovery rotary heat wheels.

1.02 SUBMITTALS

A. Requirements for Submittals and Product Substitutions, Division 01, apply to work specified in all Division 23 Sections.

B. Product Data: For each type of product indicated.

C. LEED Submittals:

1. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

D. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Wiring Diagrams: For power, signal, and control wiring.

E. Operation and maintenance data.

F. Performance data:

1. Performance data at scheduled air flows including: pressure drops, purge CFM, and recovery efficiencies.

1.03 QUALITY ASSURANCE

A. Energy Recovery Rotary Heat Wheels: Wheels shall be manufactured by a company regularly engaged in the manufacturer of such wheels and having catalogue performance data and certified test data.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ARI Compliance:

1. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."

2. Capacity ratings for air coils shall comply with ARI 410, "Forced-Circulation Air- Cooling and Air-Heating Coils."

D. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."

E. UL Compliance:

1. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."

2. Electric coils shall comply with requirements in UL 1995, "Heating and Cooling Equipment."

1.04 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.

B. Energy Recovery Wheels shall carry a full parts and labor warranty for (5) years from the date of shipment. The extended warranty shall cover both thermodynamic performance and mechanical operation of the entire rotating assembly except for belts, motor, and AC frequency inverter. The manufacturer of the total Energy Recovery Wheel Transfer Media (not employees of the contractor or wheel casing fabricators that purchase the transfer media from others) shall provide field service engineer for start-up adjustment and calibration of controls, and instruction to operating personnel, and for annual inspection and documentation of thermodynamic performance and mechanical operation for the duration of the warranty period.

1.05 COORDINATION

A. BAS Communication Capability: Notify wheel manufacturer at time of submittal as to the desired communication protocol, so the Controller can be properly configured prior to shipment.

B. Coordinate work of this Section with work of other Sections.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide platforms, bases, wall mountings, hanger rods, inserts, and special supporting devices for equipment specified in this section as recommended by the manufacturer of a specified item.

2.02 TOTAL ENERGY RECOVERY ROTARY HEAT WHEELS

A. Acceptable manufacturers, subject to compliance with requirements:

1. EXCLU-SIEVE by SEMCO Mfg., Inc.

B. Rotor Media: Shall be made of aluminum coated to prohibit corrosion; etched or oxidized surfaces are not acceptable. All surfaces shall be coated with a non-migrating adsorbent desiccant specifically developed for the selective transfer of water vapor. Verification in writing shall be presented from the desiccant manufacturer confirming that the internal pore diameter distribution inherent in the desiccant being provided limits adsorption to materials not larger than the critical diameter of a water molecule (2.8 angstroms). Dry particles up to 800 microns shall freely pass through the media. Equal sensible and latent recovery efficiencies shall be documented through a certification program conducted in accordance with ASHRAE 84-78P and ARI 1060 standards. The certification shall have been conducted by a qualified independent organization.

1. Protective-Face Coating for Enthalpy Wheel: In addition to the desiccant coating that is applied to the surfaces of the aluminum substrate prior to being formed into the total energy wheel media (i.e. no dipped or oxidized coatings), the two faces of the total energy wheel shall be covered and sealed with a two part polymer heavy duty coating specifically chosen for chemical resistance.

C. Purge Sector: Provided with a factory set, field adjustable purge sector designed to limit cross contamination to less than 0.04 percent of that of the exhaust airstream concentration when

operated under appropriate design conditions.

D. Rotor Seals: Shall be supplied with labyrinth seals only, which at no time are required to make contact with any rotating surface of the exchanger rotor.

E. Rotor Support System: Rotor media shall be provided in a segmented fashion to allow for field erection of one section at a time without requiring side access. The media shall be rigidly held by a structural spoke system made of extruded aluminum.

F. Unit Housing: Shall be a structural framework which limits the deflection of the rotor due to air pressure differential to less than 1/32 of an inch. The housing shall be made of galvanized steel and shall be of tubular construction. The rotor shall be supported by two pillow block bearings which can be maintained or replaced without removal of the rotor from its casing or the media from its spoke system.

1. Provide factory painted finish. Manufacturer's standard color.

G. Drive System: The rotor shall be driven by a self-adjusting urethane belt system, A/C motor and adjustable frequency drive. Motor characteristics shall comply with requirements specified in SECTION 15055 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

H. Temperature Control Panel: The wheel control is designed to deliver tempered air to the space/main air-handling unit year round, with enthalpy based summer/ winter changeover and wheel condensation control.

1. Variable speed control is accomplished by the use of a variable frequency drive (VFD). The VFD includes all digital programming with am annual speed adjustment pot mounted on the front of the enclosure. The drive system will allow for a turndown ratio of 80:1 (20 rpm to 1/4 rpm).

2. Setpoint Control: The supply setpoint may be entered at the keypad, or received from the BAS. A local/remote setpoint switch may be toggled either through the keypad, or the BAS. The condensation control setpoint is automatically calculated and set by the controller.

3. Enthalpy Wheel Control:

a. If the outdoor enthalpy is less than the return enthalpy, the wheel modulates to maintain the supply temperature setpoint.
b. If the outdoor enthalpy is greater than the return enthalpy, the wheel rotates at full speed (20 RPM) in summer cooling mode.
c. If the outdoor enthalpy is less than the return enthalpy but the outdoor temperature is greater than the supply setpoint, the wheel will rotate at minimum speed (about 0.2 RPM) in economizer mode.
d. The controller will automatically calculate an exhaust temperature condensation control setpoint based on the space humidity.
e. If the exhaust temperature drops below the condensation control setpoint, the wheel will modulate slower to maintain the exhaust setpoint.
f. The wheel receives the minimum signal from the supply temperature and condensation control loops.

4. Hardware: Components include an Automated Logic 6104 Controller, and Large BACview1 LCD keypad. Sensors include a temperature and RH sensor which should be located in the Outdoor air, supply air, and return air streams. Provide temperature point sensor for installation in the exhaust air stream. Provide rotation detector and variable

frequency drive.

5. Display: Inputs, outputs, and setpoints may be viewed at the unit mounted LCD display or remotely using communications software. Setpoints may be adjusted either at the unit or remotely.

6. Alarm Functions: Digital alarm input consist of a wheel rotation detector. If an alarm trips, the alarm light on the unit will energize, and the source of the trip may be seen on the keypad.

7. Communication Capabilities: The standard IO Controller will communicate BACnet over 2-wire EIA-485 or 4-wire EIA-232, Modbus, or Johnson N2. Lontalk and BACnet over Ethernet communications are possible using optional boards or drivers. The BAS start stop command can be either a hard-wired dry contact, or a software command using one of the protocols above.

8. Digital Performance Display Module: Digital read out of the temperature readings recorded by these sensors and control set points shall be displayed by the control panel.

9. Furnish a rotation detector with sensors.

10. Health and safety energy monitor (HSEM)
The HSEM provides humidity sensors, an exhaust air side pressure transducer and additional programming to allow for real-time measuring and reporting of recovery efficiency. The measured airflows are also combined with the reported recovery efficiency to calculate and accumulate annual energy savings which can be reported in BTUs and dollars.

    a. The health and safety energy monitor (shall be provided to ensure that proper purge operation is maintained actively through the modulation of the recovery wheel speed in response to a change in system pressures, for example as occurs with a variable volume system or systems where pressure changes appreciably due to filter loading or damper modulation. The health and safety monitor shall be housed in a 24” x 20” NEMA rated control panel, housing the DDC controller and expander boards, three high precision pressure transducers and a large, face mounted LCD display screen to allow viewing and changing key parameters included in the custom programming provided. Four, field mounted high precision temperature and relative humidity sensors shall be provided and located in accordance with SEMCO recommendations to measure the temperature and humidity levels that exist at each air stream around the recovery wheel. These sensors shall be wired to the expander board located within the HSEM panel. Factory provided pressure tubing and probes shall be field installed in accordance with SEMCO recommendations, and connected to the pressure transducers located within the HSM or HSEM panel.

    b. A combined rotation – counter rotation detector module shall be provided to simultaneously confirm that (1) the recovery wheel is rotating and that (2) it is rotating in the correct direction, allowing for effective purge operation. Magnetic proximity sensors are provided that detect motion at the outer rim of the recovery wheel and are field wired back to the HSEM panel.

    c. Programming of the DDC control panel will allow for the following capabilities:

        1) Conversion of temperature and relative humidity readings into grains, dew point and enthalpy
        2) Conversion of pressure readings across the wheel into supply and return airflow estimates
        3) Calculation and reporting of real time unit effectiveness
        4) Calculation and reporting of accumulation of energy (BTUs) recovered over time
        5) With user input of energy costs, calculation and accumulation of dollars saved over time

6) Startup mode to monitor system pressures and calculate an initial purge angle setting
7) Automatic wheel speed adjustment to ensure effective purge operation (<.045%) over the range of flow modulation down to 25% of maximum flow.
8) An alarm output if the system pressures do not allow for proper purge and/or seal operation
9) An alarm output if the wheel is not rotating
10) An alarm output if the wheel is rotating in the wrong direction
11) Programming for integration of enthalpy based summer-winter change over, frost prevention and supply temperature control such that they also function correctly as the wheel speed is modulated to optimize purge operation
12) Allow for communications and data transfer with on-site energy management system via BACNET or BCNET over IP.

d) All components, sensors and programming shall be completed by the recovery wheel manufacturer to ensure that responsibility resides with one source. Startup of the HSEM shall be provided by SEMCO in conjunction with the wheel/system startup/commissioning.

I. Disposable Panel Filters:

1. Provide MERV 7 disposable panel filter as specified in section 234100.

2. Filters shall be removable as shown on drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify dimensions by measurement at site.

B. Verify that conditions and prior construction are acceptable for energy recovery wheel installation.

1. If conditions or prior construction are not acceptable for energy recovery wheel installation, notify Architect.

2. Commencing energy recovery wheel installation indicates that conditions and prior construction are acceptable.

3.02 INSTALLATION

A. Install and adjust the energy recovery wheel(s) and automatic control system(s) in compliance with the wheel manufacturer's installation instructions.

3.03 FACTORY START-UP

A. Installation: After the wheel(s) and their control system(s) have been installed, a factory technician shall inspect the installation and place them into operation.

1. If the wheel(s) and control system(s) have been installed correctly and are operating properly, the technician shall document this in writing.

2. If the wheel(s) and/or control system(s) have not been installed properly, the technician shall indicate what remedial action must be taken, and shall re-inspect and re-document the installation after the remedial action has been completed.

B. Performance: After documenting that the wheel(s) and control system(s) are operating properly, a factory technician shall adjust all control system set-points and evaluate wheel performance.

1. If the energy recovery wheel is performing properly at the time and under conditions that

wheel performance was evaluated, the technician shall document all technical data in writing.

2. If the wheel is not performing as predicted by factory supplied data, the technician shall trouble-shoot the cause and undertake remedial action at no additional cost to the Owner. He shall then re-evaluate and re-document wheel performance after the remedial action has been completed.

C. Documentation in Writing: Furnish all start-up documentation to the Owner.

3.04 OWNER TRAINING

A. A factory technician shall train Owner personnel for a period of 12 working hours at the project work site. At a minimum, training shall cover the following:

1. How the wheel and its automatic control system work.

2. Trouble-shooting critical areas of operation, i.e. supply/exhaust airflows, wheel rotation, entering/ leaving air temperatures, entering/leaving air relative humidity, automatic controls.

3. Routine maintenance.

+ + END OF SECTION + +

SECTION 15740 - HYDRONIC PUMPS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes the following centrifugal pumps for hydronic and aqueous brine systems:

1. Vertical in-line, close-coupled.

2. In-Line Circulator, split-coupled, horizontal.

3. End-suction, split-coupled, base-mounted.

1.02 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, materials of construction, final impeller dimensions, and accessories for each type of product indicated.

1. Performance Curves: Indicate pump's operating point on curves. Include system curve, brake horsepower curve and efficiency curves.

a. Variable Speed Pumps: Include multiple-speed operating curves, and clearly indicate the minimum permissible speed.
b. Open Systems: Include NPSH curve and indicate the minimum NPSH required at the operating point for the pump.
c. Parallel and Series Pump Operation: Include combined pump curve.

B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.

C. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.03 QUALITY ASSURANCE

A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated.

1. Pump Selection: Select pumps to operate at or near their point of peak efficiency.

a. Design Impeller Diameter: Select diameter such that the design capacity of the pump (GPM and TDH) shall not exceed 90 percent of the capacity obtainable with maximum impeller diameter at the design speed for that model.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and

treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.05 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.01 GENERAL –APPLICABLE TO ALL PUMPS

A. Electric Motors: Furnish as shown on contract drawings for each pump, and in compliance with SECTION 230513 requirements.

1. Pumps Installed Indoors: Furnish open drip-proof (ODP) motors; explosion-proof (TEXP) only where specifically indicated on contract drawings.

2. Pumps Installed Outdoors: Furnish totally-enclosed, fan-cooled (TEFC) motors.

B. Coupling Guard: Furnish for shaft coupling of each split-coupled pump. Guard shall be dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

2.02 VERTICAL IN-LINE PUMPS, CLOSE-COUPLED

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Armstrong Pumps Inc.

2. Aurora Pump; Division of Pentair Pump Group.

3. Bell & Gossett; Div. of ITT Industries.

4. Burks Pumps; Div. of Crane Pumps & Systems.

5. Demming Div.; Crane Co.

6. Flowserve Corporation; Div. of Ingersoll-Dresser Pumps.

7. Grundfos Pumps Corporation.

8. Little Giant Pump Co.; Subsidiary of Tecumseh Products Co.

9. MEPCO (Marshall Engineered Products Co.).

10. PACO Pumps.

11. Patterson Pump Co.; a Subsidiary of The Gorman-Rupp Co.

12. Peerless Pump; a Member of the Sterling Fluid Systems Group.

13. Taco, Inc.

14. Thrush Company Inc.

15. Weinman; Div. of Crane Pumps & Systems.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, vertical in-line pump as defined in ANSI/ HI 1.1-1.2 and ANSI/ HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

1. Unless otherwise indicated on contract drawings, rate pump for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.

2. Alternative Design: Dual-arm type vertical in-line pumps, by Armstrong Pumps, may be furnished, where system design consists of only two pumps.

3. Alternative Design: End-suction, close-coupled, vertical-mounted pumps with steel support stand and long radius or long radius reducing elbow, by Aurora Pump or PACO Pumps, may be furnished.

C. Pump Construction: Bronze-Fitted.

1. Casing: Radial split, cast or ductile iron, with replaceable bronze wear rings, threaded gage tapping at inlet and outlet, and 125 Class ANSI drilled flange or threaded companion-flange connections.

a. Floor-Mounted Pumps: Furnish with cast iron support base.

2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.

3. Pump Shaft:

a. Indoors: Steel, with copper-alloy shaft sleeve.
b. Outdoors: Stainless steel.

4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring. Include water slinger on shaft between motor and seal.

a. Continuous Water Temperature up to 225 deg. F: Buna-N bellows and gasket.
b. Continuous Water Temperature 226 to 250 deg. F: EPT bellows and gasket.

5. Pump Bearings: Permanently lubricated ball bearings up to 5.0 HP. Re-greasable ball bearings for larger horsepower pumps.

D. Motor: Rigidly mount to pump casing.

2.03 IN-LINE CIRCULATORS, HORIZONTAL, PIPE-MOUNTED, SPLIT-COUPLED

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Armstrong Pumps Inc.

2. Aurora Pump; Division of Pentair Pump Group.

3. Bell & Gossett; Div. of ITT Industries.

4. Flowserve Corporation; Div. of Ingersoll-Dresser Pumps.

5. Grundfos Pumps Corporation.

6. MEPCO (Marshall Engineered Products Co.).

7. PACO Pumps.

8. Taco, Inc.

9. Thrush Company Inc.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, split-coupled, in-line pump as defined in ANSI/ HI 1.1-1.2 and ANSI/ HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

1. Unless otherwise indicated on contract drawings, rate pump for 175 psig minimum working pressure and a continuous water temperature of 225 deg F.

C. Pump Construction: Bronze-Fitted.

1. Casing: Radial split, cast iron, with threaded gage tapping at inlet and outlet, and threaded companion-flange or union end connections.

2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.

3. Pump Shaft: Steel, with copper-alloy shaft sleeve.

4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring. Include water slinger on the shaft between motor and seal.

a. Continuous Water Temperature up to 225 deg. F: Buna-N bellows and gasket.
b. Continuous Water Temperature 226 to 250 deg. F: EPT bellows and gasket.

5. Pump Bearings: Permanently lubricated ball bearings up to 5.0 HP. Re-greasable ball bearings for larger horsepower pumps.

D. Shaft Coupling: Interlocking frame with interconnecting springs capable of absorbing vibration.

E. Motor: Resiliently or rigidly mounted to pump casing.

2.04 END-SUCTION PUMPS, FRAME-MOUNTED, SPLIT-COUPLED, BASE-MOUNTED

A. Acceptable Manufacturers, subject to compliance with requirements:

1. American-Marsh Pumps.

2. Armstrong Pumps Inc.

3. Aurora Pump; Division of Pentair Pump Group.

4. Bell & Gossett; Div. of ITT Industries.

5. Buffalo Pumps, Inc.; an Ampco Pittsburgh Co.

6. Burks Pumps; Div. of Crane Pumps & Systems.

7. Deming Pumps; Div. of Crane Pumps & Systems.

8. Flowserve Corporation; Div. of Ingersoll-Dresser Pumps.

9. MEPCO (Marshall Engineered Products Co.).

10. PACO Pumps (Sulzer Pumps).

11. Peerless Pump.

12. Scot Pump; Div. of Ardox Corp.

13. Taco, Inc.

14. Thrush Company Inc.

15. Weinman; Div. of Crane Pumps & Systems.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, split-coupled, end-suction pump as defined in ANSI/ HI 1.1-1.2 and ANSI/ HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

1. Unless otherwise indicated on contract drawings, rate pump for 175 psig minimum working pressure and a continuous water temperature of 225 deg F.

C. Pump Construction: Bronze-fitted.

1. Casing: Radial split, cast or ductile iron, with replaceable bronze wear rings, threaded gage tapping at inlet and outlet, drain plug at bottom and air vent at top of volute, and threaded companion-flange or 125 Class ANSI drilled flange connections.

a. Back-Pullout Design: Provide integral mount on volute to support the casing, and attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.

2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.

3. Pump Shaft.

a. Indoors: Steel, with copper-alloy shaft sleeve.
b. Outdoors: Stainless steel.

4. Mechanical Seal: Internally-flushed, carbon rotating ring against a ceramic seat held by a stainless-steel spring.

a. Continuous Water Temperature up to 225 deg. F: Buna-N bellows and gasket.
b. Continuous Water Temperature 226 to 250 deg. F: EPT bellows and gasket. Furnish with small air-to-water heat exchanger in flushing line and flush-line filter.

5. Pump Bearings: Permanently lubricated ball bearings up to 5.0 HP. Grease-lubricated ball bearings contained in cast-iron housing with grease fittings for larger horsepower pumps.

D. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration.

1. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor.

2. Variable Speed Applications: EPDM coupling sleeve.

E. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

F. Motor: Secure to mounting frame, with adjustable alignment.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 CONCRETE HOUSEKEEPING PADS

A. Install concrete housekeeping pads of dimensions indicated for pumps and controllers. Refer to SECTION 15070.

1. Install dowel rods to connect concrete pad to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch (450 mm) centers around full perimeter of base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.03 PUMP INSTALLATION

A. Comply with ANSI/ HI 1.4 “Centrifugal Pump Operations” and ANSI/ HI 2.4 “Vertical Pump Operations” Standards.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Install continuous-thread hanger rods and vibration isolators of sufficient size to support pump weight. Vibration isolation devices are specified in SECTION 15070. Fabricate brackets or supports as required. Hanger and support materials are specified in SECTION 15070

E. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with

motor and pump shafts vertical. Use continuous-thread hanger rods and vibration isolators of sufficient size to support pump weight. Vibration isolation devices are specified in SECTION 15070. Hanger and support materials are specified in SECTION 15060.

3.04 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

1. Comply with pump and coupling manufacturers' written instructions.

2. Adjust pump and motor shafts for angular and offset alignment by methods specified in ANSI/ HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation" and ANSI/ HI 2.1-2.5, "Vertical Pumps for Nomenclature, Definitions, Application and Operation." Standards.

3. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with non-shrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.05 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes as shown on contract drawings, not the generally smaller pump suction inlet and discharge outlet nozzles sizes.

1. Dual-Arm Type Vertical In-Line Pumps Alternative Design:

Flow (GPM)	Suction & Discharge Pipe Sizes (IN.)
23 to 38	2
39 to 72	2-1/2
73 to 135	3
136 to 270	4
271 to 480	5
481 to 720	6
721 to 1250	8
1251 to 1950	10

2. Install valves on discharge and suction side of pumps as shown on contract drawings.

3. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves, but only where shown on contract drawings or so specified.

4. Provide for differential pressure readout across pump and strainer. Install single pressure gage connected to pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.

5. Install silent check valves and calibrated balancing valves on steam condensate pump unit discharge.

3.06 START-UP SERVICE

A. Engage a factory-authorized service representative to perform start-up service.

1. Complete installation and startup checks according to manufacturer's written instructions.

a. Check piping connections for tightness.
b. Clean strainers on suction piping.
c. Perform the following startup checks for each pump before starting:

1) Verify bearing lubrication.
2) Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
3) Verify that pump is rotating in the correct direction.

a) Prime pump by opening suction valves and closing drains, and prepare pump for operation. Do not operate the pump “dry”.
b) Start motor.
c) Open discharge valve slowly.

+ + END OF SECTION + +

SECTION 15761- AIR COILS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes:

1. Hydronic coils.

1.02 SUBMITTALS

A. Product Data: Include performance data, airside pressure drop, water pressure drop, and materials of construction.

B. ARI Certification.

C. Field quality control test reports.

D. Operation and maintenance data.

1.03 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.

2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Acceptable Manufacturers, subject to compliance with requirements, provide products by one of the following:

1. Coils in Custom Air Handling Units:

a. Heatcraft.
b. Aerofin.
c. RAE.

2. Other Fluid Coil Applications:

a. Carrier.
b. York.
c. Trane.
d. McQuay.

2.02 GENERALS

A. Minimum water velocity shall be 2.5 feet per second (fps) at design flow.

B. Certify coil performance in accordance with ARI Standard 410.

2.03 CONSTRUCTION - HYDRONIC COILS

A. Cores

1. Provide 5/8 inch O.D by 0.035-inch wall thickness seamless copper tubes for all coils within air handling units; 5/8 inch OD by 0.020 inch wall thickness elsewhere.

2. Provide 0.010-inch thick **[aluminum] [copper]** plate or spiral fins with flanged collars.

3. Mechanically secure fin collars to tubes.

4. Provide split coils with required supports where indicated on Drawings.

B. Headers

1. Hydronic and Refrigerant Coils: Provide copper headers and nipples with connections located on same end.

2. Hydronic Coils: Provide tapping at bottom of headers for 1/2 inch ball valve drain, and tapping at top of headers for 3/8 inch ball valve to vent non-condensable gases.

3. Braze cores into headers so that tubes are self-draining.

4. Construct headers for 250 psig operating pressure.

C. Special Construction for Glycol Coils

1. Materials shall be suitable for 30%, by volume, propylene inhibited glycol/water solution.

2. For exhaust air heat recovery coils, coat tube, fin, casing and header surfaces with a phenolic resin.

a. Prepare the coil surface, apply 2 coats and bake the coils in accordance with the coating manufacturer's instruction.
b. The minimum dry film thickness of the coating shall be 1.5 mils.
c. Coatings shall pass 720 hours in a salt-spray fog test in accordance with ASTM B 117.
d. Acceptable coatings are:

3. Casings and all support hardware shall be Type 304 stainless steel.

D. Factory Testing

1. Leak test each coil with 250 psig compressed air under water for 10 minutes at the factory before shipment.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine preliminary work required before air coils can be installed.

B. Coordinate with work of other Sections to make preliminary work acceptable for installation of air coils.

C. Do not begin installation until preliminary work is complete and in accordance with manufacturer's requirements.

D. Commencing air coil installation indicates that preliminary work is satisfactory for installation of air coils.

3.02 INSTALLATION

A. Install air coils in accordance with manufacturer's installation instructions.

B. Install coils level and plumb.

C. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

D. Straighten bent fins on air coils.

E. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

F. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

G. Install piping adjacent to coils to allow service and maintenance.

H. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping.

I. Control valves are specified in Div. 17, and other piping specialties are specified in Division 15.

J. Provide insulated access doors in ductwork upstream and downstream of duct-mounted coils as specified in Section 15250.

K. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

+ + END OF SECTION + +

SECTION 15763 - FAN COIL UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes fan coil units.

1.02 SUBMITTALS

A. Submit for review:

1. Product data for all units.

2. Color samples for exposed fan coil units.

3. Sound power level ratings by octave band for fan coil units.

PART 2 - PRODUCTS

2.01 FAN COIL UNITS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Airtherm

2. Dunham-Bush

3. Carrier

4. Envirotec

5. International

6. McQuay

7. Trane

8. York

B. Water Coils: Seamless copper tubing, mechanically bonded aluminum fins with continuous fin collars and sleeved coil end supports, designed for 2-pipe or 4 pipe system, as scheduled, at 200 psi and 250° F. Provide with a manual air vent.

C. Cabinets: Reinforced 18 gauge galvanized steel, baked enamel finish, insulated with 1 inch thick vinyl-faced 1.5 pcf fiberglass fastened with waterproof adhesives. Make enclosure large enough to accommodate heating coil control valve and piping connections on opposite end from cooling coil control valve and piping connections.

1. All parts shall be phosphatized and finished with baked-on enamel, standard color as selected by Architect.

D. Provide a removable front access panel for accessing fan, motor, coil, and drain pan.

E. Provide a track for a 1 inch thick throwaway filter at the return air inlet.

F. Provide stamped inlet and discharge grilles on non-ducted models.

G. Fans: Resiliently-mounted on an integral base. Forward-curved, centrifugal, double width-double inlet factory test, statically and dynamically balance fans.

H. Condensate Drain Pan: Galvanized steel, sloped to drain connection, insulated with 1/2" thick fire-retardant closed-cell insulation on the underside.

1. Provide auxiliary drain pan/drip lip.

I. Valve Control Packages: Provide a factory pre-piped valve control package consisting of a modulating electronic two-way auto control valve, unions, manual air vent, strainer, a calibrated balancing valve and a shut-off ball valve.

J. Filters: Minimum 20-25% ASHRAE efficiency, throwaway type.

K. Controls: Refer to Division 17.

L. Fan Motor: 3-speed permanent split capacitor type with thermal overload protection and automatic reset.

1. Provide integral disconnect switch.

2. Provide integral receptacle for 3-prong plug of condensate pumps.

3. Provide single point power connection.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

A. Install equipment in accordance with manufacturer's instructions.

B. Install fan-coil units to comply with NFPA 90A.

C. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.

E. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

F. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.

2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.

3. Connect condensate drain to indirect waste.

a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

G. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Section 233300. Comply with safety requirements in UL 1995 for duct connections.

3.02 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

+ + END OF SECTION + +

SECTION 15764 - CONVECTION HEATERS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes terminal heat transfer equipment.

1.02 SUBMITTALS

A. Submit for review:

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated..

2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Field quality-control test reports.

4. Color samples for exposed cabinet unit heaters convectors, exposed fan coil units and finned tube radiation.

5. Color samples for finned tube radiation.

6. Operation and maintenance data.

B. Test and rate all products in accordance with the referenced Hydronics Institute Baseboard and Finned Tube (Commercial) Ratings.

1.03 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.01 FINNED TUBE RADIATION

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Vulcan.

2. Sterling.

3. Trane.

4. Rittling.

B. Heating Coils: Seamless, nominal 3/4 inch diameter copper tubes with 0.020 inch wall thickness, mechanically expanded into 0.020 inch thick aluminum fins. Support coils in accordance with manufacturer's recommendations.

C. Enclosure

1. Fabricate enclosure from 16 gauge cold-rolled steel with rolled corners and spot-welded joints.

2. Enclosure: Provide tight-closing access doors without visible hinges at all valves.

   a. Enclosure shall have continuous heavy extruded anodized finish aluminum air outlet grille.

3. Enclosure shall have dampers with tamperproof operators.

4. Provide enclosure in sections to match building modular grid layout. Provide 6 inch overlapping enclosure trim and corner end cap enclosure trim. Provide corner trim in angles required to match wall layout.

5. Support enclosure in accordance with manufacturer's recommendations. Provide back enclosure mounting strips, back strip or wall mullion brackets to suit wall construction, and plastic coated slide cradle element supports. Provide slotted holes in brackets for cradles to allow vertical adjustment of piping.

6. Provide enclosure with a custom color finish as selected by the Architect.

D. Trim

1. Fabricate trim from galvanized sheet steel.

2. Use plastic-coated saddle supports to support tubes.

2.02 ELECTRIC RADIATION - TYPE A

A. Approved Manufacturers: Erincraft Model PHA/FB, Markel/American Stabilis.

B. Unit shall consist of:

1. 18 gage steel back panel with baked enamel finish

2. 14 gage anodized aluminum front cover

3. 14 gage extruded aluminum recessed grille

4. 18 gage anodized aluminum adjustable end caps and sleeves

5. 3/4-inch prewired raceway

C. Color selection shall be by Architect.

D. Unit shall be floor-mounted; pedestals shall be fabricated from steel and painted with aluminum finish.

E. Factory-install single-pole, line-voltage thermostats to automatically shut off heater in event of element or space temperature overheating. Provide a line disconnect switch.

F. Heaters shall be UL-approved and meet all requirements for verification by National Electrical Manufacturers' Association. Heaters shall be UL-approved for mounting on any floor surface including carpeting.

2.03 HOT WATER PANEL RADIATORS

A. Acceptable manufacturers, subject to compliance with requirements:

1. Runtal

2. Sterling

3. Viessmann

B. Radiators shall be manufactured of cold rolled low carbon steel, fully welded and consisting of header pipes at each end, connected by flat oval water tubes.

C. Tube thickness: High Pressure - 0.078-inch minimum wall thickness.

D. Radiator header pipes shall be square 0.109-inch minimum wall thickness and include all necessary supply, return, and air vent connections. provide internal baffling as required.

E. Standard piping connections shall be 1/2" NPT taper threaded sockets, located in either side, or vertical positions. 3/4" NPT connections are acceptable. Air vent connections shall be 1/8" NPT taper threaded sockets.

F. Working Pressure: High pressure - 128 psi max (tested at 184 psi).

G. Radiator expansion shall not exceed 0.016-inch per linear foot at 215 deg. F.

1. Expansion compensation to be provided in the piping as required, by installing Contractor.

H. Radiators shall be cleaned and phosphatized in preparation for the powder coat finish.

I. Radiators shall be painted with a gloss powder coat finish, for a total paint thickness of 2 to 3 mils (0.002-inch - 0.003-inch).

J. Custom color of the finish paint shall be selected by the Architect prior to ordering.

1. Furnish with a gray primer powder coat finish as a base coat for the custom paint finish.

2. Furnish mounting brackets for all radiators.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

A. Install equipment in accordance with manufacturer's instructions.

3.02 INSTALLATION - CONVECTORS

A. Provide vibration isolation devices as specified in Section 15071.

B. Install units level and plumb.

C. Install valves within reach of access door provided in enclosure.

D. Install air-seal gasketing between wall and recessing flanges or front cover of fully recessed unit.

E. Install piping within pedestals for freestanding units.

3.03 INSTALLATION - FINNED TUBE RADIATION

A. Install enclosure continuously from wall-to-wall or column-to-column, with filler sections at wall or

column.

B. Set enclosures with level tops and plumb fronts and ends. Attach all components of enclosures to adjacent construction.

C. Fit and securely fasten joints between components of enclosures. Fit joints between enclosures and adjoining construction to be tight and neat.

D. Conceal all fasteners.

E. Install valves and operators in the horizontal position.

F. Install acoustical baffles at each partition. Cut baffles around piping and other interferences; tape all joints.

+ + END OF SECTION + +

SECTION 15768 - UNIT HEATERS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes terminal heat transfer equipment.

1.02 SUBMITTALS

A. Submit for review:

1. Product data for all units.
2. Color samples for exposed cabinet unit heaters.

PART 2 - PRODUCTS

2.01 CABINET UNIT HEATERS

A. Acceptable Manufacturers: Subject to compliance with requirements:

1. Airtherm.
2. Sterling.
3. Trane.
4. Vulcan.

B. Heating Coils: Seamless copper tubes, mechanically expanded into aluminum fins.

C. Filters: Throwaway type, 1 inch thick.

D. Fans:

1. Forward-curved, centrifugal, double-width, double-inlet.
2. Statically and dynamically balanced.
3. Resiliently-mounted.

E. Motors:

1. Multispeed, permanent split-capacitor type, with overload protection and automatic reset.
2. Provide motors as specified in Section 230513.
3. Provide integral disconnect switch.

F. Cabinets:

1. 20 gage cold-rolled steel, reinforced and braced, with rounded corners.
2. Vertical Recessed Wall-Mounted Units: 20 gage backs, tops and sides; 16 gage fronts.

3. Horizontal Concealed, Above-Ceiling: Provide with supply and return duct collars.

4. Non-Ducted Models: Furnish with plates with stamped intake and discharge grilles, and valve and electrical access doors.

5. Flush-mount wall plates with concealed hinges and tamperproof latches.

G. Valve Control Packages: Provide a factory pre-piped valve control package consisting of a modulating electronic two-way auto control valve, unions, manual air vent, strainer, calibrated balancing valve and shut-off ball valve.

H. Controls:

1. Vertical Units: Provide integral thermostat and 3-speed fan switch. Thermostat shall energize fan and open hot water control valve on a call for heating.

2. Horizontal Units: Provide wall-mounted thermostat with 3-speed fan switch. Thermostat shall energize fan and open hot water control valve on a call for heating.

I. Accessories:

1. For Recessed or Semi-Recessed Cabinet Unit Heaters: Provide a perimeter trim guard/flange.

2. Insulate the back panels with 1" thick, 3 pcf density fiberglass board.

J. Finish

1. Chemically clean and paint all exposed areas of each cabinet unit heater with standard color as selected by the Architect.

2.02 HOT WATER UNIT HEATERS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Airtherm.

2. Reznor.

3. Sterling.

4. Trane.

5. Vulcan.

B. Heating Coils:

1. Seamless copper tubes, mechanically bonded to fins, brazed to steel headers.

2. Fins: Aluminum

C. Casing:

1. 20 gage galvanized steel with baked enamel finish. Provide threaded connections for hanger rods.

2. Provide adjustable vertical and horizontal discharge louvers or outlet vanes for horizontal discharge units, and deflection cone diffuser for vertical discharge units.

D. Fans and Motors: Direct-drive propeller type. Furnish with fan blade guard.

1. Provide integral disconnect switch.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

A. Install equipment in accordance with manufacturer's instructions.

3.02 INSTALLATION - UNIT HEATERS

A. Provide vibration isolation devices as specified in Section 15070

B. Adjust discharge louvers for diffusion to suit field conditions.

C. Provide ceiling or wall brackets as required to meet the field mounting condition.

+ + END OF SECTION + +

SECTION 15820 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes

1. Dampers.
2. IRIS Manual volume dampers.
3. Manual volume dampers.
4. Backdraft dampers.
5. Fire dampers.
6. Smoke dampers.
7. Turning vanes.
8. Duct access doors.
9. Flexible duct connectors.
10. Round branch duct connections.
11. Air volume control boxes.
12. Fan powered air volume control boxes.
13. Grilles, registers, and diffusers.
14. Air plenum supply duct outlets and ceiling plenum return duct inlets
15. Air flow measuring stations.
16. Other duct-mounted accessories.

1.02 SUBMITTALS

A. Dampers:

1. Product Data: Showing damper materials, gauges, pressure drops.

2. Shop Drawings: Dimensions, and fabrication, design and installation details.

3. Certifications: AMCA and UL Certifications.

4. Installation instructions.

5. Operation and Maintenance Data.

B. Air Volume Control Boxes:

1. Product Data: Show published catalog data.

a. Include insulation, flow sensor and damper actuator.
b. Performance data, box system accuracy, box leakage, certified discharge and radiated sound test data, and sound power level ratings by octave bands for each type of box.

2. Shop Drawings: Dimensions, and fabrication, design and installation details. Include wiring and control diagrams.

3. Certifications: AMCA and UL Certifications.

4. Installation instructions.

5. Operation and Maintenance Data.

C. Turning Vanes, Access Doors, Flexible Connections, Air Blenders and Spin-In Fittings:

1. Product data: Show published catalog data.

2. Installation instructions.

3. Operation and Maintenance Data.

D. Grilles, Registers and Diffusers:

1. Product data: Show published catalog data.

a. Include performance data for each size air terminal scheduled.

1) Inlet static pressure in inches w.g.
2) Maximum and minimum airflow in cfm.
3) Throw in feet at maximum cfm and 25 percent of cfm for terminal velocities of 50 and 100 fpm.
4) Noise Criteria (NC) curve at maximum air terminal cfm rating with blades in full-open and closed positions.

E. Samples: For products that can be furnished in different colors, submit color chips from full range of manufacturer's standard colors for selection by Architect.

1.03 QUALITY ASSURANCE

A. Construct damper in contact with the airstream from the same material as the ductwork in which it is installed.

B. Design dampers to withstand the duct pressure classification and the design air velocity.

PART 2 - PRODUCTS

2.01 DAMPERS

A. Acceptable Manufacturers: Subject to compliance with requirements, products of the following are acceptable. Shop-fabricated dampers are not acceptable:

1. Dampers:

a. Cesco.
b. Ruskin.
c. Nailor.
d. Air Balance.
e. Pottorff.
f. Greenheck.
g. NCA Manufacturing.
h. American Warming and Ventilating.

2. Factory Calibrated IRIS S.S. Balancing Dampers with Air Pressure Taps and Manually Retractable Blade Segments:

a. Ruskin VFBD35.
b. Continental Fan Manufacturing, Inc. (CFM)
c. Aeroflo.
d. Fantech.

3. Damper Hardware:

a. Ventlok.

b. Duro-Dyne.
c. Young.

4. Dampers Installed in Ductwork Rated at 1 Percent System Leakage Class:

a. Duro-Dyne Corporation, model Spec-Seal, with airtight shaft seal assemblies consisting of double gaskets with compression seats and bearings.

2.02 MANUAL VOLUME DAMPERS

A. For round ducts up to 24 inches in diameter, provide butterfly-type manual volume dampers with the following features:

1. Frame: No. 20 gage galvanized steel, 10 inches long.

2. Blade: Circular, double-thickness galvanized steel; No. 14 gage, equivalent thickness, butterfly type.

3. Blade Seal: One-piece neoprene or EPDM, sandwiched between two sides of blade.

4. Finish: Mill galvanized.

5. Axle: 1/2-inch diameter, galvanized or plated steel.

6. Bearings: Oil-impregnated bronze sleeve, nylon or stainless steel sleeve pressed into frame.

7. Control Shaft: Axle, extending 6 inches beyond frame exterior.

8. Stop: Galvanized steel angle at open and closed positions.

9. Maximum Size: 24 inch diameter.

10. Minimum Size: 4 inches diameter.

11. Quadrant: 3/8 inch or 1/2 inch, 16 gage, cold rolled steel base plate, die-cast handle, and 1/4 inch, chome-plated wing nut for locking the handle in placed. Provide 2 inch standard bracket for insulated ducts.

B. For rectangular ducts, provide following manual volume dampers with the following features:

1. Frame: 5 inch by 1 inch by No. 16 gage galvanized steel channel with corner braces. Low profile top and bottom 3-1/2 inch by 3/8 inch by No. 16 gage galvanized steel channel for units 9 inches high and under.

2. Blades: 8 inch maximum, galvanized steel.

3. Finish: Mill galvanized.

4. Axles: 1/2 inch hexagon or 1/2 inch diameter.

5. Bearings: Molded synthetic.

6. Control Shaft: 3/8 inch square or 1/2 inch diameter plated steel.

7. Maximum Size: 48 inches by 48 inches.

8. Minimum Size: 6 inches by 5 inches.

a. Dampers 11 inches high and smaller shall be single-blade type.
b. Dampers 12 inches high and larger shall be multi-blade, opposed-blade type.

9. Attach damper blade to control shaft with regulator mounted on the surface of the duct. Acceptable model: Ventlok 555 or 560.

10. On insulated ductwork, extend control shaft and provide mounting bracket so that the damper regulator can be installed at the surface of the insulation.

2.03 BACKDRAFT DAMPERS

A. Dampers shall be low-leakage, parallel-blade type. Damper sizes shall be suitable for duct sizes noted on the contract drawings. The dampers shall be suitable for a minimum 4000 fpm velocity.

B. Damper frames shall be minimum No. 12 gage galvanized steel and blades shall be minimum No. 16 gage galvanized steel or Type 6063T5 aluminum with press-fit ball bearings.

C. Dampers shall be complete with adjustable counterweights and linkage for the duty.

D. Provide neoprene or silicone rubber blade seals.

2.04 FIRE DAMPERS

A. Fire dampers shall be dynamic, Type B for rectangular duct, Type C for round duct, meeting UL Standard 555. Rate the dampers to close at 4 inches water pressure differential at 2375 feet per minute.

B. Provide galvanized steel sleeves with perimeter angles at sides of openings.

C. The frames shall match the fire rating of adjacent construction and shall have a pressure drop of 0.04 inch water at 2000 fpm.

D. Dampers shall have a replaceable 165 degrees F fusible link.

E. Frame: 20 gage galvanized steel channel.

F. Blades: 24 gage galvanized steel curtain type out of air stream.

G. Closure Springs: Type 301 stainless steel constant-force type.

H. Fire Damper Sleeve:

1. Damper sleeve shall be of thickness as follows for connection to adjoining ductwork with rigid connections in accordance with UL 555, subject to a maximum thickness of 0.135 inch for uncoated steel and 0.138 inch for coated steel unless a larger sleeve thickness is tested.

a. For damper not exceeding either 36 inches wide or 24 inches high, minimum 0.053 inch thick for uncoated steel and 0.056 inch thick for coated steel except where a greater thickness is required by the specified SMACNA construction standards.
b. For damper larger than either 36 inches wide or 24 inches high, minimum thickness of 0.067 inch thick for uncoated steel and 0.070 inch thick for coated steel except where a greater thickness is required by the specified SMACNA construction standards.

2. Where Contractor elects to have the damper sleeve furnished by the damper manufacturer, it shall be the full responsibility of the Contractor to inform the damper manufacturer where the adjoining ductwork will be thicker than the minimum herein

before specified, and to verify that such a thicker sleeve is furnished by the damper manufacturer.

2.05 SMOKE DAMPERS

A. Smoke dampers shall be two position, opposed-blade or parallel-blade type dampers, designed and tested in accordance with AMCA 500. Obtain and verify the location, size and pressure rating of each damper assembly prior to fabrication and delivery. Damper shut-off pressure rating shall exceed the fan maximum total head-pressure.

B. Construct in accordance with the following:

1. Frame: 5 inch minimum by 1 inch formed channel, Type 6063T5 extruded aluminum with a nominal wall thickness of 0.125 inch. Finish shall be mill.

2. Blades: Airfoil-shaped; Type 6063T5 extruded aluminum with a nominal wall thickness of 0.081 inch. Maximum blade width shall be 6 inches.

3. Seals: Blade edge shall be extruded vinyl or silicone rubber; jamb seals shall be aluminum, flexible metal compression type.

4. Bearings: Stainless steel or bronze sleeve type, pressed or bolted into frame.

5. Axles: Minimum 0.5 inch plated steel hexagonal rods.

6. Operation Temperature Range: Minus 50 to plus 250 degrees F.

C. Smoke dampers shall utilize linkages concealed in the frame such that no blade linkages or connecting rods are located in the airstream.

D. The smoke damper supplier shall coordinate, with the smoke damper installer, the locations and sizes of each smoke damper such that the maximum velocity rating of each smoke damper is not exceeded. Smoke damper assemblies consisting of multiple sections shall be sized (maximum blade width) to meet the maximum duct velocity in which the individual smoke damper assembly is to be installed, and under no circumstances shall the maximum individual smoke damper blade width be greater than 36 inches. Smoke dampers shall be capable of withstanding up to 6000 fpm with a 12-inch damper width.

E. Smoke dampers and smoke damper assemblies shall be classified under UL Standard 555S and shall meet the Class II leakage requirements of UL Standard 555S.

F. Provide with electric actuators sized to provide sufficient torque to limit leakage to the specified rate.

1. Electric Damper Position Indicator Switch Package: Provide to allow Fire Alarm System indication of damper blade position.

G. Combination Fire/Smoke Damper: Where a combination fire/smoke damper is used, damper construction shall also comply with the requirements for Fire Dampers specified in the preceding article.

2.06 TURNING VANES

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Aerodyne.

2. Ductmate model Pro-Rail.

3. Elgen Mfg. Co.

B. Provide turning vanes in all square-throat rectangular duct elbows, offsets greater than 30 degrees, curved throat elbows with a centerline less than 1.5 times the duct width, and where shown in other locations.

C. Construct turning vanes of the same material as the ductwork in which they are installed.

D. Turning vanes shall be one of the following designs:

1. Double-thickness, airfoil design with a smoothly rounded entry nose and an extended trailing edge. Sound power level: 54 dB in Band 4 at 2000 fpm in a 24 x 24 duct.

2. Harper double wall turning vanes. Mounting rails shall have friction insert tabs that align the vanes automatically.

a. Tab spacing shall be as specified in latest edition SMACNA Manual, "HVAC duct Construction Standards, Metal & Flexible".
b. Vanes shall be capable of supporting 250 pounds when secured according to the manufacturer's instructions.

2.07 DUCT ACCESS DOORS

A. Acceptable Manufacturers, subject to conformance to requirements:

1. Ductmate Industries, Inc.

2. Elgen Mfg. Co.

3. Flexmaster USA, Inc.

4. Kees, Inc.

5. McGill Airflow LLC

6. Nailor Industries, Inc.

7. Ruskin Co.

B. Provide with matching insulation or acoustical lining where duct is insulated or lined at locations where the following equipment is installed in the ductwork:

1. Fire, Smoke and Control Dampers and Damper Linkages.

2. Airflow Measuring Devices (inlet and outlet sides).

3. In-Line Fans, at inlet and discharge sides.

4. Other Duct-Mounted Devices, including instrumentation and control devices and smoke detectors provided under other Sections.

5. Other locations shown on the Contract Drawings.

C. Paint duct access doors serving a fire damper, smoke damper or combination fire-smoke damper with not less than 1/2 inch high red letters reading "FIRE DAMPER" "SMOKE DAMPER" or "COMBINATION FIRE-SMOKE DAMPER".

1. No external ductwork insulation shall conceal a fire damper access door unless there is a

label attached to the insulation indicating the exact location of the access door.

D. Provide building access panels required for access to duct-mounted access doors.

E. Fabricate access doors of the same material as ductwork with closed cell full sealing gaskets and quick fastening locking devices. For insulated (or acoustically lined) ductwork, fabricate double wall door with internal insulation not less than the thickness of adjacent ductwork or casing.

F. Construct as shown in applicable sections of SMACNA standards except that construction of duct access doors shall not reduce free area of duct and doors shall have a minimum of 4 latches. Provide raised hinge type when installed in insulated ductwork.

G. Access door size shall be a minimum of 18 inches by 18 inches, unless otherwise indicated. Make as large as possible where the size of the duct will not accommodate this size.

H. Access doors, installed in ducts rated for Pressure Class of 3 inches w.g. and less, shall be hinged and cam, square-framed type.

I. Access doors, installed in ducts rated for Pressure Class 4 inches w.g. and higher, shall be of sandwich-type construction in compliance with the SMACNA Manual, "HVAC Duct Construction Standards, Metal & Flexible", latest edition.

J. Provide neoprene gasket around the perimeter of the access door.

2.08 FLEXIBLE DUCT CONNECTORS

A. For all locations:

1. Acceptable Manufacturers, subject to compliance with requirements:

a. VentFabrics, Inc., model “Ventlon.”
b. Duro-Dyne Corp, model “#10011 MF6D Durolon or Dynalon Super Metalfab”.
c. Ductmate Industries, Inc., model PROflex.

2.09 ROUND BRANCH DUCT-TO-RECTANGULAR DUCT CONNECTIONS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Buckley Air Products, Inc. models 3300, BM or M-BM.

2. Elgen Mfg. Co. HET.

1. Spiral Fittings, Inc.

2. Spiral Manufacturing Co., Inc.

B. Furnish, in order of preference, 45° high efficiency take-off, full bellmouth or mini-bellmouth round branch connections of all welded construction with a dense polyethylene or neoprene gasket and pre-drilled mounting holes.

1. Always furnish higher preference fittings where their installation is physically possible.

2. Material of construction (G-90 galvanized steel, stainless steel) to match that of ductwork.

3. Without damper, suitable for use in all pressure class ductwork up to 10" W.G. construction.

4. Residential products are not acceptable.

C. Furnish manual volume dampers where shown on drawings, and as specified elsewhere in this section. Furnish dampers installed in insulated ductwork with heavy duty stand-off.

2.10 SINGLE INLET AIR VOLUME CONTROL BOXES (SUPPLY, AND EXHAUST])

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Anemostat (a Mestek Co.)EZT with "Velocity Wing" Airflow Sensor.

2. Enviro-Tec (Johnson Controls, Inc.) SDR or SDL with "Flow Star" Airflow Sensor.

3. Krueger LMHS with "K4 LineaCross" Airflow Sensor.

4. Nailor Industries, Inc. series 3000 with "Diamond Flow" Airflow Sensor.

5. Price Industries SDV with "SP300" Airflow Sensor.

6. Titus (ASCD Companies) ESV with "AeroCross" Airflow Sensor.

7. Tuttle & Bailey SDV with "Flo-Cross" Airflow Sensor.

B. Boxes shall be DDC powered, system static pressure independent throughout the entire operating range and capable of accurate control at all setpoints.

C. Description:

1. Supply boxes shall be internally lined with insulation of a minimum 1/2-inch thick, 1.5 pounds density fiberglass insulation with an aluminum foil face. It shall meet the UL 181 erosion test requirements for a recommended service velocity of 5000 ft. per minute, maximum, and satisfy NFPA Standard 90-A requirements for flame spread and smoke developed ratings.

2. Boxes shall be pressure independent and shall meet air volume within plus or minus 5 percent of indexed airflow, regardless of changes in system air pressure.

a. Unless otherwise indicated, where spaces are neutral or positive pressurization supply boxes shall be normally open, return boxes normally closed and exhaust air valves normally shall be normally open.

3. The pressure drop of each box shall not exceed 0.50 inch w.g. for all sizes when handling maximum air volume. Maximum leakage through the casing: 2 percent of design flow at 6 inches w.g. pressure differential.

4. Construct supply and return boxes of 22 gauge galvanized steel. Construct exhaust air valves of [G90 galvanized steel.

5. Controllers shall be furnished as part of Division 17 work for factory installation by the box manufacturer.

D. Exposed non-metal air terminals, controls, and accessories shall be of non-combustible materials, or covered with non-combustible materials or enclosures suitable by building code for installation in return air plenum ceilings and in compliance with NFPA smoke and fire ratings.

E. Coordinate with work of Division 17. to ensure proper compatibility of control signals to the terminal boxes. Provide the necessary control action, reverse acting or direct acting to accommodate Sequence of Operations.

F. Furnish each box with a factory-calibrated damper-airflow sensor assembly consisting of a

gasketed damper controlled by a multi-point, center averaging and amplified velocity-pressure sensor and controller with control action that is directly responsive to variations in inlet static pressure, and by an externally-mounted control actuator which positions the damper in response to controlling signals.

G. Factory install airflow sensor, tubing, controller, actuator, and relay with appropriate linkages to provide specified functions.

H. For all boxes, provide flow sensors as specified, and furnish pressure differential taps for field calibration and testing. Include a flow chart for each box.

1. Furnish one 0 - 1 inch w.g. Dwyer Magnahelic gage and deliver to Owner's Representative.

I. Airflow setpoint shall be field adjustable to allow for future changes in box airflow rates.

J. Furnish each box with an identification label and airflow indicator. Identification label shall include information such as unit nominal cfm at static pressure scheduled, maximum factory-set cfm, and minimum factory-set cfm.

K. Air leakage through the gasketed volume control damper at fully-closed position shall not exceed 5 percent of design airflow when tested at 4 inches w.g. positive pressure on supply systems and negative pressure on exhaust systems.

L. Furnish actuator with sufficient torque to position the damper with no mechanical hysteresis at all damper positions and at all system upstream and downstream static pressure conditions required.

1. Furnish required linkages, mounting plates, and fittings for a complete actuator-controller installation.

2. Actuator shall be adjusted to position the damper blade full closed and provide minimum leakage when the minimum flow setpoint signal is sent to the actuator.

3. Actuator shall position the damper blade from the full close off position to the minimum control position without significant overshoot.

4. Actuator shall be adjusted to position the damper blade full open and provide minimum box pressure drop when the maximum flow setpoint signal is sent to the actuator.

M. For all supply boxes furnish a multi-point, center averaging cross-flow sensor with signal amplification, which traverses the box inlet opening. For exhaust air valves furnish orifice-amplifying plates in addition to the cross-flow sensor.

N. Provide the damper blade with a solid aluminum shaft. Seal the shaft penetration through the casing leak tight. Mark the end of the damper shaft to show position of damper blade.

2.11 FAN POWERED AIR VOLUME CONTROL BOXES

A. Manufacturers: Subject to conformance to requirements, provide products by:

1. Anemostat (a Mestek Co.)QST with "Velocity Wing" Airflow Sensor.

2. Enviro-Tec (Johnson Controls, Inc.) CFL with "Flow Star" Airflow Sensor.

3. Krueger KLPS with "K4 LineaCross" Airflow Sensor.

4. Nailor Industries, Inc. 37SWST with "Diamond Flow" Airflow Sensor.

5. Price Industries FxCLP with "SP300" Airflow Sensor.

6. Titus (ASCD Companies) DFLS with "AeroCross" Airflow Sensor.

7. Tuttle & Bailey LPC with "Flo-Cross" Airflow Sensor.

B. Provide "low profile" fan powered VAV boxes with factory-mounted controls with a high velocity connection for primary air from supply system and return air inlet for supplementary air to provide constant volume.

C. Construct cabinets of 20 gage, galvanized steel with factory-applied enamel paint finish.

1. Internal surfaces shall be insulated with glass fiber with an aluminum foil facing, which has UL approval and meets NFPA Standard 90A.

2. Fans shall be forward curved centrifugal type with permanently lubricated split-capacitor type motor.

3. Fan assembly shall be internally suspended and isolated from the casing on rubber in shear isolators.

D. Damper blades shall have extruded ribs, which key into grooved shaft. Internal damper pivot points shall be nylon fitted requiring no lubrication. Base performance of the units on tests conducted in accordance with ASHRAE Standard 36B.

E. Exposed non-metal air terminals, controls, and accessories shall be of non-combustible materials, or covered with non-combustible materials or enclosures suitable by building code for installation in return air plenum ceilings and in compliance with NFPA smoke and fire ratings.

F. Coordinate with the work of Section 230900 to ensure proper compatibility of control signals to the terminal boxes. Provide the necessary control action, reverse acting or direct acting, to accommodate Sequence of Operation.

1. Furnish each box with a factory-calibrated damper-airflow sensor assembly consisting of a gasketed damper controlled by a multi-point, center averaging and amplified velocity-pressure sensor and controller with control action that is directly responsive to variations in inlet static pressure, and by an externally-mounted control actuator which positions the damper in response to controlling signals.

G. Sensing device, controller, actuator, and relay shall be factory mounted with appropriate linkages to provide specified functions. Provide wiring from relay to control actuator.

H. Furnish device with 0 to 1 inch w.g., scaled draft gauge. Include flow chart for each terminal. Where flow cross-sensors are specified or scheduled, provide an averaging airflow sensor, which traverses the box opening.

I. Temperature Sensors: Provided as work of Division 17.

J. Air volume setpoints shall be field adjustable to allow for future changes in box airflow rates.

K. Each box shall be clearly marked with an identification label and airflow indicator. Identification label shall include information such as unit nominal cfm at static pressure scheduled, and maximum and minimum factory-set airflow rate.

L. Provide a medium-efficiency disposable filter and an unlined elbow at the secondary (plenum) air inlet.

2.12 GRILLES, REGISTERS, AND DIFFUSERS

A. Acceptable Manufacturers: Subject to compliance with requirements:

1. Anemostat (a Mestek Co.).

2. Krueger.

3. Nailor Industries, Inc.

4. Price Industries.

5. Titus (ASCD Companies).

6. Tuttle & Bailey (T & B).

B. General:

1. Grilles, registers and diffusers, except where indicated otherwise on the drawings, shall be steel, factory finished with baked enamel finish of color selected by Architect.

C. Ceiling Diffusers

1. Furnish all diffusers with an equalizing deflector and volume damper. If diffuser is to be used for return or exhaust air, omit equalizing deflector. If diffuser is to be used as a return or exhaust air grille, omit volume damper. Gasket supply diffusers to prevent streakage, unless installed in T-bar ceiling or where duct collar is female to diffuser collar. Blank-off diffusers to prevent airstream from contacting obstructions. Diffuser frames and margins shall be compatible with ceiling construction.

2. Diffusers shall be round, square, rectangular, or linear square or rectangular neck as indicated on Drawings.

a. Louvered Face Diffusers:

1) Diffusers shall be of the jet-induction, air-mixing type and shall be assembled in combinations of louver sections arranged to discharge air from each side in quantities proportional to the area served. Between the louvers, diffusing vanes shall extend to the diffuser face and shall be designed to compress the air into jets, which will induce room air. Jets from adjacent channels shall discharge in opposite directions to ensure rapid mixing of primary and room air. Weld diffuser louvers and vanes to prevent tampering.

b. Slot Type Linear Diffuser:

1) Construct diffusers of aluminum with quick positioning pattern control permitting 180 degree air pattern adjustment.
2) Diffuser shall have dampers which operate separate from pattern control and an air stop at each end.
3) Inner pattern control and brackets shall be black coated.
4) Slot opening shall be as shown on plans.
5) Provide linear supply diffusers with a sheet metal insulated plenum for entire length, height as required for branch connection, 12 inches minimum.
6) Miter diffuser frames at corners and joints and assemble so that the frame appears continuous.
7) Provide frames with internal fasteners drawn together with internal bolts so the frame appears continuous.

c. Architectural Square Plaque Ceiling Diffuser:

1) Diffuser shall have a 22 gage steel face panel that captures a secondary 22 gage panel. Face panel removable by means of four hanger brackets. Exposed surface of the face panel shall be smooth, flat, and free of visible fasteners. Face panel shall project 1/4 inch below the outside border of the diffuser back pan. Back of the face panel shall have an aerodynamically shaped, rolled edge to ensure a tight horizontal discharge pattern.
2) Ceiling diffusers with a 24 x 24 inch full face shall have no less than and 18 x 18 inch face panel size.
3) Ceiling diffusers with a 12 x 12 inch full face shall have no less than a 9" x 9" face panel size.
4) Back pan shall be one piece precision die-stamped, shall include an integrally drawn inlet, and shall be constructed of 22 gauge steel.
5) Diffuser neck shall have a minimum of 1-1/4 inch depth available for duct connection.
6) Finish shall be #26 white, baked anodic acrylic paint.
7) Round damper shall be constructed of heavy gauge steel.
8) Damper must be operable from the face of the diffuser.
9) Furnish directional blow clips to restrict the discharge air in certain directions.

D. Grilles and Registers

1. Supply Air Grilles and Registers:

a. Registers shall be double deflection type with individually adjustable vertical face bays and horizontal back deflector blades and key operated opposed dampers.
b. Omit opposed blade volume dampers for supply air grilles.

2. Return, Transfer and Exhaust Air Grilles and Registers:

a. Registers shall be single deflection with opposed-blade damper and fixed blades set at 40 degrees.
b. Omit opposed blade dampers for return, transfer and exhaust grilles.
c. Provide aluminum control grids at the rear of each supply air grille to product uniform air distribution over the entire grille. Each blade of the control grid shall be reinforced and individually adjustable. Attach control grid frame to grille collar.
d. Provide an integral single or multiple blade volume control damper at the rear of each supply, return, relief and exhaust grille.
e. Ceiling-mounted return and exhaust registers shall be suitable for installation in the ceiling type indicated on the Architectural Reflected Ceiling Plans. Where a grille or register is mounted on a plaster, dry wall, tile furred, concrete block or precast concrete surface, provide a plaster-stop flush-mounting frame. Furnish frame with latex foam or sponge rubber gasket to prevent air leakage. Grilles on exposed ducts will not require a frame.
f. Where grilles or registers are installed on sheet metal collars, provide mounting frame with 1-inch wide flange. Provide collars of the minimum size and depth required to install a controller that will produce uniform airflow over the face of the grille or register.
g. Where grille or register is larger than normally manufactured in a single section, provide two or more equal sections with matching angle frames to join grille or register sections together.

E. High Volume, Low Velocity Radial Flow Pattern Diffuser

1. Acceptable Manufacturers, subject to compliance with requirements:

a. Anemostat “HCR”
b. Price “FRFDP”

c. Titus “TriTec”
d. Tuttle & Bailey “Vector”

2. Description: Perforated, flat-faced diffuser of welded construction with internal directional grid vanes. Provide for each diffuser a plenum with round or oval top inlet collar and volume damper.

a. The plenum shall be made of welded 18 gage steel or aluminum construction and permanently installed in the ceiling for a leak-free installation.

1) Provide 1/2 inch thick aluminum foil-faced fiberglass insulation applied to entire exterior of plenum.

b. The perforated radial diffuser plate shall be retained to the diffuser mounting frame through the use of quarter turn lock or unlocking fasteners.
c. Safety retainers of vinyl coated stainless steel cable shall prevent accidental drop of perforated plate assemblies during disassembly.
d. Volume damper shall be operable through the diffuser.

3. Performance:

a. Diffusers shall provide a very low velocity radial air pattern, projecting air horizontally, vertically, and all directions in between, to provide optimum ventilation of the space.
b. Diffusers shall be capable of increasing the space particle removal rate, for class 3000 rooms and above, three (3) times over laminar flow diffusers without increasing the supply air quantity, as determined by tests in an ADC Certified facility using Laser Particle Count technology.
c. Diffusers shall be tested in an ADC Certified Laboratory for Sound Generation and Pressure Drop in accordance with ADC GRD 1062-84. Room air velocities shall be determined in accordance with ASHRAE Std 113.87.

2.13 AIR PLENUM SUPPLY DUCT OUTLETS AND CEILING PLENUM RETURN DUCT INLETS

A. Provide sheet metal collars, of the sizes indicated, on the side of the air plenum supply duct or return duct in sizes indicated on Drawings.

B. Provide each collar with a manual quadrant damper and a locking device, accessible through the ceiling if required, to balance and control the air volume.

C. Provide galvanized steel wire mesh bird screen with mounting frame to cover opening.

2.14 AIR FLOW MEASURING STATIONS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Tek-Air

2. Ebtron

B. Provide airflow measure as scheduled.

C. Each station shall be capable of measuring the airflow rate within an accuracy of 2 percent. The sound level within the duct shall not be amplified, nor shall additional sound be generated.

D. Actual final locations of airflow stations shall be the work of Division 17, and shall be in accordance with the airflow station manufacturer's recommendations. Airflow station locations are shown on mechanical drawings for arrangement purposes and relative position.

PART 3 - EXECUTION

3.01 OVERALL MECHANICAL/ELECTRICL/CONTROLS COORDINATION TABLE

ITEM	FURNISHED BY	INSTALLED BY	POWER BY	CONTROL BY	MONITOR BY	OTHER/COMMENTS
Smoke damper integral to air handler	HVAC	HVAC	Div. 17	Div. 17	Div. 17	Smoke damper to be supplied with integral actuator
Smoke damper external to air handler	HVAC	HVAC	Controls	Div. 13, FAS	Div. 13	Smoke damper to be supplied with integral actuator
Fire damper	HVAC	HVAC	N/A	N/A	N/A	
Variable frequency drive	HVAC	Div. 16	Div.16	Div. 17	Div. 17	
Smoke detectors/fan shutdown for fire/smoke alarm	Div. 13	HVAC	Div. 16	Div. 13	Div. 13	FAS to provide addressable relay for fan shutdown. BAS to monitor spare contacts on FAS relay or direct from smoke detector. Wiring from addressable relay to fan motor starter or variable frequency drive by Section 230900.
VAV/CS boxes for temperature control (not for lab airflow control)	HVAC	HVAC	Div. 17	Div. 17	Div. 17	
Control power to VAV boxes	N/A	Div. 17	Div. 17	N/A	N/A	Division 26 to supply dedicated breaker or adequate spare breaker capacity. Section 230900 to find best method to get power from breaker panel to VAV controller, and perform all necessary installation thereof.
Flow meters (air, gas, water,, etc.)	HVAC	HVAC	Div. 17	N/A	Div. 17	Furnished and installed by HVAC. Power and control wiring by Section 230900.
Lab Control System (air valves, controls, etc.)	Div. 17	HVAC	Div. 17	Div. 17	Div. 17	* Furnished by Section 230900. ** HVAC installs all airflow control valves. Section 230900 installs control components provided by Section 230900 and places unit in service.
Fume Hood Monitors	Fume Hood Manufacturer	Fume Hood Manufacturer	Fume Hood Manufacturer	Fume Hood Manufacturer	Fume Hood Manufacturer	Factory or field installed by fume hood manufacturer. Calibration/setup by fume hood manufacturer.

3.02 INSTALLATION - DAMPERS

A. Install dampers in accordance with manufacturer's instructions and as indicated on the Drawings.

B. After duct system has been adjusted, tested and balanced, lock manual volume dampers in

position. Make a permanent mark on the quadrant to indicate correct position.

C. Damper actuators that are located in plenums shall be mounted on damper frames. Damper actuators shall not be installed inside ducts or fresh-air intakes.

D. Install fire dampers of proper rating where indicated on the Drawings, in accordance with the conditions of their approval and tests by Underwriters Laboratories, Inc. Install fire dampers so that damper blades are positioned up in recessed hat section of frame and do not protrude into the airstream. Make necessary repairs to walls, floors and ceilings after the dampers are installed to restore integrity of fire rating.

E. Automatic and Smoke Dampers:

1. Install dampers in accordance with manufacturer's recommendations.

2. Coordinate size and location of dampers before fabricating or installing associated ductwork.

3. Support dampers either by properly reinforcing the ductwork at damper locations to carry the weight of the dampers, or by supporting them independently of the ductwork from the floor or building structure, as required by conditions at the site.

3.03 INSTALLATION - TURNING VANES

A. Weld turning vane runners and turning vanes to the duct where applicable.

3.04 INSTALLATION - FLEXIBLE CONNECTIONS

A. Install flexible duct connections at the inlet and outlet connections of fans, except at double-inlet fans free-standing in plenums, inlet and outlet connections of fan-powered boxes, at building expansion joints, and other locations where indicated on the Drawings or required by Section 15070.

B. The clear space between connected parts shall be minimum 3 inches, and the connection shall have minimum additional 1.5 inches slack material.

C. Ductwork or plenum openings shall be squarely aligned with the fan discharge, fan intake or adjacent duct section prior to installation of the flexible duct connection, so that the clear length is approximately equal all the way around the perimeter.

1. Do not install flexible duct connections until this provision is met.

2. The fan unit or adjacent duct section shall be able to move 1 inch in any direction without causing metal-to-metal contact or stretching taut the flexible duct connection.

3.05 INSTALLATION - AIR VOLUME CONTROL BOXES

A. Install and adjust actuators to allow smooth travel and full controllability over the entire operating range of the damper. The linkage shall not allow movement or mechanical hysteresis at any control position.

B. Install boxes in accordance with the manufacturer's recommendations. Provide a minimum straight entry length of sheet metal ductwork at each box in accordance with manufacturer's recommendations.

C. Where duct size indicated on the Drawings differs from box inlet or outlet dimensions provide metal ductwork transitions for terminal box inlet and outlet connections in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

D. Do not support boxes with perforated metal straps, or from ducts, pipes or furring.

E. Support boxes independently of the ceiling construction.

F. Temperature control signals between wall-mounted thermostats or sensors and terminal boxes/heating coils will be provided under Division 17.

G. Install fan-powered terminal boxes with external vibration isolation devices specified in Section 15070.

H. Do not use flexible ductwork at the inlet connection of air volume control boxes.

3.06 INSTALLATION - GRILLES, REGISTERS AND DIFFUSERS

A. Install air terminals in accordance with manufacturer's recommendations.

B. Review Architectural Specification and Drawings describing the types of walls, floors and ceilings required for the project.

C. Coordinate with work of related Sections for selecting the proper type of frame and mounting for each air terminal.

D. Support grilles registers and diffusers independently.

+ + END OF SECTION + +

SECTION 15837- CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Centrifugal fans.

2. Centrifugal plenum fans.

3. Tubular mixed flow and centrifugal fans.

4. Square inline centrifugal fans.

5. Coordinate the work of this Section with work of other Sections.

6. Verify applicable dimensions at the job site.

7. Incidental items not indicated on the drawings nor mentioned in the specifications that belong to the work described or required to provide a complete system.

1.02 SUBMITTALS

A. General: Division 01, Specification section for Submittals applies to this Section.

B. Product Data: Technical data, including specialties, accessories, and the following:

1. Certified fan performance curves (total and static pressure versus air flow at design fan speed) with system operating conditions clearly indicated.

a. Show a family of curves for fans driven by variable frequency drives.
b. Indicate unstable operating conditions.

2. Certified fan sound power ratings for all centrifugal, fiberglass centrifugal, tubular mixed flow and centrifugal fans.

3. Variable frequency drives (VFDs), motor ratings and electrical characteristics plus drive, motor and fan accessories.

C. Shop Drawings: Detailed equipment assemblies indicating dimensions, weights, required clearances, all components, and location and size of field connections.

1.03 QUALITY ASSURANCE

A. Performance: Fan sizes, connections, dimensional requirements and efficiencies indicated on the drawings, are based on the specific manufacturer types and models shown. Fans having equal performance characteristics by other manufacturers may be considered, provided deviations in dimensions, efficiencies and motor sizes do not change the design concept or intended performance as judged by the Architect.

1. Fans with smaller wheel diameters operating at higher speeds, with higher power consumption and higher sound power ratings over those indicated as basis of design on the drawing are unacceptable.

2. Motor sizes shall be selected to be non-overloading over the entire system performance

range of the fan wheel size selected.

3. Design fan speed shall be selected so as not to exceed 95% of the fan's listed maximum speed.

4. System performance requirements shall intersect the rising portion of the selected fan pressure curve on the negative slope.

B. Motors, variable frequency drives (VFDs) and electrical accessories shall comply with the requirements of Division 15.

C. All fans shall bear the Air Movement and Control Association, Inc. (AMCA) Certified Ratings Seal. Test and rate fan performance in accordance with AMCA Standard 210 "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Testing."

D. Actual design air flows are indicated on the drawings. Correct fan performance for inlet vane dampers (if present), altitude and temperature.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish fans that are factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics.

B. Fans and Shafts: Statically and dynamically balanced. Fan shafts shall be of solid ANSI C-1040 or 1045 hot rolled steel accurately turned and polished, and keyed to the fan wheel.

1. Belt Guards: Furnish a removable OSHA type guard for each belt-driven fan. Guard shall be fabricated of expanded metal with provision at motor and fan shaft for use of speed counter.

2. Shaft Guards: Furnish a removable OSHA type expanded metal guard enclosing the shaft for each belt-driven fan.

C. Motors and Drives: Rubber and fabric V-belt drives with ratings minimum of 150 percent of nameplate rating of connected motor; 200 percent of rating for laboratories and hospitals. Cast iron sheaves statically balanced.

1. Motor sheave pitch shall be adjustable, except on fans driven by 25 HP or larger motors.

2. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design condition.

3. Provide fixed-pitch “initial” motor sheaves for belt-drive fans with motors 25.0 HP and larger. When correct “final” sheave size has been determined by the Testing and Balancing Contractor in accordance with Division 15, furnish and install a permanent fixed-pitch sheave for the motor to replace the “initial” variable-pitch motor sheaves. Turn over the “initial” variable–pitch motor sheaves to the Owner.

D. Factory Finish: Finish all fans of steel construction, and of aluminum construction where indicated on the drawings. Prime coat all sheet metal parts prior to final assembly.

1. Fans Handling Moisture-Laden Air (Down-stream of Sprayed Cooling Coils, Air Washers, Evaporative Coolers, Rack Washers, Cage Washers and Dishwashing Machines): Finish all surfaces in contact with the airstream in (2) coats of an air-dried epoxy (Eisen-Heiss #320), (5) mils thick.

2. Fans Installed Outdoors, Weather-Exposed: Finish with (4) coats of an air-dried phenolic (Heresite VR500), (4-6) mils thick.

3. Indoor Fans Handling Building Air: Finish with (1) coat of a vinyl enamel, (3) mils thick.

4. Fans Handling Corrosive-Fume Laden Air: Finish all surfaces in contact with the airstream in a corrosion-resistant finish (CRF) (4) coats of an air-dried phenolic (Heresite VR500), (4-6) mils thick, as a minimum.

5. Fans operating at Elevated Temperatures (181 to 800 deg. F): As specified for given fan type.

E. Bearings shall be air handling quality, heavy-duty grease-lubricated, ball or roller type. Select bearings for a Basic Rating Life L-10 of 80,000 hours at the maximum operating speed and horsepower for each construction level.

2.02 CENTRIFUGAL FANS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Barry Blower.

2. Greenheck Fan Corporation.

3. Loren Cook Company.

4. Twin City Fan and Blower Company.

5. ACME Engineering and Manufacturing. Corp.

B. General: Belt-driven or direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly and support structure.

C. Wheels: Single-width, single-inlet (SWSI) or double-width, double-inlet (DWDI), steel multi-blade, welded to shroud, with backplate and inlet backplate keyed to shaft, and spun wheel inlet shroud operating at close tolerance to deep spun inlet cone. Impeller shall be of rigid construction without the use of stiffening rings or tie rods. Blades shall be backward-curved airfoil (AF), backward-curved flat-plate (BI), or forward-curved (FC), as indicated on drawings.

D. Scroll: Reinforced full-housed, steel or steel alloy involutely formed housing with continuously welded seams. Properly brace to insure adequate support.

E. Flanges: When connected to ductwork, furnish predrilled welded-on inlet and/or outlet flanges.

F. Scroll Access Doors: Furnish gasketed, bolted-on; flush-mounted for uninsulated housings and raised-mount for insulated housings.

G. Inlet Screens: Where not connected to ductwork, furnish OSHA type heavy wire mesh screens, mounted inside of shaft bearings.

H. Drain Fittings: Where fan handles moisture or grease-laden vapors, or the fan outlet is upblast open to outdoor weather, furnish a threaded one-inch NPS, capped nipple installed at lowest point of housing.

I. Shaft Seals: For operating temperatures up to 275 deg. F, furnish elastomeric rotary shaft friction seals backed by a bolted metal plate.
1. Furnish spare seals for each fan.

J. Weather Cover: Where fans are outdoor weather-exposed, furnish weather-resistant cover with stamped vents over motor and drive compartment.

K. Elevated Temperature Operation (276 to 800 deg. F): Where fans are indicated on the drawings to be operating at elevated temperatures, furnish them of all steel construction and with high temperature aluminum paint, motor heat shield, high temperature bearings, high temperature grease, ceramic felt shaft seals and aluminum split wheel shaft cooler with guard.

L. Accessories, where indicated on drawings, furnish the following:

1. Backdraft Dampers (BDD): Gravity-actuated with counterweight and interlocking aluminum blades and blade edge seals in steel frame installed on fan discharge.

2. Flanged Split Housing, Bolted and Caulked.

3. Weep Holes on Airfoil Blades.

2.03 CENTRIFUGAL PLENUM FANS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Barry Blower.

2. Greenheck Fan Corporation.

3. Loren Cook Company.

4. Twin City Fan and Blower Company.

5. ACME Engrg. & Mfg. Corp.

B. General: Belt-driven or direct driven unhoused centrifugal fans consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure.

C. Wheels: Single-width, single-inlet (SWSI) steel multi-blade, welded to shroud, with backplate and inlet backplate keyed to shaft, and spun wheel inlet shroud operating at close tolerance to deep spun inlet cone. Impeller shall be of rigid construction without the use of stiffening rings or tie rods. Blades shall be backward-curved airfoil (AF), or backward-curved flat-plate (BI), as indicated on drawings.

D. Flanges: When connected to ductwork, furnish predrilled welded-on inlet flanges.

E. Inlet Screens: Where not connected to ductwork, furnish OSHA type heavy wire mesh screens, mounted inside of shaft bearings.

F. Protective Enclosure: Furnish expanded metal screen with heavy gauge steel frame to completely enclose the fan wheel and support structure.

G. Accessories, where indicated on drawings, furnish the following:

2.04 TUBULAR MIXED FLOW AND CENTRIFUGAL FANS

A. Acceptable manufacturers, subject to compliance with requirements:

1. Barry Blower

2. Greenheck Fan Corporation

3. Loren Cook Company

4. Twin City Fan and Blower Company

5. ACME Engrg. & Mfg. Corp.

B. General: Inline, belt-driven centrifugal fans consisting of tubular housing, wheel, outlet guide vanes, fan shaft, bearings, drive assembly, motor, mounting brackets and accessories.

C. Motor Mount: Motor externally mounted with adjustable sheave and base. Lubricating tubes shall be provided from the shaft bearing to the housing for lubrication. All units shall have support brackets standard with the manufacturer for mounting the unit.

D. Wheels: Steel multi-blade, welded to shroud, with backplate and inlet backplate keyed to shaft, and spun wheel inlet shroud operating at close tolerance to deep spun inlet cone. Blades shall be backward-curved airfoil (AF) or mixed flow type.

E. Scroll: Reinforced, galvanized steel, formed housing with welded seams.

F. Access Door: Furnish gasketed, bolted on for inspection and maintenance of fan wheel.

G. Inlet and Outlet Screens: Where not connected to ductwork, furnish OSHA type heavy wire mesh screens.

H. Weather Cover: Where fans are outdoor weather-exposed, furnish weather-resistant cover with stamped vents over motor and drive compartment.

I. Drilled Companion Flanges: Furnish to receive sheet metal duct or flexible connectors. Companion flanges shall be of the same thickness as the fan flanges.

J. Fan Mounting:

1. Ceiling Hung Fans: Furnish four (4) suspension clips welded to fan housing.

2. Floor or Wall Mounted Fans: Furnish support legs at each end.

3. Vertically Mounted Fans: Furnish four (4) vertical brackets welded to either end of the fan housing.

K. Accessories, where indicated on drawings, furnish the following:

1. Roof Curb Cap, Roof Curb and Stack Cap: Furnish roof curb cap, roof curb and stack cap with built-in butterfly backdraft damper. Roof curbs as specified elsewhere in this section.

2. Corrosion-Resistant Finish (CRF): As specified in Article 2.01. Furnish backdraft dampers and inlet vanes of Type 304 stainless steel.

2.05 SQUARE INLINE CENTRIFUGAL FANS

A. Acceptable manufacturers, subject to compliance with requirements:

1. Penn Ventilation

2. Carnes Company, Incorporated

3. Loren Cook Company

4. Greenheck Fan Corporation

5. Breidert Air Products, Inc.

6. Jenco

7. ACME Engineering and Manufacturing. Corp.

B. General: Inline, belt-driven or direct-drive as indicated, centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, drive assembly, motor and disconnect switch, mounting brackets and accessories.

C. Wheels: Aluminum hub and wheel with backward-inclined, flat-plate blades. Statically and dynamically balanced.

D. Housing: Fabricated from formed and reinforced galvanized or painted steel panels with welded seams, spun inlet cone, and inlet and outlet flanges.

E. Direct-Drive Unit: Permanently lubricated motor encased within housing in the air stream, factory-wired to disconnect located on outside of fan housing.

1. Speed Control (For balancing purposes, 115V/1 phase up to 1/2 HP): Furnish solid-state speed controller, with integral ON-OFF switch, capable of controlling fan speed from full speed to approximately half speed. Controller shall include an L-C filter circuit to suppress radio frequency interference noises generated by the switching action of the thyrister. Factory mounted and wired on the fan housing, unless shown otherwise on the drawings.

F. Belt-Drive Units: Motor mounted on adjustable base, with adjustable sheaves, and enclosure around belts within fan housing. Shaft, bearings and wheel easily removable without disconnecting fan from duct.

G. Disconnect Switch: Furnish nonfusible type, factory mounted and wired on the outside of the fan housing.

H. Shaft Bearings: Permanently lubricated and sealed, self-aligning, pillow block-type ball bearings.

I. Access Door: Furnish screwed-on or hinged and gasketed door for inspection and maintenance of fan wheel.

J. Inlet and Outlet Screens: Where not connected to ductwork, furnish OSHA type heavy wire mesh screens.

K. Weather Cover: Where fans are outdoor weather-exposed, furnish weather-resistant with stamped vents over motor and drive compartment.

L. Fan Mounting:

1. Furnish four (4) mounting brackets for ceiling, floor, wall or vertical mounting.

M. Accessories, where indicated on drawings, furnish the following:

1. Roof Curb Cap, Roof Curb and Vertical Stack Cap: Furnish roof curb cap, roof curb and stack cap with built-in butterfly backdraft damper. Roof curbs as specified elsewhere in this section.

2. Backdraft Dampers: Counterbalanced, parallel-blade, factory set to close when fan stops.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install equipment as shown on drawings and in accordance with manufacturer's recommendations.

B. Engage the services of the Electrical Contractor, and pay for them, to install all control devices being furnished with the fans and ventilators, and provide all electrical control wiring, including stepdown control circuit transformers that may be required. Products and methods shall be as specified in Section 15120.

C. Provide all equipment supports indicated on mechanical and structural drawings and specified in this section, in DIVISION 3 – CONCRETE, in DIVISION 5 – METALS and in Section 15060. Anchor equipment to supports in locations provided.

1. Secure roof-mounted fans and ventilators with stainless steel hardware, as required by the manufacturer.

D. Install all vibration control and seismic restraint devices indicated on mechanical drawings and specified.

E. Make final duct connections with flexible connections. See Section 15815 for flexible duct connections specification.

F. Adjust all damper linkages for proper operation.

+ + END OF SECTION + +

SECTION 15838 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Centrifugal power roof exhausters.

2. Centrifugal power roof supply fans.

3. Air intake and relief ventilators.

4. Prefabricated roof curbs.

1.02 SUBMITTALS

A. Product Data: Technical data, including specialties, accessories, and the following:

1. Certified fan performance curves, showing total and static pressure versus air flow at design fan speed, with system operating conditions clearly indicated.

a. Show family of curves for fans driven by variable frequency drives.
b. Indicate unstable operating conditions.

2. Certified fan sound power ratings.

3. Variable frequency drives (VFDs), motor ratings, electrical characteristics, drive, motor, and fan accessories.

4. Vibration test report for induced radial dilution roof exhausters.

B. Shop Drawings: Detailed equipment assemblies indicating dimensions, weights, required clearances, all components, and location and size of field connections.

C. Operation and maintenance data.

1.03 PERFORMANCE REQUIREMENTS

A. Performance: Fan sizes, connections, dimensional requirements and efficiencies indicated on the drawings, are based on the specific manufacturer types and models shown. Fans having equal performance characteristics by other manufacturers may be considered, provided deviations in dimensions, efficiencies and motor sizes do not change the design concept or intended performance as judged by the Architect.

1. Fans with smaller wheel diameters operating at higher speeds, with higher power consumption and higher sound power ratings over those indicated as basis of design on the drawing are unacceptable and will be rejected.

2. Motor sizes shall be selected to be non-overloading over the entire system performance range of the fan wheel size selected.

3. Design fan speed shall be selected so as not to exceed 95 percent of the fan's listed maximum speed.

4. System performance requirements shall intersect the rising portion of the selected fan

pressure curve on the negative slope.

B. Motors, variable frequency drives (VFDs) and electrical accessories shall comply with the requirements of Division 15.

C. All fans shall bear the Air Movement and Control Association, Inc. (AMCA) Certified Ratings Seal.

D. Actual design air flows are indicated on the Drawings. Correct fan performance for inlet vane dampers (if present) altitude and temperature.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics.

B. Fans and Shafts: Statically and dynamically balanced. Fan shafts shall be of solid ANSI C-1040 or 1045 hot rolled steel accurately turned and polished, and keyed to the fan wheel.

1. Belt Guards: Provide removable OSHA type guard for each belt-driven fan. Guard shall be fabricated of expanded metal with provision at motor and fan shaft for use of speed counter.

2. Shaft Guards: Provide removable OSHA type expanded metal guard enclosing the shaft for each belt-driven fan.

C. Motors and Drives: Provide rubber and fabric V-belt drives with ratings minimum of 150 percent of nameplate rating of connected motor; 200 percent of rating for laboratories and hospitals. Provide cast iron sheaves, statically balanced.

1. Motor sheave pitch shall be adjustable, except on fans driven by 25 HP or larger motors.

2. Select sheave so that pitch adjustment is at the middle of the adjustment range at fan design condition.

3. Provide fixed-pitch “initial” motor sheaves for belt-drive fans with motors 25 hP and larger.

4. When correct “final” sheave size has been determined as work of Division 15, provide permanent fixed-pitch sheave for the motor to replace the “initial” variable-pitch motor sheaves. Turn over the “initial” variable–pitch motor sheaves to the Owner.

D. Factory Finish: Finish fans of steel construction, and of aluminum construction where indicated on the Drawings. Prime coat sheet metal parts prior to final assembly.

1. Fans Installed Outdoors, Weather-Exposed: Finish with (4) coats of an air-dried phenolic (Heresite VR500), (4-6) mils thick.

2. Indoor Fans Handling Building Air: Finish with (1) coat of a vinyl enamel, (3) mils thick.

E. Bearings shall be air handling quality, heavy-duty grease-lubricated, ball or roller type. Select bearings for a Basic Rating Life L-10 of 80,000 hours at the maximum operating speed and horsepower for each construction level.

2.02 CENTRIFUGAL POWER ROOF EXHAUSTERS

A. Acceptable manufacturers, subject to compliance with requirements, provide products of one of the following:

1. Penn Ventilation

2. Carnes Company, Incorporated

3. Loren Cook Company

4. Greenheck Fan Corporation

5. Breidert Air Products, Inc.

6. Jenco

7. ACME Engineering & Manufacturing Corp.

B. General: Belt-driven or direct-drive as indicated, centrifugal consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base and accessories.

C. Housing: Aluminum, rigidly braced with heavy angle iron frame and beaded for additional strength, and hinged to the fan frame, with stainless steel lockable hasp, providing ready access to fan components.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.

2. Low Profile Single Side Discharge Units: Fabricated from formed galvanized steel or aluminum panels with single horizontal side discharge openings. Motor and drive compartment accessible.

a. Kitchen Range Hoods: Where fans exhaust smoke and grease-laden vapors, provide UL listed type with deflecting cowl to direct discharge air upward and an external collector to trap any grease run-off.

3. Low Silhouette Lateral Discharge Units

a. Louvered Penthouse Type: Furnish this type unless hood type is specifically indicated. Hinged cover, extruded aluminum louver with heli-arc welded mitered corner and integral water baffle.
b. Hood Type: Rectangular, hinged, heavy gage, aluminum construction with continuously welded curb base and integral water baffle.

D. Fan Motor, Drive and Bearings: Mounted above the fan wheel in a compartment isolating these components from the air handled by the fan.

1. Upblast Units: Furnish with automatic belt tensioner when available from fan manufacturer.

E. Fan Wheel: Backwardly inclined centrifugal type, all welded construction, having blades of not less than 12 gage and wheel plates of not less than 10 gage.

F. Disconnect Switch: Furnish NEMA 3R nonfusible type, factory mounted and wired.

G. Backdraft Dampers, Other Than Kitchen Range Hood Exhaust: Counterbalanced, parallel-blade, mounted in curb base, factory set to close when fan stops.

H. Bird Screens: Removable 1/2-inch mesh, 16 gage, aluminum, brass or galvanized steel wire, or plastic.

I. Roof curbs: Furnished as specified elsewhere in this section.

J. Accessories, where indicated on drawings, furnish the following:

1. Fans Handling Corrosive-Fume Laden Air: Finish all surfaces in contact with the airstream in a corrosion-resistant finish (CRF) (4) coats of an air-dried phenolic (Heresite VR500), (4-6) mils thick, as a minimum.

2. Two Speed Motors: As specified in Division 15.

2.03 CENTRIFUGAL POWER ROOF SUPPLY FANS

A. Acceptable manufacturers, subject to compliance with requirements, provide products of one of the following:

1. Greenheck Fan Corp.

2. Loren Cook Co.

3. Penn Ventilation

4. Jenco

5. Breidert Air Products, Inc.

6. ACME Engineering & Manufacturing Corp.

B. General: Belt-driven or direct-drive, as indicated, centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Housing: Internally insulated, heavy-gage, removable, aluminum, top and outlet baffle; and square, one-piece, hinged, aluminum or painted steel base.

1. Louvered Type: Hinged cover, extruded aluminum louver with welded mitered corners and integral water baffle.

D. Fan Wheel: Aluminum or steel hub and blades, forward-curved

E. Direct-Drive Unit: Motor encased in housing out of air stream, factory-wired to disconnect located on outside of fan housing.

1. Speed Control For Balancing Purposes, 115V/1 Phase up to 1/2 hP: Provide solid-state speed controller for direct-driven fans, with integral ON-OFF switch capable of controlling fan speed from full speed to approximately half speed. Controller shall include an L-C filter circuit to suppress radio frequency interference noises generated by the switching action of the thyister.

a. Factory mount and wire within the motor cover, unless otherwise indicated on Drawings.

F. Belt Drive Assembly: Resiliently mounted to housing, with cast iron, adjustable-pitch pulleys, permanently lubricated, permanently sealed, self-aligning ball bearings, and a turned, ground, polished steel drive shaft keyed to wheel hub.

G. Disconnect Switch: Furnish NEMA 3R nonfusible type, factory-wired through an aluminum conduit.

H. Bird Screens: Removable, 1/2-inch mesh, 16 gage aluminum, brass or galvanized steel wire.

I. Filters: 1 inch thick removable, permanent washable media type with aluminum frame.

J. Automatic Dampers: Parallel blade dampers with blade edge seals. Two-position, spring return, UL listed, line voltage electric damper actuators; factory-wired with the fan motor to open when fan starts.

K. Duct Adapter: Furnish when supply air discharge is ducted.

L. Roof Curbs: Provide as specified elsewhere in this Section.

M. Accessories, furnish where indicated on drawings.

2.04 AIR INTAKE AND RELIEF VENTILATORS

A. Acceptable manufacturers, subject to compliance with requirements, provide products of one of the following:

1. Penn Ventilation

2. Carnes Co., Inc.

3. Loren Cook Company.

4. Greenheck Fan Corporation.

5. Breidert Air Products, Inc.

6. Jenco

7. ACME Engineering & Manufacturing Co.

B. General: Gravity-operated, pressure relief or outside air inlet ventilators consisting of housing, curb base, and accessories.

C. Louvered Penthouse Type: Furnish this type unless hood type is specifically indicated. Hinged cover, extruded aluminum louver with heli-arc welded mitered corners and integral water baffle.

D. Hood Type: Rectangular, hinged, heavy gage, aluminum construction with continuously welded curb base and integral water baffle.

E. Bird Screens: Removable 1/2-inch mesh 16 gage aluminum, brass or galvanized steel wire.

F. Backdraft Dampers: Parallel-blade with blade edge seals, mounted in curb base, factory set to close. Provide counterbalanced units with adjustable weights to achieve very low resistance to air flow.

G. Roof Curbs: Furnish as indicated elsewhere in this Section.

H. Accessories, provide where indicated on drawings:

1. Intake Unit Filters: 2 inch thick, removable, permanent washable media type with aluminum frame.

2. Automatic Dampers: Parallel blade dampers with blade edge seals. Two-position, spring return, UL listed, line voltage electric damper actuators; stepdown transformer and disconnect switch factory-mounted and wired. Where automatic dampers are indicated, backdraft dampers shall not be furnished.

3. Provide snow screens where indicated on Drawings.

2.05 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15.

B. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 16 Sections.

2.06 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

2.07 PREFABRICATED ROOF CURBS

A. Acceptable Manufacturers, subject to compliance with requirements, provide products of one of the following:

1. Custom Curb.

2. Pate.

3. ThyCurb.

4. Vent Products.

5. Curbs Plus.

6. RPS.

B. General: Size curbs and equipment supports as required to suit roof opening and fan or equipment base.

C. Curbs shall be a minimum of 18-inches high, unless indicated otherwise on Drawings.

D. Refer to Architectural and Structural drawings for roof slope at curb/support location and for installation details.

E. Construct to fit single or double roof pitches as required.

F. Construct and certify load carrying capacity to suit equipment weight and wind loads with not less

than 100 percent safety factor.

G. Self-Flashing Roof Curbs: Heavy-gage, aluminum sheet and extruded aluminum shapes; mitered and welded corners; 2-inch thick rigid fiberglass insulation adhered to inside walls; aluminum insulation liner; extended flashing and mounting flange with cant; and neoprene gasket around top of entire curb.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install equipment as indicated on Drawings, and in accordance with manufacturer's recommendations.

B. Engage and pay for the services of the Division 16 Contractor to install control devices furnished with the fans and ventilators, and provide electrical control wiring, including control power transformers that may be required.

1. Install in accordance with Section Division 17.

C. Provide equipment supports indicated on mechanical and structural drawings and specified in this section, in Division 03 – CONCRETE, in Division 05 – METALS and in Section 15060. Anchor equipment to supports in locations provided.

1. Secure roof-mounted fans and ventilators with stainless steel hardware, as required by the manufacturer.

D. Install vibration control and seismic restraint devices indicated on Drawings or specified.

E. Make final duct connections with flexible connections. See SECTION 15820 for flexible duct connections specification.

F. Adjust damper linkages for proper operation.

+ + END OF SECTION + +

SECTION 15840 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. This section describes metal and flexible ductwork for HVAC duct systems, including fittings and sealants.

1.2 SUBMITTALS

A. Submit for review:

1. Sheet Metal Shop Drawings:

a. After coordination with trades, prepare floor plan drawings at minimum 1/4-inch to 1 ft. scale and Mechanical Room drawings at minimum 3/8-inch to 1 ft. scale, of all sheet metal and flexible round ducting, showing the following:

1) Fittings, access doors, and duct-mounted equipment such as fire, smoke, automatic control and balancing dampers, sound attenuators, airflow measuring stations, airflow control valves, smoke detectors and fans.
2) Elevation views, locating dimensions from column lines or other references.
3) Duct acoustical lining or external insulation.
4) Pressure classification and seal class.
5) Reflected ceiling plans, room names and numbers.
6) Major building and structural elements.
7) Major equipment and piping for Mechanical Rooms.
8) Interferences between ductwork and piping, lights or structure.

2. Leak test procedures, including test pressures, ductwork system definition and method for approving a total system.

3. Product data and installation details of prefabricated double-wall casing.

B. Submit for record:

1. Leak Test Field Reports (refer to Part 3 of this section)

2. Duct Cleaning Debris Disposal Plan (refer to Part 3 of this section)

1.3 DELIVERY, STORAGE AND HANDLING

A. Deliver sealants, mastics and fire-stopping materials to site in original unopened containers with labels displaying manufacturer, product name and designation, approved use, color, date of expiration or manufacture date, curing times, and mixing instructions for multi-component materials.

B. Store and handle sealants, mastics and fire-stopping materials in compliance with manufacturers' recommendations.

1.4 QUALITY ASSURANCE

A. All ductwork shall be free from pulsation, chatter and vibration. If any of these defects appear after a system is in operation, correct by removing and replacing, or reinforcing the ductwork at no additional cost to the Owner.

B. Close the open ends of ducts during construction to prevent dirt and debris from entering.

C. Touch-up all welded and scratched galvanized steel surfaces with zinc-rich paint.

1.5 WARRANTY

A. Boilers Exhaust System: Manufacturer of these exhaust system shall warrant their exhaust system against defects in material and workmanship, in normal use, for ten (10) years from the date of delivery to the construction site, when installed, maintained and used in accordance with his specifications.

1. Any portion of the exhaust system, repaired or replaced, under this warranty shall also be warranted for the remainder of the original ten (10) year warranty period.

PART 2 - PRODUCTS

2.1 GENERAL

A. Sealants, mastics, adhesives, coatings, acoustical lining materials, and other non-metallic components shall have maximum allowable flame spread value of 25, and a maximum smoke developed rating value of 50, in accordance with the referenced ASTM Standard E 84.

B. Package and mark sheet metal in accordance with the referenced ASTM Standard A 700.

C. When the pressure classification of the referenced SMACNA HVAC Duct Construction Standards is exceeded, construct ductwork in accordance with the referenced SMACNA Industrial Duct Construction Standards.

2.2 GALVANIZED SHEET METAL DUCTWORK

A. Construct ducts of galvanized steel sheet with a G60 coating, with gauges in accordance with the more stringent of the requirements of the SMACNA HVAC Duct Construction Standards, the International Mechanical Code, and this specification.

B. For rectangular ducts, the minimum gage shall be not less than 26.

C. Provide mill phosphatized finish where ducts are exposed.

2.3 STAINLESS STEEL DUCTWORK

A. Construct ducts of Type 304L or Type 316L stainless steel, as specified in Part 3, complying with ASTM Standard A 167.

B. Round stainless steel ductwork transverse joints shall be slip joints with the specified tape sealant applied over each joint.

C. Weld rectangular stainless steel ductwork transverse joints in accordance with the referenced AWS Standard D9.1.

2.4 ROUND AND FLAT-OVAL SINGLE-WALL DUCTWORK

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Eastern Sheet Metal, LLC.
2. Lindab USA, Inc.
3. SEMCO, Inc.
4. United McGill Corp.

B. Provide factory-fabricated round and flat-oval ducts. Gauges and construction details shall comply with the referenced SMACNA HVAC Duct Construction Standards and SMACNA Round Industrial Duct Construction Standards.

C. Provide ducts of spiral lock-seam construction.

D. Use slip joints, joints with a double-lipped EPDM jacket, or the following joining system for transverse duct joints and fittings.

1. Install using a three-piece, gasketed flanged-joint consisting of two internal flanges, with integral mastic sealant, and one external closure band to compress the gasket between the internal flanges. Acceptable System: Ductmate Spiralmate.

2.5 ROUND DOUBLE-WALL INSULATED DUCTS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Eastern Sheet Metal, LLC.
2. Lindab USA, Inc.
3. SEMCO, Inc.
4. United McGill Corp.

B. Fabricate with outer shell, metal liner, and insulation that completely fills annular space.

C. Provide outer shell 2 inches longer than metal liner and insulation. Provide 1-inch thick fiberglass insulation meeting requirements of Sections 15070 and 15250.

D. Provide insulation caps where double-wall duct connects to single-wall acoustically-lined duct or non-lined duct. Insulation cap shall terminate and contain insulation, and reduce outer shell diameters to match liner diameters.

E. Construct liner of solid sheet metal.

2.6 RECTANGULAR DOUBLE-WALL INSULATED DUCTWORK

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Eastern Sheet Metal, LLC.
2. Lindab USA, Inc.
3. SEMCO, Inc.
4. United McGill Corp. Rectangular-k27.

B. Provide factory-fabricated rectangular double-wall insulated ducts where shown on drawings.

1. Duct Sizes: Unless otherwise indicated, all rectangular double-wall insulated duct sizes shown on drawings are inner liner dimensions.

C. Construct rectangular double-wall duct of perforated or solid, as indicated, inner liner, an outer pressure shell and a layer of fiberglass sandwiched between the two. Pressure Class construction in accordance with the requirements of PART 3 of SECTION 15840.

1. Inner Liner: Construct of G90 galvanized steel.

2. Inner Liner Perforations, Galvanized Steel only: 3/32-inch diameter with an overall open area of 23 percent.

3. Outer Shell

a. Outdoors: Construct of aluminum.

4. Insulation Barrier Material:

a. Supply Air and Return Air Ductwork: Provide a tedlar sheet between the fiberglass insulation and the perforated inner liner.
b. Exhaust Air Ductwork: Provide tight woven silicon impregnated glass fiber cloth between the fiberglass insulation and the perforated inner liner.

D. Maximum Thermal Conductivity (k): 0.27 (BTU) (inch)/(hour) (square foot) (degree F).

1. Provide 2-inches of fiberglass insulation sandwiched between the outer shell and inner liner. Insulation shall meet requirements of SECTION 15250.

E. Provide insulation ends to terminate the insulation where internally-insulated duct connects to single-wall duct or to any non-insulated component.

F. Construct double-wall fittings with a perforated or solid inner liner, insulation, and perforation size, the same as for the straight duct. Construct double-wall fittings of an outer shell the same as for the straight duct.

2.7 ROUND DUCT FITTINGS

A. Provide matching fittings with continuously welded seams and joints.

B. Elbows for 3 through 12 inch diameter and 90° bends shall be two-section stamped with welded seams. All other elbows shall be constructed of mitered sections with all seams and joints welded in accordance with the following schedule:

Elbow Angle (Degrees)	Number of Gores
Thru 35	2
36 thru 71	3
Over 71	5

C. Elbows shall be two-section stamped with welded seams.

D. Construct all elbows with a centerline radius equal to 1.5 times the diameter.

E. Make all take-off connections to duct headers using tee (90°), lateral (45°), tee cross, lateral cross and "Y" branch fittings of the conical type. All fittings fabricated as separate fittings shall have continuous welds along all seams and joints.

F. The use of two-piece, mitered, vaned elbows is permitted only where long radius elbows cannot be installed.

G. The use of bullhead tee fittings without turning vanes is not permitted.

2.8 FLAT-OVAL DUCTS AND FITTINGS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Eastern Sheet Metal, LLC.
2. Lindab USA, Inc.
3. SEMCO, Inc.
4. United McGill Corp.

B. Provide spiral flat-oval ducts, having a minor axis (height) and a major axis (width), machine-

formed from round ducts with spiral lock-seam construction.

C. Flat-oval ductwork for sizes not available in spiral lock-seam construction shall be welded longitudinal seam.

D. Provide matching galvanized steel fittings with continuously welded seams and joints.

E. Brace flat-oval ducts of welded longitudinal seam construction on 4 foot centers with reinforced couplings or angle ring flanges to limit maximum wall deflection to 0.52 inch at 6 inches w.g. operating static pressure.

F. Install reinforcement and bracing for all flat-oval ducts to limit the wall vibration amplitude to plus/or minus 0.008 inch and the maximum wall deflection to 0.52 inch at 6 inches w.g. operating static pressure.

G. Construct elbows of mitered sections with all seams and joints welded in accordance with the following schedule:

Elbow Angle (Degrees)	No. of Gores
Through 35	2
36 thru 71	3
Over 71	5

H. All take-off connections to duct headers shall be made using tee (90 degrees), lateral (45 degrees), tee cross, lateral cross and "Y" branch fittings of the conical type. All fittings fabricated as separate fittings shall have continuous welds along all seams and joints.

I. The use of bullhead tee fittings without turning vanes is not permitted.

J. Shop-fabricated and contractor-designed fittings are not permitted.

2.9 BOILER FACTORY PRE-FABRICATED DOUBLE WALL

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Metal-Fab Inc., Corr/Guard.
2. Selkirk-Metalbestos model SAF-T Vent.
3. The Schebler Co. model Event-Plus.

B. Double wall, factory prefabricated, laboratory tested and UL listed for use with high efficiency, condensing heating equipment burning gas, as described in NFPA 211. Provide ventilated roof thimble or tall cone flashing as required to suite construction, exit cone and drain section below roof, stack cap, drain section or drain tee cap, and other accessories specified in Part 3 of this section or as required for a complete installation. Comply with National Safety Standards, NFPA 211 and all building codes when installed according to the manufacturer's installation instructions.

C. Inner Wall: material, AL29-4C.

D. Outer Jacket: Type 430 stainless steel with thickness of 0.020-inch for sizes through 24 inches, and 0.034 inch for sizes larger than 24 inches when installed outside of building.

E. Outer surface of inner shell internally insulated at factory to maintain maximum outside surface temperature of 150 deg. F. at 100 deg. F. ambient and 500 deg. F. flue gas temperature.

F. System designed by system manufacturer so that there will be no excessive stresses due to weight, inertia, bending movements or thermal expansion

G. Manufacturer shall warrant the complete system against functional failure due to defects in material and workmanship for 10 years from date of delivery. The system manufacturer shall be responsible for checking the sizing, design and installation of the system. If any component fails to perform its intended function of exhausting combustion by-products from the boiler equipment, for any reason, within 10 years of shipment, the system supplier shall, at no expenses to the Owner, provided a replacement part or parts FOB job site.

2.10 INSULATED FLEXIBLE ROUND DUCTS

A. Acceptable Manufacturers, subject to compliance with requirements: Clevaflex Type DB Acoustical, Flexmaster Type 6B Acoustical.

B. Acoustical insulated flexible round ducts shall be UL 181 listed as Class 1 Air Ducts, and comply with requirements of NFPA Standards 90A and 90B.

C. Inner Core: Perforated and corrugated aluminum with interlocked seams or SPUNBOND nylon fabric mechanically locked.

D. Helix: Galvanized steel construction, mechanically locked to the inner core.

E. Vapor Barrier Permeance: Maximum of 0.17 perm when tested in accordance with ASTM E96, Method A.

F. Operating Temperature Range: 10 deg. F to 200 deg. F.

G. Insulation: Flexible fiberglass wrap, thermal resistance of R=>6.0.

H. Flame Spread: Less than 25.

I. Smoke Developed: Less than 50.

J. Working Pressure: Minimum of 2 in. w.g. positive and negative for all sizes.

K. Burst Pressure: Minimum of 4 in. w.g.

L. Maximum Air Velocity: 3,000 FPM.

2.11 TAPE SEALANTS

A. Acceptable Manufacturers:

1. McGill Airflow Uni-Cast System.

2. Hardcast, Inc. DT Tape, and FTA-20 Adhesive (indoor applications) and RTA-50 Adhesive (outdoor applications).

B. Sealing Tape: Woven fiber, impregnated with gypsum mineral compound and modified acrylic activator.

C. Adhesive: Non-flammable, clear-drying and compatible with sealing tape.

D. Service Conditions: Sealing system shall be UL-listed with Flame Spread of 10 and Smoke Developed of 0, suitable for operation between 0°F and 200°F.

2.12 MASTIC SEALANTS

A. Acceptable Manufacturers, subject to compliance with requirement:

1. Ductmate Proseal.
2. Elgen Manufacturing.
3. Hardcast Iron-Grip 601.
4. United McGill Corp. "United Duct Sealer".

B. Mastic shall be one-part, acid-curing, elastomeric type, complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

2.13 FIRE-STOPPING SEALANTS

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Dow Corning Fire Stop Foam and Fire Stop Sealant.
2. 3M Fire Barrier Caulk CP-25.

B. Provide two-part, foamed-in-place fire-stopping silicone or one-part, elastomeric fire-stopping, sealant formulated for use in fire-stop system for filling openings around duct penetrations through walls, floors and partitions where a fire damper is not required. System shall have fire-resistance ratings as required by UL.

2.14 DOUBLE-WALL INSULATED CASINGS, FACTORY PRE-FABRICATED

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Industrial Acoustics (IAC).
2. Price Industries.
3. SEMCO, Inc.
4. United McGill Corp.

B. Construct casings of factory-fabricated and tested, insulated, sound-isolating metal panels. Provide all bolts, nuts, cement, gaskets, corner pieces, base channels, reinforcing, bracing, and similar components required for complete assembly. Field-fabricated components shall not be acceptable.

C. Construction: Panels shall be of interlocking tongue-and-grove design, 2-inch, 3-inch, 4-inch or 6-inch nominal thickness, as specified in Part 3, and shall be fabricated with 20-gauge galvanized steel exterior and 22-gauge galvanized solid steel interior. Sound-retarding insulation fill shall comply with Division 15. Provide Tedlar film minimum 2 mils thick between insulation and perforated liner. Spot-weld exterior sheets onto 18-gauge galvanized framing and stiffening members. Trim angles and channels shall be 16-gauge galvanized steel, factory-punched. Exposed galvanized metal shall receive shop coat of gray enamel primer.

D. Access Doors:

1. Unless noted otherwise, provide 24 inches X 66 inches access doors, with 18-gauge solid liner and outer shell, of the nominal thickness as adjacent panels. Doors shall have two hinges, two cast-aluminum latches with interior and exterior release handles and single continuous neoprene seals around sills, jambs and heads. Arrange door swing so that the differential pressure across the door compresses the gasket.

2. Provide each door with 12-inch square windows consisting of two layers of wire-mesh-reinforced safety glass separated by air space and hermetically sealed.

E. Penetrations: Provide sealed sleeves to accommodate piping, conduit, etc, passing through panels. Seal space between pipe and sleeve with hydrostatic modular mechanical seals. Size, type and installation of seals shall be as recommended by seal manufacturer. Piping shall not be supported from casings.

F. Entire casing system shall be self-supporting and airtight and shall withstand pressure differential of

10 inches water gauge without deflecting more than greater of: 1/200 of span between supports, or 1/8-inch.

G. Thermal Performance: Assembled casing system shall have maximum overall thermal transmittance at 50°F mean temperature, of 0.12 btu/h·ft²·°F for 2-inch thick panels and 0.07 Btu/h·ft²·°F for 4-inch thick panels. Panel manufacturer shall submit design data to verify compliance.

H. Acoustical Performance:

1. Panels shall be rated for following minimum sound transmission loss when tested in accordance with the referenced ASTM Standard E 90.

Frequency, Hz	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Loss, 4-inch panel, dB	23	30	42	51	59	58	37
Loss, 2-inch panel, dB	18	21	29	38	49	55	33

2. Panels shall have following minimum absorption coefficients when tested in accordance with the referenced ASTM Standard C 423.

Frequency, Hz	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Loss, 4-inch panel, dB	0.63	1.09	1.17	1.08	1.03	0.97	1.09
Loss, 2-inch panel, dB	0.22	0.64	1.06	1.06	0.98	0.87	0.94

I. Install the casings in accordance with manufacturer's recommendations.

2.15 DUCT JOINTS AND SEAMS

A. Except for ductwork specified to be welded, duct transverse joints shall be selected and used consistent with the static pressure class, applicable sealing requirements, materials, duct support intervals and other provisions for proper assembly of ductwork outlined in the SMACNA HVAC Duct Construction Standards - Metal and Flexible, Transverse Joint T-15 through T-24, shown in Figure 1-4 of SMACNA HVAC Duct Construction Standards - Metal and Flexible, are acceptable construction.

B. Transverse duct joints may also be constructed with a factory-fabricated 4-bolt connection system with manufacturer-furnished gaskets for ducts deeper than 6 inches. Construct these connections in accordance with Construction Standard T-25 a/b in the referenced SMACNA Duct Construction Standard.

C. Except for ductwork specified to be welded, transverse duct joints for ducts with a depth of 6 inches and less shall be slip-and-drive.

D. Type L-2 (button punch snap lock) or Type L-3 (grooved seam) longitudinal seams, are not acceptable.

E. Seams shall be the Pittsburgh type (Type L-1), in accordance with the referenced SMACNA HVAC Construction Standard.

PART 3 - EXECUTION

3.1 GENERAL

A. Except indicated otherwise, construct straight duct lengths, elbows, transitions, offsets, branch connections, and other fittings, of galvanized sheet steel in accordance with the referenced SMACNA HVAC Duct Construction Standards. Comply with this standard for metal thickness, reinforcement types and intervals, tie rod applications, and joint types and intervals.

1. Should any ductwork remain inadvertently unsized on the drawings, size it at a pressure loss of 0.10 IWG per 100 ft.

2. Straight tap branch duct connections are not permitted.

3. Provide offsets per SMACNA HVAC Duct Construction Standards.

B. Provide exposed vertical ducts passing through mechanical equipment room floors that are not slab-on-grade with 4-inch high concrete curb extending around floor opening.

C. Where ducts pass through floors or partitions required to have a fire-resistance rating and fire, smoke, or combination fire/smoke dampers are not required, the opening in the construction around the duct shall not exceed 1 inch average clearance on all sides and shall be filled solidly with a UL listed through-penetration firestop sealant capable of preventing the passage of flame and hot gases. Provide angle collars and galvanized steel sheet metal safing as required to cover gap between ductwork and opening. Angle collars shall be required when safing is used for duct support at floors.

D. Where ducts pass through floors or partitions required to have a fire-resistance rating and fire, smoke, or combination fire/smoke dampers are required, the ductwork shall not be installed continuous through the opening in the construction, but shall connect on each side of the opening to a damper installed in a sleeve or frame secured by perimeter mounting angles on both sides of the opening. Refer to Part 3 of this section for specific details regarding sleeve thickness. For perimeter angle dimensions, size and frequency of fasteners, clearance of expansion, duct-sleeve connections, and fire damper access doors, refer to NFPA standard 90A and the fire damper manufacturer's installation instructions.

E. Where ducts pass through floors or partitions not required to have a fire-resistance rating, the opening in the construction shall be packed with mineral fireproofing and sealed on both sides. Provide angle collars and galvanized steel sheet metal safing as required to cover gap between ductwork and opening. Angle collars shall be required when safing is used for duct support at floors.

F. Rectangular Duct Elbows

1. Supply Air Ductwork to Inlet of Air Volume Control Units: Provide only long radius elbows or short radius elbows with (3) splitter turning vanes.

2. Supply Air ductwork from Discharge Outlet of Air Volume Control Units, and for Air Systems containing no Air Volume Control Units: Provide long radius wherever possible; square throat elbows with turning vanes only where physical space restrictions do not permit installation of long radius elbows.

   a. Exception: Provide only long radius elbows or short radius elbows with (3) splitter turning vanes for Classrooms, Conference Rooms, Meeting Rooms, Libraries, Reading Rooms and Seminar Rooms.

3. Exhaust Air and Return Air Ductwork to Inlet of Room Air Volume Control Units, and for Air Systems containing no Air Volume Control Units: Provide long radius elbows wherever possible; square throat elbow with turning vanes only where physical space restrictions do not permit installation of long radius elbows.

   a. Exception: Provide only long radius elbows or short radius elbows with (3) splitter turning vanes for Classrooms, Conference Rooms, Meeting Rooms, Libraries, Reading rooms and Seminar Rooms.

4. Exhaust Air and Return Air Ductwork from Discharge Outlet of Air Volume Control Units: Provide only long radius elbows or short radius elbows with (3) splitter turning vanes.

5. Long Radius Elbows: Construct with centerline radius equal to 1-1/2 times the duct width in plane of bend.

6. Square Throat Elbows with Turning Vanes: Construct with single thickness turning vanes up to a duct width of 36 in.; double wall vanes for wider ducts.

G. Round Duct Elbows: Provide long radius elbows wherever possible; mitered elbows with turning vanes only where physical space restrictions do not permit installation of long radius elbows.

H. Branch to Main Duct Connections:

1. Rectangular-to-Rectangular Ducts: Provide SMACNA 45 deg. "boot" connections. Depth of "boot" shall increase with the width of the duct per SMACNA Duct Construction Standards.

2. Round-to-Rectangular Ducts: Provide round to rectangular transitions modified to SMACNA 45 deg. "lead-in" connection construction.

a. At the point of connection to the main duct, "lead-in" cross-sectional area shall be at least 125% that of the branch duct.
b. Do not use conical or bellmouth connections.

3. Round-to-Round Ducts: Provide 45 deg. laterals or United McGill's "LOLOSS" tees; conical tees only where physical space restrictions do not permit installation of aforementioned laterals or tees.

I. Dampers: Provide duct collars and flanges for automatic dampers. Install automatic dampers provided under other Sections.

J. Double-Wall Insulated Casings, Factory Pre-Fabricated: Install casings on 4-inch high concrete curbs in accordance with manufacturer's installation instructions. Provide floor channels for bolting to curbs.

K. Provide metal sleeves for air transfer openings in partitions and floors. Fabricate sleeves of galvanized sheet metal of gauges corresponding to similar duct sizes, as detailed in SMACNA Duct Construction Standards.

L. Provide roof curbs as specified in Sections that specify roof mounted equipment for ducts passing through roof. Counterflash ductwork over curbs.

M. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines. Avoid, where possible, diagonal runs. Install duct systems in shortest route that does not obstruct useable space or block access for servicing building and its equipment. Contract drawings are diagrammatic.

N. Route ducting to avoid passing through transformer rooms, and electrical equipment spaces and enclosures.

O. Do not install piping and conduit penetrating ductwork.

P. At Contractor's option, and subject to fit in available space, round spiral lock-seam ductwork of equivalent or greater cross section area, as determined from the ASHRAE "Equivalent Rectangular Duct Dimensions" table, may be provided.

3.2 FIRE DAMPERS AND COMBINATION FIRE/SMOKE DAMPERS

A. Make rigid duct connections to fire dampers and combination fire/smoke dampers in accordance with UL 555. Where damper sleeve is provided by this section, sleeve shall be of thickness as

follows, subject to a maximum thickness of 0.135 inch for uncoated steel and 0.138 inch for coated steel unless a larger sleeve thickness is tested:

1. For damper not exceeding either 36 inches wide or 24 inches high, minimum 0.053 inch thick for uncoated steel and 0.056 inch thick for coated steel except where a greater thickness is required by the specified SMACNA construction standards.

2. For damper larger than either 36 inches wide or 24 inches high, minimum thickness of 0.067 inch thick for uncoated steel and 0.070 inch thick for coated steel except where a greater thickness is required by the specified SMACNA construction standards.

B. Where Contractor elects to have the damper sleeve furnished by the damper manufacturer, it shall be the full responsibility of the Contractor to inform the damper manufacturer where the adjoining ductwork will be thicker than the minimum hereinbefore specified and to verify that such a thicker sleeve is furnished by the damper manufacturer.

3.3 INSULATED FLEXIBLE ROUND DUCTS

A. Where acoustical flexible round duct is used, provide 60 to 84 inches length of duct. Otherwise, limit flexible duct to 60 inches maximum.

B. Install in accordance with the more stringent of manufacturer's installation instructions or SMACNA HVAC Duct Construction Standards, latest edition.

C. When located at the end of a duct run, limit the number of 90 degree bends to one. Bends shall be made with not less than 1 duct diameter centerline radius.

D. Support ducts with minimum 1-inch wide straps or hangers, spaced no more than 5 feet apart, so that horizontal runs do not sag more than 1/2-inch per foot of horizontal spacing between supports.

E. Attach insulated flexible round duct to sheet metal duct collars or sleeves having a "bead" or "lances".

1. Apply adhesive over the collar or sleeve and/or inside the duct core before pulling the internal core at least 2 in. over them.

2. Secure the internal core to the collar or sleeve with a draw band, applying additional adhesive over the connection. Use of duct tape instead of draw bands is unacceptable.

a. For vertical connections, install at least 3 screws below the strap to prevent it from slipping off.

3. Pull insulation and vapor barrier to completely cover the collar or sleeve, and mechanically fasten them with another draw band. Use of duct tape instead of draw bands is unacceptable.

3.4 BOILER SMOKE VENT, FACTORY FABRICATED

A. Provide for boiler(s) with pressure burner in compliance with local building code and NFPA 211.

B. Make gastight so that no leaks will occur. Make connection for each boiler full size of the unit smoke (flue) outlet.

C. Firmly support in place so that no undue stress is placed on equipment. Provide all necessary structural steel supports and bracing. Provide expansion joints as indicated or as required.

D. Extend smoke vent above roof as required by NFPA 211 and applicable Building Code, and terminate with a 2-1/2 inch angle ring around the outlet. Attach rain hood to angle ring.

E. Maintain a minimum clearance in boiler room of 2 feet 6 inches between the finished surface of any vertical run and the nearest wall and 6 feet 0 inches between the finished surface of any horizontal run and the floor.

3.5 LEAKAGE TESTS

A. Indoors: Leak test 25% of the ductwork system, 4 in. w.g. SMACNA Duct Pressure Class Construction and higher, before ductwork is insulated and concealed.

B. Outdoors: Leak test 100% of the ductwork system, all SMACNA Duct Pressure Class Constructions, before ductwork is insulated and concealed.

C. For positively-pressurized ductwork follow general procedures (Chapter 3) and use apparatus (Chapter 5) as outlined in the referenced SMACNA HVAC Air Duct Leakage Test Manual. For negatively-pressurized ductwork, follow general procedures (Chapter 3) and use apparatus (Chapter 5) as outlined in the referenced SMACNA HVAC Air Duct Leakage Test Manual, except that the test blower shall exhaust air from the ductwork being tested.

1. Test all duct risers enclosed in shafts which extend more than one floor.

2. Test 25% for each duct construction pressure classification for each individual supply, return and exhaust air system with 4 in w.g. and higher pressure class.

3. Duct locations on each floor shall be selected by the Owner or Owner's Representative.

D. Duct construction pressure classifications for all ductwork are shown in the Ductwork Schedule at the end of this Section.

1. Test all ductwork at 100 percent of the specified pressure classifications, not the working pressure.

E. The maximum allowable leakage shall be in accordance with the equation F = CLP 0.55.

F. If tests show that ductwork system leakage is greater than that allowed, ductwork shall be resealed and retested until allowable leakage is not exceeded, at no additional cost to the Owner. All tests may be witnessed and results verified by the Owner's Representative.

1. Submit field test report certifying that the ductwork does not exceed the maximum SMACNA allowable leakage.

3.6 SEALANTS

A. Clean metal surfaces with cleaning agent as recommended by duct sealing system manufacturer.

B. Apply duct sealing components in accordance with manufacturer's written instructions.

C. Seal all duct transverse joints and all longitudinal seams, SMACNA Seal Class A, with mastic and/or tape sealants as required to meet specified maximum allowable leakage rates.

3.7 INSTALLATION WORK FOR BUILDING AUTOMATION CONTROLS

A. Provide work specified in Division 17.

3.8 DUCTWORK SCHEDULE

A. Construct duct systems to the following duct pressure classifications and maximum allowable leakage rates using the scheduled materials, unless otherwise noted on the contract drawings.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

AIR SYSTEM	DUCTWORK MATERIAL	PRESSURE CLASSIFICATION (IN W.G.)	Seal Class	Leakage Class Rectangular/ Round
Supply Air from Air Handling Unit	Galvanized steel	+6 Between AHU and roof penetration into 3rd floor ceiling;	A	4/2
		+4 Between 3rd floor ceiling penetration and constant or variable volume control boxes or valves	A	4/2
		+3 downstream of constant or variable air volume control boxes or valves	B	8/4
Exhaust Air from Fumehoods	Galvanized unless noted otherwise	-2 between fume hood and constant or variable air volume control boxes or valves	B	8/4
		-4 between constant or variable air volume control boxes or valves and galvanized metal manifolded exhaust main	A	4/2
Exhaust Air from Laboratories and Exhaust Air from offices, Toilet Rooms, and Conference Rooms	Galvanized,	-2 between fume hood and constant or variable air volume control boxes or valves	B	8/4
		-4 between constant or variable air volume control boxes or valves and roof penetration above the 3rd floor ceiling	A	4/2
		-6 between roof penetration above the 3rd floor ceiling and exhaust fans	A	4/2
		+4 After the exhaust fan (note, ductwork after exhaust fan located within the penthouse to be fully welded)	A	4/2
Outside Air Intake Plenum	Double-wall apparatus casing	-4	B	8/NA
Outside Air and exhaust bypass air	Galvanized steel	-2	C	16/8
Supply Air from Miscellaneous Systems such as mechanical and electrical room ventilation and ducted cabinet unit heaters	Galvanized steel	+2	C	16/8
Exhaust/Return Air from Miscellaneous Systems such as mechanical and electrical room ventilation and ducted cabinet unit heaters	Galvanized steel	-2	C	16/8
Relief Air	Galvanized	+2	C	16/8

AIR SYSTEM	DUCTWORK MATERIAL	PRESSURE CLASSIFICATION (IN W.G.)	Seal Class	Leakage Class Rectangular/ Round
	steel			
Transfer Air	Galvanized steel	+ 0.5	C	24/12

+ + END OF SECTION + +

SECTION 15857 - CHILLED BEAM INDUCTION UNITS

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes active and passive chilled beams.

1.02 SUBMITTALS

A. Submit for review:

1. Product Data: For each type of product.

   a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chilled beams.
   b. Include rated capacities, operating characteristics, and furnished specialties and accessories for chilled beams.

2. Shop Drawings:

   a. Include plans, elevations, sections, and mounting & attachment details.
   b. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   c. Operation and maintenance data.
   d. Method of attaching hangers to building structure.
   e. For active beams, generated noise in octave bands 2-7, measured as specified in ASHRAE Standard 130.

3. [Samples for Initial Custom Color Selection: Furnish colors for units with factory-applied custom color finishes.]

4. [Samples: One complete chilled beam product sample, minimum 4-ft long, for each beam style being supplied for the project.]

5. Seismic: Become familiar with requirements specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

   a. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting provisions.

6. Field quality-control reports.

7. Sample Warranty: Furnish manufacturer's warranty.

1.03 QUALITY ASSURANCE

A. Active chilled beams shall be tested using prEN Standard 15116 test method. Rate throw velocity and noise criterion in accordance with ASHRAE Standard 70.

B. Passive chilled beam shall be tested using EN Standard 14518 test method.

C. Comply with ANSI/ASHRAE Standard 55 Thermal Environmental Conditions for Human Occupancy.

PART 2 - PRODUCTS

2.01 ACTIVE CHILLED BEAMS (INDUCTION DIFFUSERS)

A. Acceptable Manufacturers, subject to compliance with requirements:

1. Dadanco-Mestek Joint Venture LLC.
2. Krueger (by Halton)
3. Price Industries
4. Semco, LLC Flexicool.
5. Swegon, Inc.
6. Trox USA, Inc.

B. Description: Sheet metal construction with pressurized (0.3”w.c – 1.25”w.c.) primary air plenum box, induction nozzles, secondary non-condensing chilled-water coil and heating hot-water coil assembly, and induction return air entry panel. The active chilled beam shall utilize induction of room air across the water coil mounted within the unit to provide sensible cooling only, or heating when required.

1. Furnish adjustable mounting-bracket supports suitable for installation in the ceiling type shown on the architectural reflected ceiling plans, whether lay-in installation flush with T-bar ceiling grid, recessed mounting, surface mounting, or exposed hangers.

2. Beams shall be 2-way, 1-way or 4-way modular air flow pattern, as shown on drawings. Furnish 1-way air flow pattern beams with symmetric face.

3. Beams shall be 2-pipe or 4-pipe, as shown on drawings.

C. Components:

1. Return Air Entry Panel: Hinged perforated front. Perforated front panel, minimum 0.0375-inch (0.95-mm) thickness, painted galvanized-steel sheet.

2. Casing: Construct primary pressurized air plenum of 24 gauge galvannealed steel, with at least one air inlet. Construct the frame of aluminum extrusions.

a. Primary Air Pressurized Plenum Insulation, External: None, uninsulated.

3. Factory Piping: ASTM B 88, Type L (ASTM B 88M, Type B) copper tube with ASME B16.22 wrought-copper fittings and brazed joints. Seal ends for shipment.

4. Hydronic Coil: Copper tube, with mechanically bonded 0.006-inch (0.15-mm) thick, aluminum fins spaced no greater than 10 fins per inch (2.5 mm), rated for a minimum working pressure of 250 psig (1758 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C).

a. Coil shall be removable from the room side, without requiring removal of the beam casing from the ceiling.
b. Manual Air Vent and Drain Valve: Furnish.
c. Cooling Coil Connections: NPS 1/2 (DN 15), sweat or threaded

connections.

d. Heating Coil Connections: NPS 1/2 (DN 15), sweat or threaded connections.

5. Furnish with integral plenum pressure port (with k-factor) for air-side balancing and flow verification.

6. Nozzles: Formed metal, fixed size nozzles, selected based on cooling and heating requirements.

D. Exposed Metal Finish: Sheet metal with baked enamel**.**

1. Color: Custom paint color as selected by Architect.

2. Surface-Mounted Trim: Sheet metal with baked-enamel finish in custom paint color as selected by Architect.

E. Internal Metal Finish: Painted black.

F. Capacities and Characteristics:

1. Nominal Panel Size: Furnish 12 by 48 inches (300 by 1200 mm), 24 by 48 inches (600 by 1200 mm), 12 by 96 inches (300 by 2400 mm), or 12 by 118 inches (300 by 3000 mm), as shown on drawings.

2. Room Temperature for Cooling, Cooling Capacity, Chilled Beam Water Inlet Temperature, Average Chilled Beam Water Temperature (57°-61°F) and Chilled Beam Water Flow: As indicated on drawings.

3. Room Temperature for Heating, Heating Capacity, Heating Hot Water Inlet Temperature (85°-115°F), Heating Hot Water Flow and Average Heating Water Temperature: As indicated on drawings.

2.02 GENERAL FINISH REQUIREMENTS

A. Appearance of Finished Work: Variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

PART 3 - EXECUTION

3.01 PRE-BID SERVICES

A. Bid shall include the costs to complete final selections and coordination with the Architect at his office. Allow for a minimum of three (3) business days.

3.02 EXAMINATION

A. Examine areas to receive chilled beams for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine rough-in for heating hot-and chilled-water piping to verify actual locations of piping connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 INSTALLATION - GENERAL

A. Install equipment in accordance with manufacturer's instructions.

1. Verify inlet duct connections are as recommended by manufacturer to achieve proper performance.

2. Verify controls and control enclosures are accessible.

3. Verify control connections are complete to control valves, as needed.

4. Verify that identification tags are visible.

5. Verify controls respond to inputs as specified.

B. Do not rest the weight of the active chilled beam on the ceiling grid, in a suspended ceiling.

C. Use clean white gloves when handling beams, in order to avoid smudging them.

3.04 INSTALLATION

A. Install chilled-beam units level and plumb.

B. Coordinate layout and installation of chilled beams and suspension-system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, communications system, security system, and partition assemblies.

C. Seismic Restraints: Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Comply with requirements for pipe hangers and supports specified in Section 15060 "Hangers and Supports for HVAC Piping and Equipment."

E. Comply with requirements for general-duty valves specified in Section 15100 "General-Duty Valves for HVAC Piping.

F. Install continuous-thread hanger rods of size required to support chilled-beam weight.

G. Comply with NECA 1.

3.05 CONNECTIONS

A. Comply with requirements for piping specified in Section 15070 Hydronic Piping. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to chilled beams, allow space for service and maintenance.

C. Comply with requirements for ductwork specified in Section 15840 "Metal Ducts." Drawings indicate general arrangement of ductwork.

D. Make piping and ductwork connections as required per coordination and/or shown on contract drawings.

3.06 IDENTIFICATION

A. Identify electrical-system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 15190 "Identification for Electrical Systems."

B. Identify hydronic piping and valves. Comply with requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.07 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections [with the assistance of a factory-authorized service representative]:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Test and adjust temperature controls and equipment. Replace damaged and malfunctioning controls and equipment.

C. Chilled beam will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.08 ADJUSTING

A. Start-Up & Training: Manufacturer’s factory-authorized representative shall provide start-up and training services to Owner’s staff to adjust, operate and maintain chilled beams. A minimum of eight (8) hours of such services shall be included in the bid.

B. Adjust initial temperature set points.

+ + END OF SECTION + +

SECTION 15861 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.01 SUMMARY

A. This section describes:

1. Metal panel filters.

2. Flat panel filters.

3. Pleated panel filters.

4. V-bank cell filters.

5. Front- and rear-access filter frames.

6. Side-service housings.

7. Filter gages.

1.02 SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

2. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

3. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.

a. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
b. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

1.03 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Manuals: Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.04 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective

covering for storage and identified with labels describing contents.

1. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.

2. Provide one container(s) of red oil for inclined manometer filter gage.

1.05 QUALITY ASSURANCE

A. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."

2. Comply with ASHRAE 52.2 2007 (B) with Appendix J for MERV and MERV A for methods of testing and rating air-filter efficiencies, dust holding capacity, resistance and particle size efficiency.

B. Comply with NFPA 90A and NFPA 90B.

C. Manufacturer shall provide evidence of facility certification to ISO 9001:2008.

1.06 COORDINATION

A. Coordinate sizes and locations of concrete housekeeping pads. Cast anchor-bolt inserts into pads.

PART 2 - PRODUCT

2.01 METAL PANEL FILTERS

A. Description: Factory-fabricated, self-supported, cleanable, all-metal, impingement-type, panel-type, permanent air filters with holding frames.

1. Acceptable Manufacturers, subject to compliance with requirements:

a. Price
b. Anemostat
c. AirGuard (a Clarcor Co.).
d. American Air Filter (AAF) International.
e. Camfil.
f. Filtration Group.
g. Flanders-Precisionaire.
h. GlasFloss Inductries, LP.
i. Purolator (a Clarcor Co.).
j. Tri-Dim Filter Corp.

B. Media: Four or Six, alternate layers of aluminum flat and herringbone-crimp screen.

1. Non-oiled for grease removal application.

2. Adhesive coating.

a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale

Environmental Chambers."

C. Filter-Media Frame: Galvanized steel or Aluminum hinged, and with pull and retaining handles fastened to the media.

1. Drain holes.

2.02 FLAT PANEL FILTERS – Industrial Grade Construction

A. Description: Factory-fabricated, self-supported, flat, non-pleated, panel-type, disposable air filters with holding frames.

1. Acceptable Manufacturers, subject to compliance with requirements:

a. AirGuard (a Clarcor Co.).
b. American Air Filter (AAF) International.
c. Camfil.
d. Filtration Group.
e. Flanders-Precisionaire.
f. GlasFloss Industries, LP.
g. Purolator (a Clarcor Co.).
h. Tri-Dim Filter Corp.

B. Filter Unit Class: UL 900.

C. Media: Cotton fibers coated with nonflammable adhesive.

1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

3. Media shall be coated with an antimicrobial agent.

4. Metal Retainer: Upstream side and downstream side.

D. Filter-Media Frame**:** Galvanized steel with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles sealed or bonded to the media.

1. Depth: 1”.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.03 PLEATED PANEL FILTERS (ASHRAE MERV 8A)

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

1. Acceptable Manufacturers, subject to compliance with requirements:

a. AirGuard (a Clarcor Co.).
b. American Air Filter (AAF) International.
c. Camfil.
d. Filtration Group.
e. Flanders-Precisionaire.
f. GlasFloss Industries, LP.

g. Purolator (a Clarcor Co.).
h. Tri-Dim Filter Corp.

B. Filter Unit Class: UL 900.

C. Media: Cotton fibers coated with nonflammable adhesive.

D. Filter-Media Frame: Cardboard frame with perforated metal retainer, and with metal grid on outlet side, sealed or bonded to the media.

1. Depth: 1”, 2” and 4”, as indicated on documents.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.04 BOX STYLE V-BANK CELL FILTERS (ASHRAE MERV 11A, 13A, 14A, 16)

A. Description: Factory-fabricated, adhesive-coated, disposable, packaged air filters with media formed into multiple V-shaped media packs, angled to airflow, and with holding frames.

1. Acceptable Manufacturers, subject to compliance with requirements:

a. AirGuard (a Clarcor Co.).
b. American Air Filter (AAF) International.
c. Camfil.
d. Filtration Group.
e. Flanders-Precisionaire.
f. GlasFloss Industries, LP.
g. Purolator (a Clarcor Co.).
h. Tri-Dim Filter Corp.

B. Filter Unit Class: UL 900.

C. Media: Fibrous glass material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.

1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

3. Media shall be coated with an antimicrobial agent.

D. Filter-Media Frames: All plastic, with handles. Single header model.

1. Depth: 12”.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.05 FRONT ACCESS FILTER FRAMES UPSTREAM ACCESS

A. Framing System: Filter holding frame shall be constructed of aluminum**.** Accepts any filter with a header**.** The frame shall be assembled from two corner sections and welded to assure a rigid and durable frame assembly for built-up bank HVAC level application. Centering dimples shall be an integral part of the frame to assist in aligning final filter and prefilter if applied.

1. Acceptable Manufacturers, subject to compliance with requirements:

   a. AirGuard (a Clarcor Co.).
   b. American Air Filter (AAF) International.
   c. Camfil.
   d. Filtration Group.
   e. Flanders-Precisionaire.
   f. GlasFloss Industries, LP.
   g. Purolator (a Clarcor Co.).
   h. Tri-Dim Filter Corp.

B. Frame-to-frame installation holes shall be an integral part of the frame, two holes on each vertical and three holes on top and bottom. The top of the frame shall be identified with etching.

C. The frame shall include eight integral corrosion resistant compression tabs, four on each horizontal member, to facilitate filter installation without the use of tools or other fasteners.

D. A 3/4” filter sealing flange shall be an integral component of the holding frame. All corners shall be flush mitered.

E. Sealing: A replaceable filter-to-frame sealing gasket shall be installed on the flange to prevent air bypass and ensure that the filter seats securely against the sealing flange. The gasket shall include an overlapping configuration at each corner to prevent air bypass at each of the corners of the frame.

2.06 REAR-ACCESS FILTER FRAMES (DOWNSTREAM ACCESS)

A. Framing System: aluminum framing members with access downstream (rear) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

1. Acceptable Manufacturers, subject to compliance with requirements:

   a. AirGuard (a Clarcor Co.).
   b. American Air Filter (AAF) International.
   c. Camfil.
   d. Filtration Group.
   e. Flanders-Precisionaire.
   f. GlasFloss Industries, LP.
   g. Purolator (a Clarcor Co.).
   h. Tri-Dim Filter Corp.

B. Prefilters: Incorporate spring clips, removable from back**.**

C. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air.

2.07 SIDE-SERVICE HOUSINGS

A. Description: Factory-assembled, side-service housings, constructed of aluminum with flanges to connect to duct or casing system.

1. Acceptable Manufacturers, subject to compliance with requirements:

   a. AirGuard (a Clarcor Co.).
   b. American Air Filter (AAF) International.
   c. Camfil.
   d. Filtration Group.
   e. Flanders-Precisionaire.

f. GlasFloss Industries, LP.
g. Purolator (a Clarcor Co.).
h. Tri-Dim Filter Corp.

B. Prefilters: The housing shall incorporate the capability of multiple stages of filtration without modification to the housing. A filter track, of extruded aluminum construction shall be an integral component of housing construction. The track shall accommodate a 2” or 4” deep pre-filter, a 2”, or 4” deep intermediate particulate or carbon filter, and a 6” or 12” deep rigid or pocket final filter.

1. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

C. Access Doors: Dual access swing-open doors shall include high-memory sponge neoprene gasket to facilitate a door-to-filter seal against all individual stages of filtration. Each door shall be equipped with adjustable and replaceable positive sealing UV-resistant star-style knobs and replaceable door hinges.

D. The housing shall include pneumatic fittings to allow the installation of static pressure gauge(s) to evaluate pressure drop across the prefilter, the secondary filter, the final filter, or any combination of the installed filters.

E. Housing leakage at rated airflow, upstream to downstream of filter and slide mechanism shall not exceed 1% at 3.0” w.g. Leakage into or out of the housing shall be less than 1% at 3.0” w.g. Accuracy of pneumatic pressure fittings, when used to evaluate a single-stage, or multiple filter stages, shall be accurate within ± 3% at 0.6” w.g.

1. Housing integrity to listed performance values shall be available on request from the housing manufacturer.

2.08 AIR FILTER GAUGES

A. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Acceptable Manufacturer, subject to compliance with requirements: Dwyer 2000 Series Magnehelic.

B. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg (0 to 750 Pa), and accurate within 3 percent of the full scale range.

C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Install filter gage for each filter bank.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

E. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages

on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling-unit installations.

3.02 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Test for leakage of unfiltered air while system is operating.

D. Air filter will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.03 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

+ + END OF SECTION + +

SECTION 15950 - TESTING, ADJUSTING, AND BALANCING (TAB) FOR HVAC

PART 1 - GENERAL

1.01 SUMMARY

A. This Section describes testing, adjusting and balancing of air, and water systems.

1.02 SUBMITTALS

A. Submit for review:

1. Inspection reports.

2. Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB) Certification.

3. Written step-by-step procedures to be used for the testing and balancing of each system before starting work, including specific reference to components and sequence of testing, adjusting, and balancing (TAB).

4. List of instruments to be used for each test. Include instrument calibration dates.

5. Testing and balancing reports, including preliminary and final balance data sheets, sound tests, and fume hood system testing and balancing.

1.03 QUALITY ASSURANCE

A. The Testing, Adjusting and Balancing Agency shall be certified by the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB).

PART 2 - PRODUCTS

2.01 SYSTEM BALANCE - GENERAL

A. Provide all instruments, materials and equipment required for testing.

B. Test and calibrate all instruments permanently installed and those portable instruments used by the balancer.

C. Perform the work, using methods and test forms published by AABC National Standards for Total System Balance, or using equivalent NEBB methods and forms.

D. Using controls and devices installed, test and balance air conditioning systems with maximum attainable internal load, including lights and equipment, or simulated maximum load using automatic temperature controls, whichever is closest to design operating conditions.

E. Perform the final testing and balancing of air handling systems and sound testing, with finished ceilings and partitions in place, and doors closed.

F. Owner may witness final system testing, adjustments and balancing.

G. Perform complete balancing services for standby equipment. Verify and report that final terminal device flows and transfer air flows are also achieved when operation is switched to standby equipment.

H. Submit certification of the accuracy of instruments used by the Testing and Balancing Agency.

Show date and method of calibration.

1. Furnish instruments that have been calibrated within six (6) months prior to the estimated commencement date of testing and balancing work.

I. Verify the accuracy of permanently-installed flow-measuring primary elements and their associated readout instruments, thermometers, sensors, and pressure gauges provided as part of the Work.

1. Verification may be by calculation and calibration of the primary element and read-out instrument, or by independent measurement of flow rate, temperature or pressure of flow, of same flowing medium using calibrated instruments.

2. Submit report of calibration accuracy.

2.02 AIR BALANCING

A. Verify that all ductwork, dampers, grilles, registers, and diffusers have been installed in accordance with Contract Documents, and set in the full open position. Perform the following TAB procedures:

1. For Supply Fans:

a. Fan Speeds: Test and adjust fan speed (RPM) to achieve design CFM.
b. Current and Voltage: 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. Pitot-Tube Transverse: Perform a pitot-tube traverse of main supply and return ducts, as applicable, to obtain total airflow CFM.
d. Outside Air: Test and adjust the outside airflow 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°F (-6.7°C), or use the difference between pitot-tube traverses of the supply and return air ducts.
e. Static Pressure: Test and record system static profile of each supply fan.
f. Determine correct "final" sheave size for belt-driven fans with electric motors 25.0 horsepower (18.65 kilowatts) and larger, and furnish this size to the Mechanical Contractor, who will, if necessary, replace "initial" fixed-pitch motor sheaves with "final" permanent sheaves, as specified in Division 15.

2. For Return, Relief and Exhaust Fans:

a. Test and adjust fan speed (RPM) to achieve design CFM.
b. Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure fan motor is not in the service factor.
c. Perform a pitot-tube traverse of the main return ducts to obtain total airflow CFM.
d. Test and record system static pressure profile of each return fan.
e. Determine correct "final" sheave size for belt-driven fans with electric motors 25.0 horsepower (18.65 kilowatts) and larger, and furnish this size to the Mechanical Contractor, who will, if necessary, replace "initial" fixed-pitch motor sheaves with "final" permanent sheaves, as specified in Division 15.

3. For Zone, Branch and Main Ducts, including Active Chilled Beams :

a. Adjust ducts to within design CFM requirements.
1) At least one zone balancing damper shall be completely open.
2) Multi-diffuser branch ducts shall have at least one outlet or inlet volume damper completely open.

b. Minimum number of points for each duct traverse = 16.
c. The balancing report must show all points of the traverse taken and not just a

summary of the data.

d. The maximum distance between test points is 6", unless the total number of readings equals over 64 points, in which case the distances can be increased over 6", but the total number of readings in this case should average around the 64 readings.

4. For Systems With Air Volume Control Units:

a. Set all air volume control units to meet design maximum and minimum CFM requirements.
b. Identification: Identify the type, location, and size of each air volume control unit.
c. Record this information on the air volume control units' data sheets.

5. Room Air Outlets & Inlets: Test and adjust individual room air outlets and inlets under procedures recommended by the their manufacturers.

a. Set outlets for air pattern required, and adjust all supply, return and exhaust air dampers for design CFM.
b. Change air patterns or settings, as necessary to achieve correct air balance.

B. Balance air systems for correct operation, at both design maximum and design minimum outside air, and design maximum and design minimum return air.

C. Balance air systems in all modes of operation, including warm-up mode.

D. Create test holes in ducts for pitot-tube traverses. Seal test holes in ducts with snap-in plugs, not tape.

1. Repair insulation where damaged.

2. Mark insulation on exterior of duct where readings were taken.

2.03 HYDRONIC BALANCING

A. Pumps

1. Test and adjust all pumps to achieve design GPM or GPH. Check pumps for proper operation. Record appropriate gauge readings for final head and dead head calculations.

2. Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure pump motor is not operating in the service factor.

B. System Mains and Branches

1. Adjust water flow to achieve maximum or design GPM.

C. Chillers

1. Verify that chillers have been started and are in operation. Test and adjust chiller water flows to achieve maximum or design GPM.

2. Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure compressor motor is not in the service factor.

3. Test and record temperature profiles of chillers.

D. Boilers

1. Verify that boilers have been filled, started and are in operation.

2. Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure motor is not in the service factor.

3. Test and record temperature and pressure profiles of boilers.

E. Heat Exchangers

1. Verify that heat exchangers have been filled and started, and are in operation.

2. Test and adjust water flow through heat exchangers.

3. Test and record temperature and pressure profiles of water or steam heat exchangers.

F. Coils and Terminal Heat Transfer Equipment, including Chilled Beams

1. Test, adjust, and balance all hydronic coils to design requirements, within the tolerance specified below.

2. Verify the type, location, final pressure drop and GPM of each coil. Record this information on coil data sheets.

G. Automatic Control Equipment: In addition to the above work, check the operation of automatic control equipment, and verify equipment set points.

2.04 PERFORMANCE TOLERANCE

A. At conclusion of testing, adjusting and balancing work, actual air and water flow rates shall be within a plus-or-minus (+/-) five(5) percent tolerance of the design flow rates.

2.05 SOUND MEASUREMENTS

A. In two (2) locations per floor, as selected by the Owner, conduct sound tests in accordance with procedures published by the AABC or NEBB, except as modified by the following:

1. At each designated location, measure the sound pressure level at each octave band mid-frequency between 63 and 8000 Hz as follows:

a. With all equipment off, room empty of personnel except test personnel, and all doors closed.

2. Based on these sound pressure level measurements, calculate and report the "NC" rating for each designated location. Plot center frequencies for each octave band on NC curve charts.

2.06 LABORATORY FUME HOOD, AND OTHER EXHAUST HOOD, SYSTEM TESTING, ADJUSTING AND BALANCING

A. Test, adjust and balance the fume hood exhaust to achieve the design fume hood face velocity, and to maintain laboratory air balance, as shown on the Contract Documents.

1. Affix a label to each fume hood indicating actual average face velocity in the design open position, and date of measurement.

2. Balance fume hoods, and other exhaust hoods, in accordance with manufacturer's recommendations.

3. Balance the airflow to the fume hoods as shown on the drawings at the design sash opening.

B. Conduct one contaminant containment test on each type of fume hood, after the fume hood face velocities have been balanced. Conduct this test with the sashes in the design open position.

1. Comply with testing requirements of ANSI/ASHRAE 110 Standard "Method of Testing Performance of Laboratory Fume Hoods."

2. Affix to the fume hood face in a clearly visible location, but not interfering with the operation or maintenance of the hood or its control components, a label with the "AS USED" contaminant containment rating determined during testing as outlined above, and the date that the test was conducted.

2.07 VIBRATION MEASUREMENTS

A. Test vibration of fans and pumps with electric motors 3.0 horsepower (2.238 kilowatts) and larger. Measure and report test deflection in mils and velocity in inches per second.

2.08 INSPECTIONS DURING CONSTRUCTION

A. During construction, on at least two separate days, inspect the installation of piping systems, sheet metal work, automatic controls, and other parts of the HVAC systems.

2.09 BUILDING/ZONE PRESSURIZATION

A. Test and adjust building/zone pressurization by setting the design flows to meet the required flow direction and pressure differential.

1. Positively Pressurized Areas, Airflow Outward: Set the supply air to design flow, and gradually reduce the exhaust air rate to obtain the required flow or pressure difference.

2. Negatively Pressurized Areas, Airflow Inward: Set the supply air to design flow, and gradually increase the exhaust air rate to obtain the required flow or pressure difference.

PART 3 - EXECUTION

3.01 REPORTS

A. Submit a separate test report for each air and hydronic system containing actual temperatures, pressure drops and flow rates at all terminal devices (i.e. air volume control units, grilles/registers/diffusers, coils, terminal heat transfer equipment, etc.), and compare totals to the flow measurements taken at the source (e.g. fans and pumps) and to the design parameters.

1. Furnish a written detailed summary for each balanced system, which must include the following:

a. A complete detailed description on the procedures followed when the system was balanced.
b. A complete description of any deficiencies that still remain after the TAB work has been completed.

2. TAB report identification numbering:

a. Furnish a system-by-system single line drawing showing all of the outlets & inlets with their corresponding TAB report numbers. This drawing must include the room numbers and a reasonable architectural layout.
b. Or, furnish a copy of the mechanical drawings, or a copy of the sheet metal shop

drawings with the TAB Contractor's numbering sequence written on them.

B. Submit a report showing the results, location, time and date of each IAQ test. Include summary of the HVAC operating conditions, and a listing of discrepancies.

C. In addition to data required on AABC or NEBB forms, the following additional information is required for all scheduled equipment:

1. Motors: Type, amps per phase, frame number, serial number, motor horsepower, and calculated brake horsepower and efficiency at final conditions.

   a. Every motor reported on, must include a calculated BHP.

2. Fans: Blade design type such as air foil, backwardly inclined (BI), single inlet single width (SISW) or double width double inlet (DWDI), class and number of blades.

3. Pumps:

   a. Design Data: Impeller size, motor hp, rpm, net positive suction head (NPSH) required at design flow, and total dynamic head (TDH) at zero flow.
   b. Test Data: Suction and discharge pressures at full flow (not throttled to obtain rated flow), and zero flow.

4. Hydronic Systems: Record GPM in each significant branch, and position of each balancing valve.

5. Fume Hoods: Record fume hood airfoil velocity, when sashes are completely closed.

6. Air Volume Control Units: Test and record air flow and pressure, IN and OUT, of air volume control units, for all modes of operation.

   a. Recalibrate factory setting of air flow on units, if it differs from Contract Documents.

7. Fan and Pump Systems: For systems controlled by static pressure, verify by test and record that devices, including high-limit controls, are calibrated to perform in compliance with Contract Documents.

   a. In cooperation with the Building Automation System (BAS) Supplier, adjust the static pressure settings, no higher than necessary, to achieve design flows at the most demanding location.
   b. Furnish and coordinate system static pressure settings with the Building Automation System.

3.02 PROCEDURES

A. Where variable or fixed sheaves have been provided, determine the correct fan speed (rpm), and advise the Contractor of the correct fan speed and the required fixed-sheave diameter.

1. Size final fixed sheaves such that, upon final balancing, the balancing devices at the fan and in the highest pressure drop duct run are open.

2. Do not "choke" excess fan capacity with dampers to achieve final system balance; instead, change the speed of the fan.

3. Verify the fan speed after the Contractor's installation of fixed sheaves.

B. Permanently installed flow measuring devices may be used to accomplish balancing after accuracy has been verified with certified calibrated instruments.

1. Record and report readouts from these devices for all flows, even if not required for testing and balancing results.

C. Where variable-speed pump or fan devices have been provided, adjust and mark their controls for proper setting to produce the design water and air flow rates.

D. Protect read-out instruments from damage, and return them in good working order to the Contractor.

E. Only direct-flow measurement may be used. Do not use indirect calculations, such as a "heat balance" or "pressure drop."

+ + END OF SECTION + +

SECTION 15960 Mechanical Systems Commissioning

PART 1 - GENERAL

1.1 DESCRIPTION

A. The purpose of this section is to specify Division 15 responsibilities in the commissioning (Cx) process.

B. The systems to be commissioned are listed in Section 01810, Part 1.10.

C. Commissioning (Cx) requires the participation of Division 15 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01810. Division 15 shall be familiar with all parts of Section 01810 and the Commissioning Plan issued by the Commissioning Authority (CA) and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 RESPONSIBILITIES

A. Mechanical, Building Automation System (BAS) and Testing, Adjusting, and Balancing (TAB) Contractors.

The commissioning responsibilities applicable to each of the Mechanical, Building Automation System (BAS) and Testing, Adjusting and Balancing (TAB) Contractors of Division 15 are as follows (all references apply to commissioned equipment only):

Construction and Acceptance Phases

1. Attend a commissioning scoping meeting and additional meetings necessary to facilitate the Commissioning (Cx) process.
2. Contractors shall provide the CA with detailed cut sheets and shop drawing submittals of commissioned equipment.
3. Provide a copy of the preliminary O&M manuals and submittals of commissioned equipment, through normal channels, to the CA for review.
4. Contractors shall assist the CA in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
5. Mechanical, BAS, and TAB Contractors shall assist the CA in preparing the specific functional performance test procedures. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
6. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the pre-functional checklists for all commissioned equipment.
7. During the startup and initial checkout process, execute the mechanical-related portions of the pre-functional testing for all commissioned equipment.
8. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.
9. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.
10. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
11. Correct deficiencies (differences between specified and observed performance) as interpreted by the Engineer and CA & retest the equipment.
12. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
13. During construction, maintain as-built red-line drawings for all drawings and final as-builts for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing).
14. Provide training of the Owner's operating staff using expert qualified personnel, as specified.
15. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

B. Mechanical Contractor. The responsibilities of the HVAC Mechanical Contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Provide startup for all HVAC equipment, except for the building automation control system.
2. Assist and cooperate with the TAB contractor and CA by putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
3. Prepare a preliminary schedule for Division 15 pipe and duct system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CA. Update the schedule as appropriate.

C. BAS Contractor. The commissioning responsibilities of the BAS Contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Sequences of Operation Submittals. The BAS Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:

    a. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.
    b. All interactions and interlocks with other systems.
    c. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
    d. Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included, but will generally require additional narrative to ensure the design intent is met).
    e. Start-up sequences.
    f. Warm-up mode sequences.
2. Normal operating mode sequences.
3. Unoccupied mode sequences.
4. Shutdown sequences.
5. Capacity control sequences and equipment staging.
    a. Temperature and pressure control: setbacks, setups, resets, etc.
    b. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
    c. Effects of power or equipment failure with all standby component functions.
    d. Sequences for all alarms and emergency shut downs.
    e. Seasonal operational differences and recommendations.
    f. Initial and recommended values for all adjustable settings, set points and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
    g. Schedules, if known.

D. Control Drawings Submittal

1. The control drawings shall have a key to all abbreviations.
2. The control drawings shall contain graphic schematic depictions of the systems and each component.
3. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
4. Provide a full points list with at least the following included for each point:

    a. Controlled system
    b. Point abbreviation
    c. Point description
    d. Display unit
    e. Control point or setpoint (Yes / No)
    f. Monitoring point (Yes / No)

g. Intermediate point (Yes / No)
h. Calculated point (Yes / No)

Key:
Point Description: DB temp, airflow, etc.
Control or Setpoint: Point that controls equipment and can have its setpoint changed (OSA, SAT, etc.)
Intermediate Point: Point whose value is used to make a calculation which then controls equipment (space temperatures that are averaged to a virtual point to control reset).
Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.
Calculated Point: "Virtual" point generated from calculations of other point values.
The BAS Contractor shall keep the CA informed of all changes to this list during programming and setup.

E. The BAS Contractor shall provide an updated, as-built version of the control drawings and sequences of operation. These documents shall be included in the final controls O&M manual submittal.

F. The BAS Contractor shall assist and cooperate with the TAB contractor in the following manner:

1. Meet with the TAB contractor prior to beginning TAB and review the TAB Plan to determine the capabilities of the control system toward completing TAB. Provide the TAB any needed unique instruments for setting equipment i.e. terminal unit boxes, and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).

2. For a given area, have all required pre functional checklists, calibrations, startup and selected functional tests of the system completed and approved by the CA prior to TAB.

3. Provide a qualified technician to operate the BAS to assist the TAB contractor in performing TAB, or provide sufficient training for TAB to operate the system without assistance.

G. Control system checkout and testing by the BAS Contractor shall be performed in the following manner:

1. Startup Testing: All testing listed in this section shall be performed by the BAS Contractor and shall make up part of the necessary verification of the operating control system. This testing shall be completed before the Owner's Representative is notified that the system is ready for demonstration.
2. The BAS Contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
3. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that all terminations are tight.
4. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures per manufacturer's recommendations.
5. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
6. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The Contractor shall check all control valves and automatic dampers to ensure proper action and closure. The Contractor shall make any necessary adjustments to valve stem and damper blade travel.
7. Verify that the system operation adheres to the Sequence of Operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum Start/Stop routines.
8. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
9. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
10. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

H. The BAS Contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing, ac-

cording to the process in Section 01810. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:

1. System name.
2. List of devices.
3. Step-by-step procedures for testing each controller after installation, including:
   a. Process of verifying proper hardware and wiring installation.
   b. Process of downloading programs to local controllers and verifying that they are addressed correctly.
   c. Process of performing operational checks of each controlled component.
   d. Plan and process for calibrating valve and damper actuators and all sensors.
   e. A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
4. A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has "passed" and is operating within the contract parameters.
5. A description of the instrumentation required for testing.
6. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the CA and TAB contractor for this determination.
7. List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).

I. <u>TAB Contractor.</u> The duties of the TAB contractor, in addition to those listed in (A) are:

1. Submit the outline of the TAB Plan and approach for each system and component to the CA for review and comments. This Plan will be developed after the TAB has some familiarity with the control system. The CA shall prepare a TAB Verification Test Plan based on these documents.
2. The submitted plan will include:

   a. Certification that the TAB contractor has reviewed the construction documents and the systems with the design engineers and contractors to sufficiently understand the design intent for each system.
   b. An explanation of the intended use of the building control system. The controls contractor will comment on feasibility of the plan.
   c. All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
   d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
   e. Final test report forms to be used.
   f. Detailed step-by-step procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffuser proportioning, branch /submain proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Criteria for using air flow straighteners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the water side.
   g. List of all airflow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
   h. Details of how *total* flow will be determined (Air: sum of terminal flows via BAS calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.).
   i. The identification and types of measurement instruments to be used and their most recent calibration date.
   j. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.
   k. Confirmation that TAB understands the outside air ventilation criteria under all conditions.
   l. Details of whether and how minimum outside air cfm will be verified and set and for what level (total building, zone, etc.).
   m. Details of how building static and exhaust fan / relief damper capacity will be checked.
   n. Proposed selection points for sound measurements and sound measurement methods.
   o. Details of methods for making any specified coil or other system plant capacity measurements.

p. Details of any TAB work to be done in phases (by floor, etc.), or of areas to be built out later.
q. Details regarding specified deferred or seasonal TAB work.
r. Details of any specified false loading of systems to complete TAB work.
s. Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.
t. Details of any required differential pressure measurements and calculations.
u. Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests.
v. Plan for formal progress reports (scope and frequency).
w. Plan for formal deficiency reports (scope, frequency and distribution).

3. A running log of events and issues shall be kept by the TAB field technicians. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the CA at least once a week.
4. Communicate in writing to the BAS Contractor all setpoint and parameter changes made or problems and discrepancies identified during TAB which affect the control system setup and operation.
5. Provide a draft TAB report within two weeks of completion. A copy will be provided to the CA for his review and comments. The CA shall spot check the data contained in the draft TAB report. The report will contain a full explanation of the methodology, assumptions and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC, NEBB or ASHRAE Standard 111.
6. Provide a final TAB report for the CA with details, as in the draft.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

3.1 QUALITY CONTROL

A. See appropriate testing forms.

3.2 STARTUP

A. The HVAC Mechanical and BAS Contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 01810. Division 15 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the CA, CM, or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CA. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre-functional checklists as soon as possible.

3.3 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the BAS Contractor has completed the installation, started up the system, and performed its own tests.
2. The tests described in this section are to be performed in addition to the tests that the BAS Contractor performs as a necessary part of the installation, startup, and debugging process. The CA

will be present to observe and review these tests. The CA shall be notified at least two (2) days in advance of the start of these functional testing procedures.

3. The approved checklists and forms for the pre-functional testing shall be completed for all systems prior to the beginning of these functional tests.
4. The BAS Contractor shall provide at least two persons with two-way communication, and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose of this test is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the Contractor.
5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed. A copy of this log shall be provided to the CA at the end of this functional testing.
6. The BAS Contractor shall demonstrate compliance with Sequence of Operation through all modes of operation.
7. Demonstrate the complete operation of the Operator Interface.
8. The BAS Contractor shall demonstrate the HVAC interface to the building fire alarm system.
9. The individual HVAC equipment supplier shall commission any device supplied by others, but connected to this Building Automation System (BAS), and verification of the interface interoperability shall be by this BAS Contractor (e.g. stand alone controllers that are monitored only by the BAS system).
10. Any tests that fail to demonstrate the operation of this system shall be repeated at a later date. The BAS Contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance

1. All tests described in this specification shall have been performed to the satisfaction of both the CA and Owner prior to the acceptance of the control system as meeting the requirements of Completion. Any tests that cannot be performed due to circumstances beyond the control of the BAS Contractor may be exempt from the Completion requirements if stated in writing by the CA. Such tests shall then be performed as part of the warranty.
2. The system shall not be accepted until the functional testing forms have been completed and signed by the CA.

3.4 OPERATION AND MAINTENANCE (O&M) MANUALS

A. Division 15 shall compile and prepare documentation for all equipment and systems covered in Division 15 and deliver to the CM.

B. Division 15 shall compile and prepare documentation for all equipment and systems covered in Division 15 and deliver this documentation to the CA for inclusion in the O&M manuals, according to this section, prior to the training of owner personnel. Refer to section 01810 for specific details.

C. Special TAB Documentation Requirements. The TAB will compile and submit the following with other documentation that may be specified elsewhere in the Specifications.

1. Final report containing an explanation of the methodology, assumptions, test conditions and the results in a clear format with designations of all uncommon abbreviations and column headings.
2. The TAB shall mark on the drawings where all traverse and other critical measurements were taken and cross reference the location in the TAB report.

3.5 TRAINING OF OWNER PERSONNEL

A. Division 15 shall be responsible for necessary training for all equipment and systems covered in Division 15.

B. The CA shall be responsible for reviewing the content and adequacy of the training of the Owner's personnel for commissioned equipment. Refer to section 01810 for specific details.

END OF SECTION 15960

SECTION 15970 Plumbing Systems Commissioning

PART 1 - GENERAL

1.1 DESCRIPTION

A. The purpose of this section is to specify Division 15 responsibilities in the commissioning (Cx) process which are being directed by the Commissioning Authority (CA).

B. The list of commissioned equipment is found in Section 01810, Part 1.10.

C. Commissioning (Cx) requires the participation of Division 15 to ensure that the Domestic Hot Water systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01810. Division 15 shall be familiar with all parts of Section 01810 and the commissioning plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 RESPONSIBILITIES

A. Plumbing Contractor. The commissioning responsibilities applicable to the plumbing contractor are as follows *(all references apply to commissioned equipment only)*:

Construction and Acceptance Phases

1. Attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the Cx process.
2. Contractors shall provide normal cut sheets and shop drawing submittals to the Commissioning Agent (CA) of domestic hot water equipment.
3. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of start-up and functional testing procedures.

    a. Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedure, pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.
    b. The Commissioning Agent may request further documentation necessary for the commissioning process.
    c. This data request may be made prior to normal submittals.

4. Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CA for review and approval.
5. Contractor shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, plumbing drawings or equipment documentation is not sufficient for writing detailed testing procedures.
6. Provide assistance to the CA in preparation of the specific functional performance test procedures. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
7. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the pre-functional checklists from the CA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CA for review.
8. During the startup and initial checkout process, execute and document the plumbing-related portions of the pre-functional checklists provided by the CA for all commissioned equipment.
9. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.
10. Address current A/E punch list items before functional testing.

11. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests and adjustments.
12. Perform functional performance testing under the direction of the CA for specified equipment in Section 01810.
13. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA and retest the equipment.
14. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
15. During construction, maintain as-built red-line drawings for all drawings and final as-builts for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line as-built drawings for all drawings and final as-builts for contractor-generated coordination drawings.
16. Provide training of the Owner's operating personnel as specified.
17. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

a. Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.
b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

1.3 RELATED WORK

A. Refer to Section 01810 for a listing of all sections where commissioning requirements are found.

B. Refer to Section 01810 for systems to be commissioned and section 01810 for functional testing requirements.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Division 15 shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 01810 for additional Division 15 requirements.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. Division 15 shall provide submittal documentation relative to commissioning to the CA as requested by the CA. Refer to Section 01810 for additional Division 15 requirements.

3.2 STARTUP

A. The plumbing contractor shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in Section 01810. Division 15 has start-up responsibility and is required to complete the solar domestic hot water preheating and the domestic hot water systems and subsystems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the Commissioning Agent or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems, or sub-systems at the discretion of the CA. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre-functional checklists as soon as possible.

3.3 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Section 01810 for a list of systems to be commissioned and for a description of the process.

3.4 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Refer to Section 01810 for specific details on non-conformance issues relating to pre-functional checklists and tests.

B. Refer to Section 01810 for issues relating to functional performance tests.

3.5 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Division 15 shall compile and prepare documentation for the domestic hot water systems and deliver to the CA for inclusion in the O&M manuals.

B. The CA shall receive a preliminary copy of the O&M manuals for review.

3.6 TRAINING OF OWNER PERSONNEL

A. Division 15 shall be responsible for necessary training for all equipment and systems covered in Division 15.

B. The CA shall be responsible for reviewing the content and adequacy of the training of the Owner's personnel for commissioned equipment. Refer to section 01810 for specific details.

3.8 WRITTEN WORK PRODUCTS

A. Written work products of Contractors will consist of the startup and initial checkout plan described in Section 01810 and the filled out startup, initial checkout and pre-functional checklists.

END OF SECTION 15970

SECTION 16030 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections include the following:

1. Division 16 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical nonmetallic tubing.

C. EPDM: Ethylene-propylene-diene terpolymer rubber.

D. FMC: Flexible metal conduit.

E. IMC: Intermediate metal conduit.

F. LFMC: Liquidtight flexible metal conduit.

G. LFNC: Liquidtight flexible nonmetallic conduit.

H. NBR: Acrylonitrile-butadiene rubber.

I. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For raceway components. Include plans, elevations, sections, details, and attachments to other work.

C. Samples for Initial Selection: For wireways and surface raceways with factory-applied texture and color finishes.

D. Samples for Verification: For each type of exposed finish required for wireways and surface raceways, prepared on Samples of size indicated below.

E. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members in the paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

F. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Qualification Data: For professional engineer and testing agency.

H. Source quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Electri-Flex Co.
5. Manhattan/CDT/Cole-Flex.
6. Maverick Tube Corporation.
7. O-Z Gedney; a unit of General Signal.
8. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.1.

C. Aluminum Rigid Conduit: ANSI C80.5.

D. IMC: ANSI C80.6.

E. EMT: ANSI C80.3.

F. FMC: Zinc-coated steel.

G. LFMC: Flexible steel conduit with PVC jacket, U.L. listed for its purpose.

H. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment

in which installed.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
2. Fittings for EMT: Steel Compression type for 2" trade size and smaller, set-screw type for 2 1/2" and larger.
3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.

I. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems, Inc.
2. Arnco Corporation.
3. CANTEX Inc.
4. CertainTeed Corp.; Pipe & Plastics Group.
5. Condux International, Inc.
6. ElecSYS, Inc.
7. Electri-Flex Co.
8. Lamson & Sessions; Carlon Electrical Products.
9. Manhattan/CDT/Cole-Flex.
10. RACO; a Hubbell Company.
11. Thomas & Betts Corporation.

B. ENT: NEMA TC 13.

C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

D. LFNC: UL 1660.

E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

F. Fittings for LFNC: UL 514B.

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Arnco Corporation.
2. Endot Industries Inc.
3. IPEX Inc.
4. Lamson & Sessions; Carlon Electrical Products.

B. Description: Comply with UL 2024; flexible type, approved for plenum installation.

2.4 METAL WIREWAYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise

indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type unless otherwise noted.

E. Finish: Manufacturer's standard enamel finish.

2.5 NONMETALLIC WIREWAYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hoffman.
2. Lamson & Sessions; Carlon Electrical Products.

B. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.6 SURFACE RACEWAYS

A. Surface Metal Raceways: Aluminum with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Wiremold Company (The);
b. Hubbell
c. Monosystems

2.7 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
3. Erickson Electrical Equipment Company.
4. Hoffman.
5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
6. O-Z/Gedney; a unit of General Signal.
7. RACO; a Hubbell Company.
8. Robroy Industries, Inc.; Enclosure Division.
9. Scott Fetzer Co.; Adalet Division.
10. Spring City Electrical Manufacturing Company.
11. Thomas & Betts Corporation.
12. Walker Systems, Inc.; Wiremold Company (The).
13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloyType FD, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

E. Metal Floor Boxes: [Cast metal] [Sheet metal] [Cast or sheet metal], [fully adjustable] [semi-adjustable], rectangular.

F. Nonmetallic Floor Boxes: Nonadjustable, round.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast ironwith gasketed cover.

I. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

J. Cabinets:

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit
2. Concealed Conduit, Aboveground: EMT
3. Underground Conduit: RNC, Type EPC-40 PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:

a. Loading dock.
b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
c. Mechanical rooms.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: IMC.
7. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental

Air: EMT.

8. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: EMT.
9. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: EMT.
10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch- trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

E. Do not install aluminum conduits in contact with concrete.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 16 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Change from ENT to RNC, , rigid steel conduit, or IMC before rising above the floor.

I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:

1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet.

1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:

a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F > temperature change.
d. Attics: 135 deg F temperature change.

2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change.
3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

O. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

P. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

Q. Set metal floor boxes level and flush with finished floor surface.

R. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 02 Section "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Division 02 Section "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of

conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 02 Section "Earth Moving."

4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
   b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

5. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits, placing them 24 inches o.c. Align planks along the width and along the centerline of conduit.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install handholes and boxes with bottom below the frost line, 36” below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.6 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

+ + END OF SECTION + +

SECTION 16051 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Electrical equipment coordination and installation.

2. Sleeves for raceways and cables.

3. Sleeve seals.

4. Grout.

5. Common electrical installation requirements.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

1.5 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.

2. To provide for ease of disconnecting the equipment with minimum interference to other installations.

3. To allow right of way for piping and conduit installed at required slope.

4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions:

1. Ambient temperature: Not less than minus 22 deg. F and not exceeding 104 deg. F.

2. Altitude: Not exceeding 6600 feet.

B. Interruption of Existing Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager no fewer than 14 days in advance of proposed interruption of electric service.

2. Indicate method of providing temporary electric service.

3. Do not proceed with interruption of electric service without Construction Manger's written permission.

4. Comply with NFPA 70E.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

3. Pressure Plates: Carbon steel Include two for each sealing element.

4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.4 THROUGH WALL / THROUGH FLOOR FIRE STOP FITTING

A. Description: Firestop device for use in through-penetration firestop systems shall be classified for use in one, two, three and four-hour rated gypsum, concrete floors having a minimum 4 1/2" thick reinforced lightweight or normal weight.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Wiremold FS Series (Basis of Design).
b. Hilti
c. 3M

2. Listings: Under writers Laboratories, Inc., to UL 1479 (ASTM E814).

B. Product Materials

1. Box: 17 gauge, G90 steel

2. Intumescent Block: Shall be constructed of a graphite base material with expansion starting at 375 degrees F and an unrestrained expansion between six and twelve times. The intumescent block shall be securely held by the box in order to prevent tampering and damage during installation.

3. Adjustable Doors: Adjustable to prevent materials from penetrating the device if the device is empty or completely full. The doors shall be constructed of 16 gauge G90 steel with No. 10-32 screws to adjust the opening size.

4. Heat Shield: Where required for retrofit applications where a conduit extends more than 7/8" out of the wall, the manufacturer's recommended heat shield shall be used in order to maintain UL fire classifications. In cases where the heat shield is used, the fire stop device shall be installed onto the heat shield.

5. Split Conduit and Wall Plate: Where required for retrofit applications without a conduit, the split conduit assembly shall be used to protect the existing cables. After installing the split conduit within the wall, the firestop wall plate shall be installed to cover any irregularity in the hole, and the firestop device is then installed onto the conduit.

6. Finish: the firestop device shall be powder-coated red.

7. Sizes: the device shall be matched to the required trade size of conduit, between 2" and 4", EMT.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping." Firestop assemblies shall carry the same (or greater) fire rating as the fire wall, floor, or ceiling assembly that is being penetrated.

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 THROUGH WALL / THROUGH FROM FIRE STOP FITTING

A. Adjustable through wall or through floor fittings shall be installed wherever cables pass through an opening in a rated structure. This shall include all data and telephone cables, MC cables, and any other cables which are not enclosed in conduit for the entire length of their run.

B. All fire stop fittings shall be installed in accordance with the UL Fire resistance Directory, along with all applicable codes and standards for general building, electrical and firestopping installation practices.

3.5 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

+ + END OF SECTION + +

16055 - POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

C. Qualification Data: For coordination-study specialist: Study shall be performed, signed, and sealed by a Professional Engineer licensed in the State of the project site.

D. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals shall be in digital and printed form.

1. Coordination-study input data, including completed computer program input data sheets.

2. Study and Equipment Evaluation Reports.

3. Coordination-Study Report.

4. Load flow and voltage drop analysis.

5. Power factor correction study.

6. Harmonic analysis.

7. Flash hazard analysis.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:

1. SKM Systems Analysis, Inc.

2. EDSA Micro Corporation.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

2. Study shall be performed, submitted, and approved by engineer prior to submission of related equipment shop drawings so as to implement any equipment modifications as a result of the study findings, at no cost or schedule impact.

3.2 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 16 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective

device submittals, input and output data, and recommended device settings.

2. Impedance of utility service entrance.

3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:

   a. Utility maximum and minimum contributions.
   b. Utility maximum and minimum X/R ratios.
   c. Circuit-breaker and fuse-current ratings and types.
   d. Relays and associated power and current transformer ratings and ratios.
   e. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
   f. Generator kilovolt amperes, size, voltage, and source impedance.
   g. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
   h. Busway ampacity and impedance.
   i. Motor horsepower (nameplate and duty point) and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

   a. Utility contribution.
   b. Special load considerations, including starting inrush currents and frequent starting and stopping.
   c. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
   d. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
   e. Generator thermal-damage curve.
   f. Ratings, types, and settings of utility company's overcurrent protective devices.
   g. Special overcurrent protective device settings or types stipulated by utility company.
   h. Time-current-characteristic curves of devices indicated to be coordinated.
   i. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
   j. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
   k. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.3 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:

   1. Switchgear and switchboard bus.

   2. Medium-voltage controller.

   3. Motor-control center.

   4. Distribution panelboard.

   5. Branch circuit panelboard.

6. Automatic transfer switch.

7. All other devices which carry a KAIC or KAWC rating including but not limited to VFD's, disconnect switches, buses, breakers, fuses, etc.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 141 IEEE 241 and IEEE 242.

1. Transformers:

a. ANSI C57.12.10.
b. ANSI C57.12.22.
c. ANSI C57.12.40.
d. IEEE C57.12.00.
e. IEEE C57.96.

2. Medium-Voltage Circuit Breakers: IEEE C37.010.

3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.

4. Low-Voltage Fuses: IEEE C37.46.

5. Available short circuit current at utility source and the generator shall e obtained from the utility and generator manufacturers data (via the Contractor) upon assignments of normal and emergency power source breakers.

6. Appropriate motor short-circuit contribution shall be included at the appropriate locations in the system so that the computer calculated values represent the highest short-circuit current the equipment will be subjected to under fault conditions.

E. Study Report:

1. A tabular computer printout shall be included which lists the calculated short-circuit currents, X/R ratios, equipment short-circuit interrupting or withstand current ratings, and notes regarding the adequacy or inadequacy of the equipment.

2. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.

3. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium-voltage breakers as needed to set relays and assess the sensitivity of overcurrent relays.

F. Equipment Evaluation Report:

1. The study shall include a computer printout of input circuit data including conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other circuit information as related to the short-circuit calculations.

2. Include a bus-to-bus computer printout identifying the maximum available short-circuit current in rms symmetrical amperes and the X/R ratio of the fault current for each bus-to-bus calculation.

3. The system one-line diagram shall be computer generated and will clearly identify individual equipment buses, bus numbers used in the short-circuit analysis, cable and bus connections between the equipment, calculated maximum short-circuit current at each bus location and other information pertinent to the computer analysis.

4. A comprehensive discussion section evaluating the adequacy or inadequacy of the equipment must be provided and include recommendations as appropriate for improvements to the system.

5. Any changes to engineering documents, as a result of short circuit analysis, shall not result in any additional cost to the Owner.

6. The contractor shall be responsible for supplying conductor information (lengths, types, number per phase, etc.) in a timely manner to allow the short-circuit analysis to be completed prior to final installation.

7. Any inadequacies shall be called to the attention of the Construction Manger and recommendations made for improvements as soon as any they are identified. Contractor shall immediately notify engineer and coordinate all remedies with manufacturers/suppliers.

8. Provide two (2) bound copies of the completed short-circuit analysis to the Construction Manger, Architect/ Engineer.

9. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

10. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.

11. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

3.4 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.

2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuit currents.

3. Calculate the maximum and minimum ground-fault currents.

B. Comply with IEEE 141, IEEE 241, and IEEE 242 recommendations for fault currents and time intervals.

C. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

a. Inrush current when first energized.
b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
c. Permissible transformer overloads according to IEEE C57.96 if required by

unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

D. Motors served by voltages more than 600 V shall be protected according to IEEE 620.

E. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

F. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:

a. Device tag.
b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
d. Fuse-current rating and type.
e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

a. Device tag.
b. Voltage and current ratio for curves.
c. Three-phase and single-phase damage points for each transformer.
d. No damage, melting, and clearing curves for fuses.
e. Cable damage curves.
f. Transformer inrush points.
g. Maximum fault-current cutoff point.

3. The time-current coordination analysis shall be performed with the aid of a digital computer and will include the determination of settings, ratings, or types for the overcurrent protective devices supplied.

4. Where necessary, an appropriate compromise shall be made between system protection and service continuity with system protection and service continuity considered to be of equal importance.

5. A sufficient number of computer generated log-log plots shall be provided to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices and other pertinent system parameters.

6. Computer printouts shall accompany the log-log plots and will contain descriptions for each of the devices shown, settings of the adjustable devices, the short-circuit current availability at the device location when known, and device identification numbers to aid in locating the devices on the log-log plots and the system one-line diagram.

7. The study shall include a separate, tabular computer printout containing the suggested

device settings of all adjustable overcurrent protective devices, the equipment where the device is located, the device number corresponding to the device on the system one-line diagram, and the number of the time-current log-log graphs where they are illustrated.

8. A computer generated system one-line diagram shall be provided which clearly identifies individual equipment buses, bus numbers, device identification numbers and the maximum available short-circuit current at each bus when known.

9. A discussion section which evaluates the degree of system protection and service continuity with overcurrent devices, along with recommendations as required for increasing system protection or device coordination. Submit curves and study as a shop drawing for approval.

10. Significant deficiencies in protection and/or coordination shall be called to the attention of the Construction Manager and recommendations made for improvements as soon as any they are identified.

11. Factory set all relays, breaker trips, and select proper HV fuses which coordinate with transformer in rush current and circuit breakers.

12. Include in study the emergency generator main breaker and associated standby power distribution system as well as the normal source breakers feeding this system.

13. Preliminary coordination study shall be made by Vendor prior to submission of shop drawings.

14. Sizes of fuses, breaker interrupting rating, bus bracing shall be minimum as shown on drawing. Exact sizing shall be according to coordination study.

15. Any changes to engineering documents, as a result of coordination study, shall not result in any additional cost to the Owner.

16. The Vendor shall contact the Engineer immediately if any delay occurs due to the lack of required information he needs to complete this study.

17. If any delay occurs due to time required for manufacturing of the indoor switchgear submit shop drawings on this switchgear prior to coordination study shop drawings.

18. Present organized time-current analysis of each protective device in series from main circuit breaker in branch circuit panelboard back to generator breaker and existing house normal power protective devices.

19. Provide two (2) bound copies of the completed protective device time-current coordination analysis to the Construction Manager, Architect/Engineer.

G. Completed data sheets for setting of overcurrent protective devices.

H. Load Flow And Voltage Drop Analysis

1. The Load Flow and Voltage Drop Analysis shall be made using a digital computer and include calculations of power flow in all three-phase branch and feeder circuits, calculated voltages at each bus and voltage drops of each feeder.

2. The analysis shall provide the calculated maximum values of kVA, kW, kVAR, power factor, and amperes for each power circuit.

3. The calculated power losses in each branch and total system losses shall be provided.

4. A computer printout listing all cables, transformers, loads, and other circuit data shall be included.

5. Provide tabular bus-to-bus computer printouts listing the calculated values.

6. The analysis shall include a computer generated system one-line diagram clearly identifying individual equipment buses, bus numbers, cable and bus connections, power flow throughout the system, and other information related to the analysis.

7. A discussion section evaluating the loading and voltage levels for the system shall be provided and recommendations included as appropriate to improve system operation.

8. Significant deficiencies in loading or voltage levels shall be called to attention of the Construction Manager and recommendations made for improvements as soon as they are identified.

9. Provide two (2) bound copies of the completed Load Flow and Voltage Drop Analysis to the Owner, Construction Manager, and Architect/Engineer.

I. Power Factor Correction Study

1. A Power Factor Correction Study shall be performed to determine the appropriate level of compensation needed to achieve the desired power factor.

2. Impacts on harmonic and transient concerns shall be evaluated in order to determine the optimum size and configuration of the equipment.

3. The study shall make appropriate recommendations in order to provide proper operation of the electrical system.

4. The study shall be based on load data collected from existing single line diagrams and vendor shop submittals in order to characterize the power factor of the system over a period of time and under varying load conditions.

5. System loading tables shall be provided which include power factor data and estimated levels of power factor compensation provided.

6. Evaluation of system operation using the estimated levels of compensation will be provided with consideration to harmonic and transient concerns.

7. Final levels of compensation will be determined and used as the basecase condition for the harmonic and transient studies.

8. All conclusions, recommendations, and equipment specifications as a result of the Power Factor Correction Study will be summarized in the final report.

9. Provide two (2) bound copies of the completed Power Factor Correction Study will be provided to the Construction Manager and Architect/Engineer.

J. Harmonic Analysis Study

1. A Harmonic Analysis Study shall be made prior to construction, to determine the levels of harmonic voltages and currents in the system.

2. The type and level of compensation needed to achieve the desired power factor and acceptable levels of harmonics shall be considered jointly with Owner and Engineer. Proposed mitigation solutions shall be implemented to comply with IEEE519 for both the utility and generator as the point of common coupling under normal and emergency power

scenarios.

3. Transient concerns shall be evaluated in order to determine the optimum equipment size, location in the system, and configuration.

4. The study shall make appropriate recommendations in order to provide proper protection and operation of the electrical system. An allowance for such proposed harmonic mitigation equipment shall be included with Contractors bid.

5. The study will shall be based on load data collected from existing single line diagrams and vendor shop submittals in order to characterize the power factor of the system over a period of time and under varying load conditions.

6. Harmonic measurements will be performed in order to provide nonlinear load (eg. dc drive) characteristics, voltage distortion levels, and model verification. The measurements will be conducted over a 1-5 day period.

7. Harmonic source models will be developed for each nonlinear load (drive, etc.) type. The load characteristics shall be approximated based on the loads indicated on the project drawings.

8. Frequency scan cases (impedance vs frequency) will be completed in order to determine the system frequency response characteristic for various system conditions.

9. If required, the application of harmonic filters will be evaluated to determine the optimum filter size and configurations.

10. Computer simulations shall be performed to determine the system harmonic voltage and current levels and voltage distortion levels (and compared with measured values to determine the effect of various system conditions).

11. If required, harmonic filter specifications shall be developed with consideration to cost, filtering options, and effectiveness of harmonic filters.

12. Provide two (2) bound copies of the completed Harmonic Analysis Study to the Construction Manager and Architect/Engineer.

K. Flash Hazards Analysis Studies

1. Scope of Study: Using the minimum, maximum, and 5 equally divided segments between the maximum and minimum short circuit currents and X/R ratios determine the short-circuit current available at the designated point of contact for each connected scenario and perform the following to provide adequate protection:

   a. Calculate the flash protection boundary.
   b. Calculate the arc-flash incident energy.
   c. Confirm the required labeling.
   d. Confirm the required personal protective equipment with arc rating to provide adequate protection for personnel working on or near energized conductors or components.
   e. Furnish and install labeling/signage identifying all of the above.

2. Provide red and white enameled warning signs and attach to equipment as required by code.

   a. As a minimum, include the following:

      1) Incident energy in "cal/cm squared."

2) Flash Hazard Boundary.
3) Limited Approach.
4) Restricted Approach.
5) Prohibited Approach.
6) Voltage Level.
7) Short Circuit Values.

3. Procedure:

a. The actual short-circuit available current is to be determined from a recent short-circuit study. The flash protection boundary will be calculated in accordance with NFPA 70E.
b. The arc-flash incident energy is to be calculated using the equations in NFPA 70E.

+ + END OF SECTION + +

SECTION 16060 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes: Grounding systems and equipment.

B. Section includes grounding systems and equipment, plus the following special applications:

1. Overhead-line grounding.
2. Underground distribution grounding.
3. Ground bonding common with lightning protection system.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.
5. Grounding for sensitive electronic equipment.

C. Qualification Data: For qualified testing agency and testing agency's field supervisor.

D. Field quality-control reports.

E. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Instructions for periodic testing and inspection of grounding features at test wells based on NFPA 70B
   a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
   b. Include recommended testing intervals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.

2. Stranded Conductors: ASTM B 8.

3. Tinned Conductors: ASTM B 33.

4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.

5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.

6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.2 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad 3/4 inch by 10 feet in diameter.

B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.

1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches long.

2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum.

1. Bury at least 24 inches below grade.

2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.

2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.

3. Connections to Ground Rods at Test Wells: Bolted connectors.

4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.3 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

E. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.

1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.

3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

F. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground

directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 16 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.

1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure

ground rod and to each indicated item, extending around the perimeter of building

1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.

2. Bury ground ring not less than 24 inches from building's foundation.

J. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.

2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.5 LABELING

A. Comply with requirements in Division 16 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.

1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells. Make tests at ground rods before any conductors are connected.

a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of

reducing natural ground resistance.

b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.

2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.

3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.

4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).

5. Substations and Pad-Mounted Equipment: 5 ohms.

6. Manhole Grounds: 10 ohms.

H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

+ + END OF SECTION + +

SECTION 16070 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This section describes the vibration control and seismic restraint systems for electrical equipment, conduits, and wiring.

B. This Section describes seismic restraint equipment for electrical equipment.

C. This Section includes the following:

1. Isolation pads.
2. Spring isolators.
3. Restrained spring isolators.
4. Channel support systems.
5. Restraint cables.
6. Hanger rod stiffeners.
7. Anchorage bushings and washers.

D. Related Sections include the following:

1. Division 16 Section "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.2 REFERENCE CODES AND STANDARDS

A. Comply with the following in accordance with Division 1.

1. 2009 International Building Code
2. ASCE 7 Minimum Design Loads for Building and Other Structures, Chapter 13.
3. National Fire Protection Association (NFPA)

1.3 PERFORMANCE CRITERIA

A. SEISMIC RESTRAINT DESIGN CRITERIA

1. General: Design seismic restraints for indicated horizontal and vertical forces acting simultaneously. Connections shall be positive anchorage without consideration of frictional resistance.

1.4 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: D

2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.

a. Component Importance Factor: Per ASCE 7.05.
b. Component Response Modification Factor: Per ASCE 7.05.
c. Component Amplification Factor: Per ASCE 7.05.

3. Design Spectral Response Coefficient at Short Periods (0.2 Second): <S_{DS} = 0.183>.

4. Design Spectral Response Coefficient at 1.0-Second Period: <S_{D1} = 0.050>.

5. Seismic Design Category: <B>.

1.6 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.

2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Engineer's insurance certificate, indicating liability insurance for seismic design errors and omissions.

2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.

a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.

3. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.

4. Field-fabricated supports.

5. Seismic-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacing's. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

D. Welding certificates.

E. Qualification Data: For professional engineer and testing agency.

F. Field quality-control test reports.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

D. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Amber/Booth Company, Inc.

2. Mason Industries.

3. Vibration Mountings & Controls, Inc. (VMC).

a. VMC is the basis of design. All part number references in this specification refer to VMC part numbers.

B. Double Deflection Mounting: VMC East Series “RD” or approved equal.

1. Construction: Shall be molded with ribbed faces on the top and bottom for applications

that do not require bolting to the floor or equipment. Bolt holes shall be provided on the bottom plate, and a tapped hole son the top for applications requiring a positive tie-down.

2. Resilient Material: Oil- and water-resistant neoprene.

3. Deflection: 0.25” when floor span is 30’ or less, 0.5” when floor span exceeds 30’.

4. Uses: Floor mounted equipment that requires vibration isolation, and all transformers (non-seismically braced).

C. Spring Isolators: Freestanding, laterally stable, open-spring isolators. VMC East Series “AC” or approved equal.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Lateral Stiffness: More than 80 percent of rated vertical stiffness, without housing, snubbers or guides.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch-thick, ribbed neoprene isolator pad attached between the baseplate and support. Baseplates shall limit floor load to 500 psig (3447 kPa).

6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

7. Deflection: 0.75” for floor span of 25’ or less, 1.0” for 30’ span or 1.5” for 40’ and greater floor span.

8. Uses: Standby generators.

2.2 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Amber/Booth Company, Inc.

2. Cooper B-Line, Inc.; a division of Cooper Industries.

3. Hilti Inc.

4. Mason Industries.

5. Vibration Mounting and Control, Inc.

B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

D. Restraint Cables: ASTM A 603 galvanized -steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Do not weld stiffeners to rods.

F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.3 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.

2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.

3. Baked enamel or powder coat for metal components on isolators for interior use.

4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install restrained isolators on electrical equipment.

2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125-inch.

3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members. Do not anchor to roof deck.

D. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.

6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.

3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.

5. Test to 90 percent of rated proof load of device.

6. Measure isolator restraint clearance.

7. Measure isolator deflection.

8. Verify snubber minimum clearances.

9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.7 ELECTRICAL VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

A. Supported Equipment: Transformers.

1. Equipment Location: As shown on plans

2. Isolator Type: Seismic Elastometer Mountings, VMC Series “RSM” or approved equal.

3. Component Importance Factor: 1.5.

4. Component Response Modification Factor: Per ASCE 7.05.

5. Component Amplification Factor: Per ASCE 7.05.

6. Deflection: 0.25” {or 0.5” for 40’ or greater span].

B. Suspended Equipment: Conduit, Cable Trays, Ceiling Suspended Transformers (regardless of importance factor of transformer).

1. Equipment Location: As shown on plans.

2. Isolator Type: Cable Restraints, VMC Series SCR, or approved equal.

3. Component Importance Factor: 1.5 (except transformers).

4. Component Response Modification Factor: Per ASCE 7.05.

5. Component Amplification Factor: Per ASCE 7.05.

6. Construction: Steel aircraft cable restraints, designed to limit motion on suspended isolated equipment, piping or ducting. Cable shall be 7 x 19 galvanized or stainless steel aircraft cable conforming to FED-STD-RR-W-410D.

7. Installation: Cables shall be installed with enough slack to engage only when 0.25” movement occurs. On suspended equipment, cables shall be installed in sets of four, located at 45 degree angles to all three axes. Where required ad pipe hangers, cables are placed, two at each location, alternating orientation at successive locations.

+ +END OF SECTION + +

SECTION 16073 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

B. Related Sections include the following:

1. Division 16 Section "Vibration And Seismic Controls For Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems.

2. Nonmetallic slotted support systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.

2. Steel slotted channel systems. Include Product Data for components.

3. Nonmetallic slotted channel systems. Include Product Data for components.

4. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.
g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.

4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

5. Channel Dimensions: Selected for applicable load criteria.

B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch-diameter holes at a maximum of 8 inches o.c., in at least 1 surface.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. Fabco Plastics Wholesale Limited.

d. Seasafe, Inc.

2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.

3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.

4. Rated Strength: Selected to suit applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Hilti Inc.
2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
3) MKT Fastening, LLC.
4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Cooper B-Line, Inc.; a division of Cooper Industries.
2) Empire Tool and Manufacturing Co., Inc.
3) Hilti Inc.
4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.

5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

6. Toggle Bolts: All-steel springhead type.

7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. MC Cable support Methods: In addition to methods described in NECA 1 and NFPA70, MC cable shall be supported and secured by independent means to structure using MC cable anchors, wire supports, and clips.

D. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

E. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.

2. To New Concrete: Bolt to concrete inserts.

3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.

4. To Existing Concrete: Expansion anchor fasteners.

5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock

washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.

7. To Light Steel: Sheet metal screws.

8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

F. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

2. Install anchor bolts to elevations required for proper attachment to supported equipment.

3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

+ +END OF SECTION + +

SECTION 16075 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:

1. White letters on a black field.

2. Legend: Indicate voltage and system or service type.

C. Colors for Raceways Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.

2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch-high letters on 20-inch centers.

D. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

E. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- wide black stripes on 10-inch centers diagonally over orange background that extends full length of raceway or duct and is 12 inches wide. Stop stripes at legends.

F. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Colors for Raceways Carrying Circuits at 600 V and Less:

1. White letters on a black field.

2. Legend: Indicate voltage and system or service type.

C. Colors for Raceways Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.

2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch-high letters on 20-inch centers.

D. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.5 FLOOR MARKING TAPE

A. 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.

2. Printing on tape shall be permanent and shall not be damaged by burial operations.

3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.

2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.

3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

C. Tag: Type I

1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.

2. Overall Thickness: 5 mils.

3. Foil Core Thickness: 0.35 mil.

4. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).

5. 3-Inch Tensile According to ASTM D 882: 70 lbf (311.3 N), and 4600 psi (31.7 MPa).

2.7 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.

2. 1/4-inch grommets in corners for mounting.

3. Nominal size, 7 by 10 inches.

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.

2. 1/4-inch grommets in corners for mounting.

3. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.8 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch-thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.

2. Punched or drilled for mechanical fasteners.

3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.9 EQUIPMENT IDENTIFICATION LABELS

A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

1. For Normal Systems: Black with White lettering.

2. For Normal/Emergency systems: Red with White lettering.

3. For Emergency Only Systems: Red with Yellow lettering.

4. UPS Systems: Blue with White lettering.

2.10 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.

2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.

3. Temperature Range: Minus 40 to plus 185 deg F.

4. Color: Black except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.

2. Tensile Strength at 73 deg F, According to ASTM D 638: 12,000 psi.

3. Temperature Range: Minus 40 to plus 185 deg F.

4. Color: Black.

C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.

1. Minimum Width: 3/16 inch.

2. Tensile Strength at 73 deg F, According to ASTM D 638: 7000 psi.

3. UL 94 Flame Rating: 94V-0.

4. Temperature Range: Minus 50 to plus 284 deg F.

5. Color: Black.

D. Apply cable ties suitable for the conditions of installation. Refer to Part 3.

2.11 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

G. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.

2. In Spaces Handling Environmental Air: Plenum rated.

I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

J. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch-wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch-high black letters on 20-inch centers. Stop stripes at legends. Apply to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.

2. Wall surfaces directly external to raceways concealed within wall.

3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl labels. Install labels at 10-foot maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and equal to or greater than 120 V to ground: Identify with self-adhesive vinyl label. Install labels at 10-foot maximum intervals.

D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage, using colors as defined in Part 2 “Equipment Identification Labels.” System legends shall be as follows:

1. Emergency Power.

2. Power.

3. UPS.

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.

b. Colors for 208/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.
4) Neutral: White.

c. Colors for 480/277-V Circuits:

1) Phase A: Brown.
2) Phase B: Orange.
3) Phase C: Yellow.
4) Neutral: Gray

d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

F. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use wraparound vinyl tape.

G. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

H. Conductors to Be Extended in the Future: Attach marker tapes to conductors and list source.

I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

J. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.

2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

K. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

L. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels

1. Comply with 29 CFR 1910.145.

2. Identify system voltage with black letters on an orange background.

3. Apply to exterior of door, cover, or other access.

4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:

a. Power transfer switches.
b. Controls with external control power connections.

M. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

N. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer load shedding and all emergency operations and equipment.

O. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch high letters on 1-1/2-inch high label; where two lines of text are required, use labels 2 inches high.
b. Outdoor Equipment: Engraved, laminated acrylic or melamine label Stenciled legend 4 inches high.
c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved , laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchgear. (All cells)
e. Switchboards. (All compartments)
f. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
g. Substations.
h. Emergency system boxes and enclosures.
i. Enclosed switches.
j. Enclosed circuit breakers.
k. Enclosed controllers.
l. Variable-speed controllers.
m. Push-button stations.
n. Power transfer equipment.
o. Contactors.
p. Remote-controlled switches, dimmer modules, and control devices.
q. Battery-inverter units.
r. Battery racks.
s. Power-generating units.
t. Monitoring and control equipment.
u. UPS equipment.

+ + END OF SECTION + +

SECTION 16120 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.

2. Connectors, splices, and terminations rated 600 V and less.

3. Sleeves and sleeve seals for cables.

B. Related Sections include the following:

1. Division 16 Section "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.

2. Division 16 Section "Undercarpet Electrical Power Cables" for flat cables for undercarpet installations.

3. Division 27 Section "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Qualification Data: For testing agency.

C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70,

Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Alcan Products Corporation; Alcan Cable Division.

2. American Insulated Wire Corp.; a Leviton Company.

3. General Cable Corporation.

4. Senator Wire & Cable Company.

5. Southwire Company.

B. Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THW THHN-THWN XHHW and SO.

D. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC, Mineral-insulated metal-sheathed cable, Type MI, and Type SO with ground wire.

2.2 CONNECTORS AND SPLICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems, Inc.

2. Hubbell Power Systems, Inc.

3. O-Z/Gedney; EGS Electrical Group LLC.

4. 3M; Electrical Products Division.

5. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Feeders: Aluminum. Stranded for #4 and larger

C. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, multi conductor MC cable

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway Branch Circuits in Cable Tray: Metal-clad cable, Type MC. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

H. Class 1 Control Circuits: Type THHN-THWN, in raceway.

I. Class 2 Control Circuits: Power-limited cable, concealed in building finishes.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 16 Section "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 16 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

+ + END OF SECTION + +

SECTION 16124 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.4 SUBMITTALS

A. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.

B. Samples: 16-inch lengths of each type of cable indicated.

C. Qualification Data: For Installer and testing agency.

D. Material Certificates: For each cable and accessory type, signed by manufacturers.

E. Source quality-control test reports.

F. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with IEEE C2 and NFPA 70.

1.6 PROJECT CONDITIONS

A. Refer to Section 260500 "Common Work Results for Electrical" for Project Conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cables:

a. General Cable Technologies Corporation.
b. Kerite Co. (The); Hubbell Incorporated.
c. Okonite Company (The).
d. Prysmian.
e. Southwire Company.

2. Cable Splicing and Terminating Products and Accessories:

a. Engineered Products Company.
b. G&W Electric Company.
c. MPHusky.
d. Raychem Corp.; Telephone Energy and Industrial Division; Tyco International Ltd.
e. RTE Components; Cooper Power Systems, Inc.
f. Scott Fetzer Co. (The); Adalet.
g. Thomas & Betts Corporation/Elastimold.
h. 3M; Electrical Products Division.

2.2 CABLES

A. Cable Type: MV105.

B. Comply with UL 1072, AEIC CS 8, ICEA S-93-639, and ICEA S-97-682

C. Conductor: Copper.

D. Conductor Stranding: Compact round, concentric lay, Class B)

E. Conductor Insulation: Ethylene-propylene rubber.

1. Voltage Rating: 15 kV.

2. Insulation Thickness: 133 percent insulation level.

F. Shielding: Copper tape , helically applied over semiconducting insulation shield.

G. Cable Jacket: PVC.

2.3 SPLICE KITS

A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.

B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete

splice, with detailed instructions.

1. Combination tape and cold-shrink-rubber sleeve kit with rejacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.

2. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.

3. Premolded, cold-shrink-rubber, in-line splicing kit.

4. Premolded EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.

2.4 SOLID TERMINATIONS

A. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.

2. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.

3. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.

4. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.

5. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

6. Class 3 Terminations: Kit with stress cone and compression-type connector.

2.5 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

C. Load-Break Cable Terminators: Elbow-type units with 200-A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

D. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.

2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.

3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.

4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

2.6 ARC-PROOFING MATERIALS

A. Tape for First Course on Metal Objects: 10-mil-thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3-inch thick, compatible with cable jacket.

C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2-inch wide.

2.7 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-94-649 before shipping.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.

2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

C. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

D. Support cables according to Division 16 Section "Common Work Results for Electrical."

E. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.

F. Install cable splices at pull points and elsewhere as indicated; use standard kits.

G. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.

H. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.

2. Portable Feed-Through Accessory: Three.

3. Standoff Insulator: Three.

I. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.

2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.

3. Smooth surface contours with electrical insulation putty.

4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.

5. Band arc-proofing tape with 1-inch- (25-mm-) wide bands of half-lapped, adhesive, glass-cloth tape 2 inches (50 mm) o.c.

J. Seal around cables passing through fire-rated elements according to Division 07 Section "Penetration Firestopping." Firestop assemblies shall carry the same (or greater) fire rating as the rated wall, floor, or ceiling assembly that is being penetrated.

K. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

L. Identify cables according to Division 16 Section "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Testing: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.

+ + END OF SECTION + +

SECTION 16140 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Receptacles with integral surge suppression units.
4. Wall-box motion sensors.
5. Isolated-ground receptacles.
6. Hospital-grade receptacles.
7. Snap switches and wall-box dimmers.
8. Solid-state fan speed controls.
9. Wall-switch and exterior occupancy sensors.
10. Cord and plug sets.
11. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

B. Related Sections include the following:

1. Division 17 Section "Communications Horizontal Cabling" for workstation outlets.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1. Cord and Plug Sets: Match equipment requirements.

1.7 EXTRA MATERIALS

A. Furnish extra materials described in subparagraphs below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Floor Service Outlet Assemblies: One for every 10, but no fewer than one.

2. Poke-Through, Fire-Rated Closure Plugs: One for every ten floor service outlets installed, but no fewer than two

3. TVSS Receptacles: One for every 10 of each type installed, but no fewer than two of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).

2. Leviton Mfg. Company Inc. (Leviton).

3. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with Fed. Spec W-C-596D as verified by UL and NEMA tests WD-1, 3.02 through 3.10 and UL498, configuration NEMA 5-20R.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; HBL5351 (single), CR5352 (duplex).
b. Leviton; 5891 (single), 5352 (duplex).
c. Pass & Seymour; 5381 (single), 5352 (duplex).

B. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with all requirements for convenience receptacles, above.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; CR 5253IG.
b. Leviton; 5362-IG.
c. Pass & Seymour; IG6300.

2. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

C. All receptacles shall be back and side wired. Use of pre-wired pigtail receptacles that accommodate Fed Spec receptacles and GFCI's shall be an acceptable substitution. All pre-wired receptacles shall have a crimped and welded right angle application within the connector.

2.3 GFCI RECEPTACLES

A. General Description: Straight blade, feed -through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, Fed. Spec WB 896, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Pass & Seymour; 2084.
b. Hubbell GF 8300.

2.4 TVSS RECEPTACLES

A. General Description: Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 1449, with integral TVSS in line to ground, line to neutral, and neutral to ground.

1. TVSS Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 volts and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.

2. Active TVSS Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."

B. Duplex TVSS Convenience Receptacles:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; HBL5362SA.
b. Leviton; 5380.
c. Pass and Seymour; IG 5362 ISP

2. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R.

2.5 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; HBL2310.
b. Leviton; 2310.
c. Pass & Seymour; L520-R.

B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; IG2310.
b. Leviton; 2310-IG.

2. Description: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.6 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.

2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

B. Pilot Light Switches, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; HPL1221PL for 120 V and 277 V.
b. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.
c. Pass & Seymour; PS20AC1-PLR for 120 V.

2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

C. Key-Operated Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Cooper; 2221L.
b. Hubbell; HBL1221L.
c. Leviton; 1221-2L.
d. Pass & Seymour; PS20AC1-L.

2. Description: Single pole, with factory-supplied key in lieu of switch handle.

D. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; HBL1557.
b. Leviton; 1257.
c. Pass & Seymour; 1251.

2.7 WALL-BOX DIMMERS

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Lutron
b. Leviton

2. 600 W; dimmers shall require no derating when ganged with other devices.

D. Electronic Low Voltage Halogen dimmers: 120 V or 277V; control shall follow revere phase dimming curve. On-off switch positions shall bypass dimmer module.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Lutron
b. Leviton

2. 300 W; dimmers shall require no derating when ganged with other devices.

E. 0-10V Dimmer Switches: 120V or 277V with 0-10V control Modular; compatible with dimmer ballasts; Linear consistent dimming with sinking controls with low end not greater than 1 percent of full brightness.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Lutron

b. Leviton

2.8 OCCUPANCY SENSORS

A. Wall-Switch Sensors:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Lutron; Maestro with XLT Technology
b. Sensorswitch: WSK-PDT
c. Wattstopper; DSW-100
d. Hubbell; LHMTS.
e. Leviton; OSSMD.

2. Description: Dual technology sensor, Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft.

2.9 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.

2. Material for Finished Spaces: To be selected by architect at time of submittal.

3. Material for Unfinished Spaces: Galvanized steel

4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum.

2.10 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular die-cast aluminum with satin finish.

D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.

E. Voice and Data Communication Outlet: Blank cover with bushed cable opening.

2.11 POKE-THROUGH ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, styles as shown on details in electrical plans:

1. Hubbell Incorporated; Wiring Device-Kellems.

2. Wiremold Company (The).

B. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.

1. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.

2. Refer to plans and details for nominal core dimensions

2.12 MULTIOUTLET ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, styles as shown on details in electrical plans::

1. Hubbell Incorporated; Wiring Device-Kellems.

2. Wiremold Company (The).

B. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: Aluminum.

D. Wire: No. 12 AWG min.

2.13 FINISHES

A. Color: Wiring device catalog numbers in Section Text do not designate device color.

1. Wiring Devices Connected to Normal Power System: As selected by Architect, unless otherwise indicated or required by NFPA 70 or device listing.

2. Wiring Devices Connected to Emergency Power System: Red .

3. TVSS Devices: Blue.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:

1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.

3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.

4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.

3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

4. Existing Conductors:

a. Cut back and pigtail, or replace all damaged conductors.
b. Straighten conductors that remain and remove corrosion and foreign matter.
c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.

2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Dimmer switches of different lamp technologies or luminaire types shall all be by one manufacturer and have the same appearance and operation.

4. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.

5. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.

6. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.

7. Use a torque screwdriver when a torque is recommended or required by the manufacturer.

8. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.

9. Tighten unused terminal screws on the device.

10. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade

at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 16 Section "Identification for Electrical Systems."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with white-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.

2. Test Instruments: Use instruments that comply with UL 1436.

3. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.

2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.

3. Ground Impedance: Values of up to 2 ohms are acceptable.

4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.

5. Using the test plug, verify that the device and its outlet box are securely mounted.

6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

+ + END OF SECTION + +

SECTION 16145 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following lighting control devices:

1. Time switches.
2. Outdoor and indoor photoelectric switches.
3. Indoor occupancy sensors.
4. Outdoor motion sensors.
5. Lighting contactors.
6. Emergency shunt relays.

B. Related Sections include the following:

1. Division 16 Sections " Modular Dimming Controls" for architectural dimming system equipment.
2. Division 16 Section "Network Lighting Controls" for low-voltage, manual and programmable lighting control systems.
3. Division 16 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Show installation details for occupancy and light-level sensors.

1. Interconnection diagrams showing field-installed wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Intermatic, Inc.

2. Leviton Mfg. Company Inc.

3. Paragon Electric Co.; Invensys Climate Controls.

4. Kele

5. TORK.

B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Configuration:

2. Contact Rating: 30-A inductive or resistive, 120 - 277 V ac

3. Programs: 4 channels; each channel shall be individually programmable with 40 on-off operations per week, plus 4 seasonal schedules that modify the basic program, and an annual holiday schedule that overrides the weekly operation on holidays.

4. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.

5. Astronomic Time: All channels.

6. Battery Backup: For schedules and time clock.

C. Electromechanical-Dial Time Switches: Type complying with UL 917.

1. Contact Configuration:

2. Contact Rating: (30-A inductive or resistive, 120-277-V ac)]

3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.

4. Astronomic time dial.

5. Eight-Day Program: Uniquely programmable for each weekday and holidays.

6. Skip-a-day mode.

7. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 24 hours.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Intermatic, Inc.

2. Paragon Electric Co.; Invensys Climate Controls.

3. TORK.

B. Description: Solid state, with DPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.

2. Time Delay: 15-second minimum, to prevent false operation.

3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.

4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

C. Description: Solid state, with DPST dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.

1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.

2. Time Delay: 30-second minimum, to prevent false operation.

3. Lightning Arrester: Air-gap type.

4. Mounting: Twist lock complying with IEEE C136.10, with base.

2.3 INDOOR PHOTOELECTRIC SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Nexlight

2. Cooper Controls

3. Watt Stopper (The)

4. Lutron

B. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.

1. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.

2. Relay Unit: Dry contacts rated for 20 A ballast load at 120- and 277-V ac, for [20] A tungsten at 120-V ac, and for 1/4 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.

3. Light-Level Monitoring Range: 10 to 200 fc with an adjustment for turn-on and turn-off levels within that range.

4. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.

5. Indicator: Two LEDs to indicate the beginning of on-off cycles.

2.4 INDOOR OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hubbell Automation.

2. Nexlight

3. Cooper Controls

4. Watt Stopper (The)

5. Lutron

B. General Description: Ceiling-mounting, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.

3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.

4. Relay shall be provided with a separately controlled N.O./N.C. dry contact closure for interface to an auxiliary system.

5. Mounting:

a. Sensor: Suitable for mounting in any position on a standard outlet box.
b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

6. Indicator: LED, to show when motion is being detected during testing and normal

operation of the sensor.

7. Bypass Switch: Override the on function in case of sensor failure.

8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc keep lighting off when selected lighting level is present.

C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.

1. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.

2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10-foot high ceiling.

D. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.

2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96-inch- high ceiling.

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch high ceiling.

4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96-inchhigh ceiling.

5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot- high ceiling in a corridor not wider than 14 feet.

E. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.

2. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

2.5 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ASCO Power Technologies, LP; a division of Emerson Electric Co.

2. Eaton Electrical Inc.; Cutler-Hammer Products.

3. Square D; Schneider Electric.

4. TORK.

B. Description: Electrically operated and mechanically held, combination type with fusible switch complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).

2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.

3. Enclosure: Comply with NEMA 250.

4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

C. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.

1. Monitoring: On-off status.

2. Control: On-off operation.

2.6 EMERGENCY SHUNT RELAY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Lighting Control and Design, Inc.

B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.

1. Coil Rating: 120 or 277 V as per application..

2.7 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14, 16 or 18 AWG as allowed per NEC. Comply with requirements in Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Division 16 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be3/4-inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 16 Section "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.

2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.

2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 16 Section "Network Lighting Controls."

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training."

+ + END OF SECTION + +

SECTION 16211 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes equipment electricity metering by Owner.

1.3 DEFINITIONS

A. KY Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay opening and closing in response to the rotation of the disk in the meter.

B. PC: Personal computer.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For electricity-metering equipment.

1. Dimensioned plans and sections or elevation layouts.

2. Wiring Diagrams: For power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.

C. Field quality-control reports.

D. Operation and Maintenance Data. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Application and operating software documentation.

2. Software licenses.

3. Software service agreement.

4. Hard copies of manufacturer's operating specifications, design user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy Submittal.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Receive, store, and handle modular meter center according to NECA 400.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Construction Manager and Owner no fewer than 14 days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's written permission.

1.8 COORDINATION

A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:

1. Comply with requirements of utilities providing electrical power services.

2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

1.9 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 90 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade his computer equipment if necessary.

PART 2 - PRODUCTS

2.1 .EQUIPMENT FOR ELECTRICITY METERING BY OWNER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following

1. Eaton Power Expert Meter equivalent to SquareD PM820

2. Square D; a brand of Schneider Electric – PM820 Series.

B. General Requirements for Owner's Meters:

1. Comply with UL 1244.

2. Meters used for billing shall have an accuracy of 0.2 percent of reading, complying with requirements in ANSI C12.20.

3. Enclosure: NEMA 250, Type 1Type 3R minimum, with hasp for padlocking or sealing.

4. Identification: Comply with requirements in Division 16 Section "Identification for Electrical Systems."

5. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.

6. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.

   a. Type: Split and solid core.

7. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.

8. Building Automation System (BAS) Interface: One digital KY pulse to a user-definable increment of energy measurement. Match signal to BAS input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.

9. Meter shall be capable of BAS interface via MODBUS RTU protocol, provide all required accessories, ethernet cards, etc for system integration.

C. Kilowatt-hour Meter: Electronic three-phase meters, measuring electricity used.

1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.

2. Display: LCD with characters not less than 0.25 inch high, indicating accumulative kilowatt-hours and current kilowatt load. Retain accumulated kilowatt-hour in a nonvolatile memory, until reset.

D. Kilowatt-hour/Demand Meter: Electronic three-phase meters, measuring electricity use and demand. Demand shall be integrated over a 15-minute interval.

1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.

2. Display: LCD with characters not less than 0.25 inch high, indicating accumulative kilowatt-hours, current time and date, current demand, and historic peak demand[, and time and date of historic peak demand]. Retain accumulated kilowatt-hour and historic peak demand in a nonvolatile memory, until reset.

E. Data Transmission Cable: Transmit KY pulse data over Class 1 control-circuit conductors in raceway. Comply with Division 16 Section "Control-Voltage Electrical Power Cables."

F. Software: PC based, a product of meter manufacturer, suitable for calculation of utility cost allocation and billing.

1. Utility Cost Allocation: Automatically import energy-usage records to allocate energy costs for the following:

   a. At least 15 departments.
   b. At least five processes.
   c. At least five buildings.

2. Tenant or Activity Billing Software: Automatically import energy-usage records to automatically compute and prepare tenant bills or activity demand and energy-use statements based on metering of energy use and peak demand. Maintain separate

directory for each tenant's historical billing information. Prepare summary reports in user-defined formats and time intervals.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Install modular meter center according to NECA 400 switchboard installation requirements.

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Division 16 Section "Identification for Electrical Systems."

1. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.

2. Equipment Identification Labels: Adhesive film labels with clear protective overlay.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.

2. Turn off circuits supplied by metered feeder and secure them in off condition.

3. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.

4. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.

C. Electricity metering will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

+ + END OF SECTION + +

SECTION 16231 - ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes packaged engine-generator sets for standby power supply with the following features:

1. Diesel engine.

2. Unit-mounted cooling system.

3. Unit-mounted control and monitoring.

4. Performance requirements for sensitive loads.

5. Outdoor enclosure.

B. Related Sections include the following:

1. Division 16 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

2. Division 16 Section “Vibration Isolation and Seismic Control for Electrical Systems” for spring and restrained spring isolators.

1.3 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

B. LP: Liquid petroleum.

1.4 SUBMITTALS

A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:

1. Thermal damage curve for generator.

2. Time-current characteristic curves for generator protective device.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.

2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing

vibration isolation bases.

3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.

4. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that [day tank,] engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: For installer, manufacturer, and testing agency.

E. Source quality-control test reports.

1. Certified summary of prototype-unit test report.

2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.

3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.

4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.

5. Report of sound generation.

6. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

H. Warranty: Special warranty specified in this Section.

I. Dynamic Load Analysis

1. Manufacturer shall provide a dynamic load analysis to verify the suitability of the proposed unit for the duty required. The analysis shall be based upon the load information provided by the engineer and shall contain the following at a minimum:

    a. The starting and running characteristics of each load;
    b. The total starting and running loads of each step;
    c. The voltage dip and recovery time of each step;
    d. The frequency dip and recovery time of each step.
    e. The frequency and voltage surge for 100% load rejection.

2. The load analysis must account for the use of reduced voltage starting, harmonic sources impact on the generator system and staging or "shipping" of loads.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

    1. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.

    2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints for engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.

    1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

D. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with ASME B15.1.

G. Comply with NFPA 37.

H. Comply with NFPA 70.

I. Comply with NFPA 99.

J. Comply with NFPA 110 requirements for Level 1emergency power supply system.

K. Comply with UL 2200.

L. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

M. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary or alternate electrical service according to requirements indicated:

1. Notify Engineer Construction Manager and Owner no fewer than 14 days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's written permission.

B. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: Minus 15 to plus 50 deg C.

2. Relative Humidity: 0 to 100 percent.

3. Altitude: Sea level to 1000 feet.

1.7 COORDINATION

A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Division 07 Section "Roof Accessories."

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion.

1.9 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.

2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each. Not required for digital displays or LED lamps.

3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Caterpillar; Engine Div.

2. MTU Onsite Energy

3. Onan/Cummins Power Generation; Industrial Business Group.

2.2 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

C. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.

2. Load Factor: 80% standby rating

3. Starting rating: 150kW/187.5SkVA@ 0.5 PF (minimum).

4. Output Connections: Three-phase, four wire, solidly grounded.

5. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

D. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.

2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.

3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.

6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.

8. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

A. Fuel: Fuel oil, Grade DF-2.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.

2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.

3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:

1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.

2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

G. Governor: Adjustable isochronous, with speed sensing.

H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum

closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.

4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

   a. Rating: 50-psig maximum working pressure with coolant at 180 deg F , and noncollapsible under vacuum.
   b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

6. Fan: Driven by multiple belts from engine shaft.

I. Cooling System: Closed loop, liquid cooled, with remote radiator and integral engine-driven coolant pump.

1. Configuration: Vertical air discharge.

2. Radiator Core Tubes: Aluminum.

3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

4. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.

5. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

6. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

J. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system that does exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.

2. Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.

K. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

L. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.

2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.

3. Cranking Cycle: As required by NFPA 110 for system level specified.

4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project

Conditions" Article to provide specified cranking cycle at least three times without recharging.

5. Redundant Battery shall be provided as described in "Battery" above.

COORDINATE SUBPARAGRAPH BELOW WITH DRAWINGS.

6. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.

7. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.

8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:

a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.
g. Provide redundant battery charging and starting systems where redundant batteries are specified.

2.4 FUEL OIL STORAGE

A. Comply with NFPA 30.

B. Base-Mounted Fuel Oil Tank (Skid Tank): Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Components:

a. 500 gallon fuel (day) tank with float control switches, high level automatic shutoff, rupture basin.
b. Float switch, located at 1/4 point of tank, shall activate low fuel level alarm.
c. Fuel gauge.
d. Press-to-test button to test all components of the assembly.
e. Removable cover for access to top components.

f. Drain in bottom of tank-threaded plug.

2. Field connections:

a. Terminal compartment for electrical connections.
b. Return piping from engine shall connect directly to fuel oil return line. Provide check valve in return line to prevent positive head on injectors.
c. Fill connections

3. Accessories – Located and coordinated with the architectural enclosure around the generator.:

a. Low and high fuel level alarm indicator, factory installed, with auxiliary contacts to be wired back to generator annunciator panel.
b. Power available light, factory installed.
c. Fuel strainer, field installed.
d. Check valve on pump intake to prevent loss of pump prime, field installed.
e. Overflow control
f. Spill Prevention

4. Other modifications and accessories as required for project.

2.5 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

D. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1system, and the following:

1. AC voltmeter.

2. AC ammeter.

3. AC frequency meter.

4. DC voltmeter (alternator battery charging).

5. Engine-coolant temperature gage.

6. Engine lubricating-oil pressure gage.

7. Running-time meter.

8. Ammeter-voltmeter, phase-selector switch(es).

9. Generator-voltage adjusting rheostat.

10. Fuel tank derangement alarm.

11. Fuel tank high-level shutdown of fuel supply alarm.

12. Generator overload.

E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

F. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Data system connections to terminals are covered in Division 16 Section "Electrical Power Monitoring and Control."

G. Fire Alarm and BAS Monitoring: A separate terminal block, factory wired to Form C dry contacts, for fire alarm and BAS monitoring of generator run conditions.

H. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Provide all required accessories, float switches, wiring, etc for monitoring of these points.

1. Engine high-temperature shutdown.

2. Lube-oil, low-pressure shutdown.

3. Overspeed shutdown.

4. Remote emergency-stop shutdown.

5. Engine high-temperature prealarm.

6. Lube-oil, low-pressure prealarm.

7. Fuel tank, low-fuel level.

8. Low coolant level.

I. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Remote Annunciator should be capable of MODBUS RTU for connection to BAS system

J. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Insulated-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.

2. Trip Settings: Selected by generator set manufacturer to coordinate with generator thermal damage curve.

3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.

4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Enclosure: Dripproof.

G. Instrument Transformers: Mounted within generator enclosure.

H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

K. Subtransient Reactance: 12 percent, maximum.

2.8 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, skin-tight, weatherproof steel housing, wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

B. Description: Prefabricated or pre-engineered skin tight enclosure with the following features:

1. Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building

erected on concrete foundation.

2. Structural Design and Anchorage: Comply with ASCE 7 for wind loads.

3. Space Heater: Thermostatically controlled and sized to prevent condensation.

4. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents. Package shall include louvers, actuators, and all controls.

5. Hinged Doors: With padlocking provisions.

6. Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.

7. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.

8. Muffler Location: Within enclosure.

9. Sound Attenuation: unit shall be constructed such that the maximum noise level is 70dBA at 10 feet.

10. The unit shall be complete with:

    a. Emergency shutdown switches.
    b. Heaters.
    c. Local 100A/3 phase 120/208 volt panelboard to serve all items noted above, along with battery charger, and auxiliary equipment as required to support this generator.

C. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.

2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

D. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.

2. DC lighting system for operation when remote source and generator are both unavailable.

E. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

2.9 MOTORS

A. General requirements for motors are specified in Division 15 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 16 Sections.

2.10 VIBRATION ISOLATION DEVICES

A. Refer to Specification Section "VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS."

2.11 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.12 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:

1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.

2. Full load run.

3. Maximum power.

4. Voltage regulation.

5. Transient and steady-state governing.

6. Single-step load pickup.

7. Safety shutdown.

8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.

9. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with required vibration/seismic controls on 4-inch-high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."

D. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."

1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."

E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect cooling-system water piping to engine-generator set and heat exchanger with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Connect fuel piping to engines with a gate valve and union and flexible connector.

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Division 23 Section "Facility Fuel-Oil Piping."

F. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 16 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.

3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
c. Verify acceptance of charge for each element of the battery after discharge.
d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.

6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.

7. Exhaust Emissions Test: Comply with applicable government test criteria.

8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.

9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.

10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations, and compare measured levels with required values.

E. Coordinate tests with tests for transfer switches and run them concurrently.

F. Test instruments shall have been calibrated within the last 12 months, traceable to standards of

NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.

G. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

H. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

I. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

J. Remove and replace malfunctioning units and retest as specified above.

K. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

L. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

M. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 01 Section "Demonstration and Training."

+ + END OF SECTION + +

SECTION 16271 - MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following types of transformers with medium-voltage primaries:

1. Dry-type distribution and power transformers.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.4 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.

B. Shop Drawings: Diagram power signal and control wiring.

C. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Underground primary and secondary conduit stub-up location.

2. Dimensioned concrete base, outline of transformer, and required clearances.

3. Ground rod and grounding cable locations.

D. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems" Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For testing agency.

F. Source quality-control test reports.

G. Field quality-control test reports.

H. Follow-up service reports.

I. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of transformers and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C2.

E. Comply with ANSI C57.12.10, ANSI C57.12.28, IEEE C57.12.70, and IEEE C57.12.80.

F. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

1.7 PROJECT CONDITIONS

A. Service Conditions: IEEE C37.121, usual service conditions except for the following:

1. Exposure to seismic shock or to abnormal vibration, shock, or tilting.

2. Exposure to excessively high or low temperatures.

3. Unusual transportation or storage conditions.

4. Unusual grounding-resistance conditions.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB

2. Cooper Industries; Cooper Power Systems Division.

3. Olson Electrics

4. MGM

B. In the case of an integrated system line-up, all equipment shall be warranted by the same manufacturer.

2.2 DRY-TYPE DISTRIBUTION AND POWER TRANSFORMERS

A. Description: NEMA ST 20, IEEE C57.12.01, ANSI C57.12.50 (Vented <500 KVA), ANSI C57.12.51 (Vented > 500 KVA) ANSI C57.12.52, UL 1562 listed and labeled] dry-type, 2-winding transformers.

B. Indoor, ventilated, vacuum-pressure impregnated and with insulation system rated at 220 deg C with an 80/115/150 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C, respectively for kVA ratings as indicated on plans.

C. Primary Connection: Throat for close coupled primary switch. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.

D. Primary Connection: Transition terminal compartment with connection pattern to match switchgear.

E. Secondary Connection: Air terminal compartment with removable hinged door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.

F. Secondary Connection: Transition terminal compartment with connection pattern to match switchgear.

G. Insulation Materials: IEEE C57.12.01, rated at 220 deg C.

H. Insulation Temperature Rise: 80/115/150 deg C, maximum rise above 40 deg C respectively for kVA ratings as indicated on plans.

I. Basic Impulse Level: 95 kV BIL for 15 kV nominal rated high voltage, line-to-line. Primary windings are 3 phase Delta unless noted otherwise. 10 kV BIL for all seconday/low voltages < 480 V, line-to-line, wye windings U.O.N.

J. Primary and secondary 60 Hz Voltage: Refer to single line diagrams.

K. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary

voltage.

L. KVA Capacity and Winding Configuration: Refer to single line diagrams.

M. Cooling System: AA/FA, self-cooled, and with forced-air-cooled rating, complying with IEEE C57.12.01.

1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.

2. Include mounting provision for fans.

N. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.

O. Impedance: 5.75 percent.

P. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

Q. Color: ANSI 61

R. Winding Material: Aluminum

S. Spring isolators (2" deflection, Mason Industries "SLR") AND double layer 3/4" neoprene vibration isolation pads (loaded to 0.2" deflection, Mason Industries "SWMSW") between core and coil assembly and transformer enclosure. Bolted connections must employ neoprene bushings and washers to isolate the bolted connection.

T. Efficiency: Shall meet or exceed requirements of latest NEMA and DOE Standards.

U. Provide infra-red scanning ports with fully adjustable field of view to allow for a full scanner view of all parts requiring thermal inspection. Window shall comply with IEEE 37.20.2 and be NEMA 4 rated.

2.3 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 16 Section "Identification for Electrical Systems."

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Perform the following factory-certified routine tests on each transformer:

1. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections. (except dry type < 500 KVA)

2. Ratios on rated-voltage connection and on tap extreme connections.

3. Polarity and phase relation on rated-voltage connection.

4. No-load loss at rated voltage on rated-voltage connection.

5. Excitation current at rated voltage on rated-voltage connection.

6. Impedance and load loss at rated current on rated-voltage connection and on tap extreme

connections. (for units greater than or equal to 500 KVA only).

7. Applied potential: as applicable.

8. Induced potential: as applicable.

9. Leak Test: as applicable.

10. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class OA/FA or Class AA/FA rating.

    a. Temperature test is not required if record of temperature test on an essentially duplicate unit is available.

11. Owner will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for medium-voltage transformers.

B. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.

2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and that requirements in Division 16 Section 16060 "Grounding and Bonding for Electrical Systems" have been met.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install transformers on concrete bases.

1. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 16 Section "Hangers and Supports for Electrical Systems."

2. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.

3. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

4. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.

5. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete

base and anchor into structural concrete floor.

6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

7. Place full switchgear line-up including transformers on double layer neoprene vibration isolation pads (loaded to 0.2" uniform deflection, Mason Industries MSWMSW) Install channel sills under transformers that are part of unit-substation assemblies. Bolted connections are required and must employ neoprene bushings and washers to isolate the bolted connection.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 16 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

C. Perform the following field tests and inspections and prepare test reports:

1. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.

2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.

3. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

E. Test Reports: Prepare written reports to record the following and submit to Engineer.

1. Test procedures used.

2. Test results that comply with requirements.

3. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.

3.6 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: If requested by Owner, perform the following voltage monitoring after Substantial Completion but not more than six months after Final Acceptance:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at secondary terminals of each transformer. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.

2. Corrective Actions: If test results are unacceptable, perform the following corrective actions, as appropriate:

a. Adjust transformer taps.
b. Prepare written request for voltage adjustment by electric utility.

3. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.

4. Report: Prepare written report covering monitoring and corrective actions performed and submit to Engineer.

B. Infrared Scanning: Perform as specified in Division 16 Section "Medium-Voltage Switchgear."

+ + END OF SECTION + +

SECTION 16280 - POWER FACTOR CORRECTION EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes automatic power factor correction equipment rated 600 V and less.

B. Scope: Provide design and engineering, labor, material, equipment, related services, and supervision required, including, but not limited to manufacturing, fabrication, erection, and installation for low voltage anti-resonant automatic capacitor banks as required for the complete performance of the work, and as shown on the drawings and as herein specified.

C. Section Includes: The work specified in this Section includes, but shall not be limited to, low voltage anti-resonant automatic capacitor banks, as specified herein and as indicated or scheduled on the Drawings.

1.3 REFERENCES

A. General: The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

B. American National Standards Institute (ANSI):

1. ANSI C37.51, "Switchgear - Metal-Enclosed Low Voltage AC Power Circuit Breaker Switchgear Assemblies - Conformance Test Procedures."

C. ASTM:

1. ASTM E 329, "Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction."

D. Canadian Standards Association (CSA):

1. CSA C.22.2 No. 190, "Capacitors for Power Factor Correction."

E. National Electrical Manufacturers Association (NEMA):

1. NEMA 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)" (copyrighted by NEMA, ANSI approved).

F. National Fire Protection Association (NFPA):

1. NFPA 70, "National Electrical Code" (copyrighted by NFPA, ANSI approved) - hereinafter referred to as NEC.

2. NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplace" (copyrighted by NFPA, ANSI approved).

G. Underwriters Laboratories, Inc. (UL):

1. UL 508, "Standard for Industrial Control Equipment" (copyrighted by UL, ANSI approved).

2. UL 810, "Standard for Capacitors."

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Power factor correction equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions, operating characteristics of multiple capacitor cells or elements, and data on features, ratings, and performance.

B. Shop Drawings: For automatic power factor correction units.

1. Detail equipment assemblies and indicate dimensions, weights, method of field assembly, components, and location and size of each field connection. Show access and workspace requirements and required clearances.

2. Wiring Diagrams: For power, signal, and control wiring.

C. Qualification Data: For qualified testing agency.

D. Seismic Qualification Certificates: For capacitors, accessories, and components, from manufacturer.

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field quality-control reports.

F. Operation and Maintenance Data: For equipment to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Lists of spare parts and replacement components recommended for storage at Project site.

2. Detailed instructions covering operation under both normal and abnormal conditions.

G. Warranty: Sample of special warranty.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site

testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with IEEE 18 and NEMA CP 1.

D. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate sensor-communication module package with data network and with monitoring equipment specified in Division 16 Section "Electrical Power Monitoring and Control" for successful transmission and remote readout of remote monitoring data specified in this Section.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace capacitor-bank components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.9 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Three for every one of each type and rating, but no fewer than three of each.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material, or product brand name, and lot number, if any.

B. Store materials in their original, undamaged packages and containers, inside a well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.

1.11 PROJECT CONDITIONS

A. Environmental Requirements: Do not install low voltage anti-resonant automatic capacitor banks until space is enclosed and waterproof, wet work in space is completed and nominally dry, work above ceilings is complete, and ambient temperature and humidity conditions are and will be continuously maintained at values near those indicated for final occupancy.

PART 2 - PRODUCTS

2.1 CAPACITORS, GENERAL

A. Comply with UL 810.

B. Service Conditions: Capacitor equipment suitable for the following conditions:

1. Operating Temperature: Minus 40 to plus 115 deg F.

2. Maximum Altitude: 6000 feet.

3. Humidity: 0 to 95 percent, noncondensing.

C. Construction: Multiple capacitor cells or elements, factory wired in three-phase groups and mounted in metal enclosures.

D. Cells: Dry metallized-dielectric, self-healing type. Each cell shall be encapsulated in thermosetting resin inside plastic container.

E. Rupture Protection: Pressure-sensitive circuit interrupter for each cell.

2.2 AUTOMATIC POWER FACTOR CORRECTION UNITS

A. Description: Capacitors, contactors, controls, and accessories factory installed in independent enclosures complying with NEMA ICS 2. Comply with UL 810.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB.

2. Square D; a brand of Schneider Electric.

3. Eaton

2.3 EQUIPMENT SIZE/RATINGS

A. Operating voltage shall be 480 volts, line-to-line, three-phase, 60 hertz.

B. Rated capacitor cell voltage shall be minimum of 570 volts for 480 volt networks, line-to-line.

C. Total kVAR size as indicated on drawings at operating voltage.

D. Capacitor steps shall be 25 kVAR each for 480 volt networks.

E. Main terminal lugs shall be copper and all copper buswork shall be braced to withstand fault level at either 42 kA, 50 kA, or 65 kA RMS amperes symmetrical plus 10 percent for four cycles per ANSI C37.51.

F. Main circuit breaker shall withstand fault level of 125 kA at 240 volts, 100 kA at 480 volts, and 65 kA at 600 volts RMS amperes symmetrical where applicable.

G. Performance Requirements: Controls permit selection of a target power factor, adjustable to any value between unity and 0.80 lagging. Controls continuously sense the power factor on circuits being corrected and, when the power factor differs from the target setting for more than 10 seconds, operate a contractor to switch a capacitor bank into or out of the circuit. Contactors are opened or closed as required to bring the corrected circuit power factor closer to the target setting. Provide number of switching steps indicated on the Three-Phase Capacitor-Bank Schedule.

H. External Current Transformer (CT):

1. A single current transformer to be installed upstream of where the automatic capacitor is attached to the electrical distribution system, the CT shall be provided with a ratio of 1200 amperes to 5 amperes. The field installable CT shall be split core type with an opening large enough to facilitate installation on the cable or buss.

2. A shorting terminal shall be provided for two incoming current transformer wires.

I. Controls: Solid-state, microprocessor-based controls, including the following:

1. Undervoltage relay that interrupts capacitor switching and disconnects capacitors for power-supply interruptions longer than 15 minutes.

2. "Advance" and "Retard" push buttons on the control panel to permit manually controlled capacitor-bank switching.

J. Contactors: Three pole; rated for the repetitive high-inrush-switching duty in the capacitor application.

K. Fuses for Protection of Capacitor Banks: Rated to protect contactor, interconnecting wiring, and capacitors.

1. Spare-Fuse Cabinet: Identified cabinet with hinged lockable door.

L. Discharge Resistors: Factory installed and wired.

M. Inductors: Air-core type, connected in capacitor circuits; rated to limit switching surges to within contactor ratings.

N. Precharge Capacitor Circuit: Resistive, precharge circuit to charge capacitors prior to switching and to limit switching surges to within contactor ratings.

O. Tuning Reactors:

1. Tuning reactors for each capacitive stage shall be selected such that filter tuning of each stage shall be equal to 4.7 by 60 hertz.

2. Reactor shall be constructed of El laminated low hysteresis core with a controlled air gap and tree copper windings of rectangular cross section glass insulated copper conductor.

3. Center leg of tuning reactor shall have an embedded thermistor wired to a thermistor relay for the stage to deenergize the associated contactor in the event of reactor overheating.

P. Control Power Requirements:

1. 120 volt AC control circuit transformer shall be provided within the enclosure.

2. Major components, including, but not limited to, both primary and secondary winding of the transformer, shall be used.

3. The control circuit shall be protected by a resettable ground fault protection breaker.

Q. Enclosure: NEMA 250, Type 1, steel or aluminum, with hinged door and hand-operated catch. Door shall be interlocked with controls or main circuit breaker to de-energize capacitors when door is opened.

1. Factory Finish: Manufacturer's standard enamel over corrosion-resistant treatment or primer coat.

R. Local Display: Backlit screen mounted in door of enclosure, indicating the following:

1. Target and actual power factors accurate to plus or minus 1 percent of reading.

2. Steps energized.

3. Step reconnection delay.

4. Real and reactive currents.

5. Voltage total harmonic distortion.

6. Alarm identification.

S. System Alarms: Alarm relay and local display indication of the following conditions:

1. Low power factor.

2. Abnormal power factor.

3. Frequency not detected.

4. Overcurrent.

5. Overvoltage.

6. Overtemperature.

7. Excessive voltage total harmonic distortion.

8. Capacitor overload.

9. Loss of capacitance.

T. Remote Monitoring Components: Sensors, associated communication modules, and network interface units, matched to and compatible with electrical power monitoring and control network. Communication module shall have capability to transmit the following data to remote monitoring devices:

1. System in alarm.

2. Power factor set point.

3. Corrected power factor.

4. Number of capacitor steps activated.

2.4 SOURCE QUALITY CONTROL

A. Factory test power factor correction equipment before shipment. Comply with NEMA CP 1. Include the following:

1. Routine capacitor production tests, including short-time overvoltage, capacitance, leak, and dissipation-factor tests.

2. Functional test of all operations, controls, indicators, sensors, and protective devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install freestanding equipment on concrete bases. Cast-in-place concrete is specified in Division 03.

B. Comply with mounting and anchoring requirements specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."

C. Maintain minimum workspace according to manufacturer's written instructions.

D. Connect remote monitoring communication module to electrical power monitoring and control data network through appropriate network interface unit.

E. Identify components according to Division 16 Section "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections: Perform each visual and mechanical inspection and electrical test stated in the following Sections, except optional tests, in NETA Acceptance Testing Specification. Certify compliance with test parameters.

1. Current Transformers.

2. Capacitors and Reactors, Capacitors.

3.3 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Connect and run installed motors and equipment to verify the automatic switching of the capacitors. Verification shall include automatic switching of the total capacity of installed capacitors.

a. Provide sufficient inductive/reactive load banks, in combination with resistive load banks, for the test.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain automatic power factor correction units.

+ + END OF SECTION + +

SECTION 16289 - TRANSIENT-VOLTAGE SUPPRESSION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes field-mounted TVSS for low-voltage (120 to 600 V) power distribution and control equipment.

B. Related Sections:

1. Division 16 Section "Switchboards" for factory-installed TVSS.

2. Division 16 Section "Panelboards" for factory-installed TVSS.

3. Division 16 Section "Wiring Devices" for devices with integral TVSS.

1.3 DEFINITIONS

A. ATS: Acceptance Testing Specifications.

B. SVR: Suppressed voltage rating.

C. TVSS: Transient voltage surge suppressor(s), both singular and plural; also, transient voltage surge suppression.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.

B. Qualification Data: For qualified testing agency.

C. Product Certificates: For TVSS devices, from manufacturer.

D. Field quality-control reports.

E. Operation and Maintenance Data: For TVSS devices to include in emergency, operation, and maintenance manuals.

F. Warranties: Submit manufacturer's warranty on defective material and workmanship for a minimum period of fifteen (15) years.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended location and application.

C. Comply with ANSI/IEEE C62.41.2 and test devices according to ANSI/IEEE C62.45.

D. Comply with NEMA LS 1.

E. Comply with IEEE 1100 (Emerald Book).

F. Comply with UL 1449.

G. Comply with NFPA 70.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Architect Construction Manager and Owner no fewer than fourteen (14) days in advance of proposed electrical service interruptions.

2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

B. Service Conditions: Rate TVSS devices for continuous operation under the following conditions unless otherwise indicated:

1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.

2. Operating Temperature: 30 to 120 deg F.

3. Humidity: 0 to 85 percent, noncondensing.

4. Altitude: Less than 20,000 feet above sea level.

1.7 COORDINATION

A. Coordinate location of field-mounted TVSS devices to allow adequate clearances for maintenance.

B. Coordinate TVSS devices with Division 16 Section "Electrical Power Monitoring and Control."

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

B. Special Warranty for Cord-Connected, Plug-in Surge Suppressors: Manufacturer's standard form in which manufacturer agrees to repair or replace electronic equipment connected to circuits protected by surge suppressors.

1.9 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Replaceable Protection Modules: One of each size and type installed.

PART 2 - PRODUCTS

2.1 SERVICE ENTRANCE SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Advanced Protection Technologies Inc. (APT).

2. Current Technology Inc.; Danaher Power Solutions.

3. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

4. Liebert Corporation; a division of Emerson Network Power.

5. Siemens Energy & Automation, Inc.

6. Square D; a brand of Schneider Electric.

7. Citel

B. Surge Protection Devices:

1. Comply with UL 1449, 3rd Edition

2. Unit shall be listed as a Type 1 SPD, suitable for Type 1 and 2 locations.

3. Non-modular design.

4. SCCR rating of device shall be 200 kAIC without a requirement for upstream protection devices or fuses.

5. Fabrication using bolted compression lugs for internal wiring.

6. Redundant suppression circuits.

7. Redundant replaceable modules.

8. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.

9. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

10. LED indicator lights for power and protection status.

11. Audible alarm, with silencing switch, to indicate when protection has failed.

12. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

13. Six-digit transient-event counter set to totalize transient surges.

14. Declared Maximum Continuous Operating Voltage (MCOV) shall be greater than 115% of the nominal system operating voltage and in compliance with test and evaluation procedures outlined in the nominal discharge surge current test of UL 1449 3rd Edition, Section 37.7.3. MCOV valves based on the components value or on the 30-minute operational test, Section 37.8 of UL 1449 shall not be acceptable.

15. Units shall not have more than 10% degredation of the UL 1449 Voltage Protection Rating (VPR) due to repeated surges. Unit shall have a monitoring system to test and determine the percentage of protection available at all times.

C. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.

D. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2

1. Line to Neutral: 70,000 A.

2. Line to Ground: 70,000 A.

3. Neutral to Ground: 50,000 A.

E. Protection Modes: SVR (6kV, 500A) and UL 1449 VPR (6kV, 3kA) for grounded-wye/delta and delta high-leg delta circuits with voltages of 480Y/277, 208Y/120 or 600Y/347 three-phase, 4-wire circuits, and 120/240V split phase shall be as follows, in compliance with UL 1449, 3rd edition section 37.6. valves depicted are based upon a system with disconnect/without disconnect.

System Voltage	Mode	MCOV	B3 Ringwave	C3 Comb. Wave	UL 1449.2nd SVR Rating	UL 1449.3rd VPR Rating
120/240 or 120/208	L-N	150	325/375	650/755	400/400	700/700
	L-G	150	400/450	650/825	500/500	900/1000
	N-G	0	350/350	500/500	500/500	900/1000
	L-L	300	400/500	950/1250	700/700	900/1000

System Voltage	Mode	MCOV	B3 Ringwave	C3 Comb. Wave	UL 1449.2nd SVR Rating	UL 1449.3rd VPR Rating
277/480	L-N	320	550/600	1075/1225	800/800	900/1000
	L-G	320	850/875	1075/1225	1000/1000	1200/1200
	N-G	0	700/700	900/900	900/900	1200/1500
	L-L	550	650/750	1950/2200	1500/1500	1800/1800

2.2 PANELBOARD SUPPRESSORS

A. Product shall meet all requirements of Part 2.1 above except for the peak single-impulse surge current rating, which shall be 80kA per mode/160kA per phase.

2.3 ENCLOSURES

A. Indoor Enclosures: NEMA 250 Type 1.

B. Outdoor Enclosures: NEMA 250 Type 4X.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install TVSS devices at service entrance on load side, with ground lead bonded to service entrance ground.

B. Install TVSS devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

1. Provide 3 pole, 60-A circuit breaker as a dedicated disconnecting means for TVSS unless otherwise indicated.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

1. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.

2. After installing TVSS devices but before electrical circuitry has been energized, test for compliance with requirements.

3. Complete startup checks according to manufacturer's written instructions.

4. Verify all voltage and clamping levels.

5. Very N-G connection.

E. TVSS device will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.3 STARTUP SERVICE

A. Do not energize or connect service entrance equipment, panelboards, control terminals data terminals to their sources until TVSS devices are installed and connected.

B. Do not perform insulation resistance tests of the distribution wiring equipment with the TVSS installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to maintain TVSS devices.

+ + END OF SECTION + +

SECTION 16341 - MEDIUM-VOLTAGE COMPACT COMPARTMENTALIZED METAL-ENCLOSED LOAD INTERRUPTER SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. References

1. ANSI / IEEE C37.20.3 - Standard for Metal-Enclosed Interrupter Switchgear.

2. ANSI / IEEE C37.20.4 - Standard for Indoor AC Medium-Voltage Switches used in Metal-Enclosed Switchgear.

3. ANSI / IEEE 24 - Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings.

4. ANSI / IEEE 48- Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Termination.

5. ANSI Z55.1 - Gray Finishes for Industrial Apparatus and Equipment.

6. NEMA

7. IEC 420 High-Voltage Alternating Current Switch-Fuse Combinations (Applicable sections to ensure proper coordination of the switch-fuse combination when fuses are utilized for opening the switch automatically) Test Duties 4 and 5

1.2 SUMMARY

A. This Section includes medium voltage compact compartmentalized metal-enclosed switchgear with load interrupter switches with the following optional components, features, and accessories:

1. Copper, silver-plated main bus at connection points.

2. Communication modules.

3. Analog instruments.

4. Relays.

5. Surge arresters.

6. Fungus proofing.

7. Control battery system.

8. Mimic bus.

1.3 DEFINITIONS

A. ATS: Acceptance Testing Specifications.

B. GFCI: Ground-Fault Circuit Interrupter.

1.4 SUBMITTALS

A. Product Data: For each type of switchgear and related equipment, include the following:

1. Rated capacities, operating characteristics, furnished specialties, and accessories for individual interrupter switches.

2. Time-current characteristic curves for overcurrent protective devices, including fusible devices.

B. Shop Drawings: For each type of switchgear and related equipment, include the following:

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field assembly and location and size of each field connection. Include the following:

a. Tabulation of installed devices with features and ratings.
b. Outline and general arrangement drawing showing dimensions, shipping sections, lifting and support points and weights of each assembled section.
c. Drawing of cable termination compartments showing preferred locations for conduits and indicating space available for cable terminations.
d. Floor plan drawing showing locations for anchor bolts and leveling channels.
e. Current ratings of buses and electrical ratings of all equipment.
f. Short-time and short-circuit ratings of switchgear assembly.
g. Nameplate legends.
h. Mimic-bus diagram.
i. Heat dissipation information.

2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting seismic restraints.

3. Wiring Diagrams: For each type of switchgear and related equipment, include the following:

a. Power, signal, and control wiring.
b. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
c. Schematic control diagrams.
d. Diagrams showing connections of component devices and equipment.
e. Schematic diagrams showing connections to remote devices.

C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where piping and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Identify field measurements.

D. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.

E. Manufacturer Seismic Qualification Certification: Submit certification that switchgear, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Qualification Data: For professional engineer and testing agency.

G. Source quality-control test reports.

H. Field quality-control test reports.

I. Installation, Operation and Maintenance Data: For switchgear and switchgear components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. In accordance with customer to specify section.

B. Manufacturer: Company specializing in medium voltage metal-enclosed switchgear with at least five years documented experience. The manufacturer of the switchgear must be the same as the manufacturer of the load interrupter switch.

C. Equipment shall be UL listed and labeled for metal-enclosed type switchgear assemblies.

D. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

E. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

F. Source Limitations: Obtain each type of switchgear and associated components through one source from a single manufacturer.

G. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear. By

submission of a bid, the contractor and manufacturer warrant that equipment will meet the requirements of both the specification and the listed space requirements.

H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

I. Comply with IEEE C2.

J. All equipment including circuit breakers shall be procured from an authorized manufacturers' distributor. proof of purchase in the form of an authorized distributor's invoice shall be required. Reconditioned or brokered equipment will not be acceptable.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of section 01650.

B. Store and protect products under provisions of Section 01660.

C. Accept equipment on site and inspect for shipping damage.

D. Protect equipment from weather and moisture by covering with heavy plastic or canvas and by maintaining heat within enclosure in accordance with manufacturer's instructions.

E. Deliver in sections of lengths that can be moved past obstructions in delivery path as indicated.

F. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

G. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:

1. Ambient temperature not exceeding 122 deg F

2. Altitude of 1000 feet above sea level.

B. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear and adjacent surfaces and other items. Comply with indicated maximum dimensions. BY submission of a bid, contractor and manufacturer warrant that the submitted equipment meets both the specification and the space requirements of the project.

D. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Architect, Engineer, Construction Manager and Owner no fewer than 14 days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Engineers, Construction Manager's and Owner's written permission.

1.8 COORDINATION

A. Coordinate layout and installation of switchgear and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.

B. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Six of each type and rating used. Include spares for future transformers, control power circuits, and fusible devices.

2. Indicating Lights: Six of each type installed.

3. Touchup Paint: Three containers of paint matching enclosure finish, each 0.5 pint.

B. Maintenance Tools: Furnish tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include the following:

1. Fuse-handling tool.

2. Extension rails, lifting device, transport or dockable dolly or mobile lift, and all other items necessary to remove circuit breaker from housing and transport to remote location.

3. Racking handle to move circuit breaker manually between connected and disconnected positions, and a secondary test coupler to permit testing of circuit breaker without removal from switchgear.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 MANUFACTURED UNITS

A. Description: Factory assembled and tested, and complying with IEEE C37.20.3.

B. Ratings: Suitable for application in 3-phase, 60-Hz, solidly grounded-neutral system.

C. System Voltage: 12.47 kV nominal; 15 kV maximum

2.3 METAL-ENCLOSED INTERRUPTER SWITCHGEAR

A. Manufacturers:

1. Eaton Corporation; Cutler-Hammer Products.

2. Siemens Energy & Automation, Inc.

3. Square D; Schneider Electric.

B. Comply with IEEE C37.20.3.

C. Comply with IEEE C37.20.7. Provide arc-resistant switchgear, Type 1.

D. Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.

E. Ratings: Comply with standard ratings designated in IEEE C37.20.3 for maximum-rated voltage specified.

F. Load Interrupter Switchgear Assembly

1. The metal-enclosed switchgear assembly shall be compartmentalized into the following distinct compartments:

   a. Main bus compartment
   b. Switch Compartment
   c. Cable connection / fuse compartment
   d. Mechanism compartment
   e. Optional Low voltage / control compartment.]

2. The metal-enclosed switchgear with load interrupter switches shall consist of a close coupled connection with the transformer, be of indoor construction. The sections shall contain the load interrupter switches and the necessary accessory components. The equipment shall be factory-assembled (except for necessary shipping splits) and operationally checked. The assembly shall be a self-supporting, floor mounted bay and shall be securely bolted to the transformer to form an integrated structure. Each incoming bay shall be 20".The equipment shall be designed for front accessibility only.

3. Cable entry shall be top.

4. The complete assembly shall be constructed in accordance with applicable provisions of ANSI / IEEE C37.20.3-1987 and the minimum construction standards of the manufacturers of the major components such as power fuses or potential transformers. Provide adequate space for fuse handling when applicable. {Insert when automatic fuse opening is specified}[For automatic fuse opening the switch-fuse combination shall meet the applicable sections of IEC 420 to ensure proper coordination of the proposed switch-fuse combination. To comply with these requirements, a time delay relay may be used for fuse ratings that do not coordinate with the switch to ensure that any fault currents have decayed to values that the load interrupter switch can safely interrupt.]

5. In establishing the requirements for the enclosure design, consideration shall be given to such relevant factors as controlled access, tamper resistance, protection from ingress of rodents and insects.

6. Switchgear rated 600 amps continuous shall not require ventilation openings to aid in cooling of the associated components.

7. The integrated fused switchgear assembly shall withstand the effects of closing, carrying

and interrupting currents up to the assigned maximum short circuit rating.

8. The switchgear shall be low maintenance designed to reduce the requirement for annual/ periodic maintenance of the equipment. Equipment with scheduled maintenance intervals of 5 or more years is preferred.

9. Two viewing ports shall be installed in the switch enclosure to enable visible verification of the switch blade position.

10. An animated mimic bus attached to the end of the operating shaft shall be provided to give visual indication of the position of the switch on each bay.

11. System Voltage: 15 kV, three phase, solidly grounded, three phase 3 wire.

12. Operating Frequency: 60 Hz.

13. Maximum Short Circuit Current: 25 kA RMS Symmetrical.

14. Maximum Design Voltage: 17.5kV.

15. Basic Impulse LEVEL (BIL): 95 kV.

16. Power Frequency Withstand: 36 kV.

17. Short-Time Current (two second):

Interrupter switch	25 kA.
Grounding switch	25 kA

18. Main Bus Ampacity: 600 amperes, continuous.

19. Integrated Short Circuit Rating: 50 kA, RMS symmetrical.

G. Load Interrupter Switches

1. Over Center Mechanism:

   a. The load interrupter switch, rated 600 amperes continuous and interrupting, shall be fixed mounted manually operated, and shall be quick-make, quick-break with the speed of operation independent of the operator. The grounding switch, on closing, shall be quick-make with the speed of operation independent of the operator.
   b. To provide for dependable operation, the device shall not rely on chains or cables to drive the blade assemblies open and closed. The operating mechanism shall be isolated from high voltage by a steel barrier and coupled through a direct drive shaft. Access to mechanism parts shall not require de-energizing of the equipment.

2. The switch shall have two positions, open and closed.

3. The switch shall have a four-time fault close capability.

4. The switch shall be capable of 100 operations at 600 Amperes.

5. The switch shall be capable of 1000 mechanical no load operations.

6. The switch blades shall be contained in a single sealed for life enclosure. The interrupting

medium pressure within the enclosure shall not exceed 6 PSI at 5 or 15kV class equipment or 22 PSI at 25.8 or 38kV class equipment. Refilling of the switch shall not be required. Maintenance of the interrupter module shall not be required over its life.

7. The switch operating handle shall be removable. The handle must be suitable to operate the load interrupter mechanism as well as the ground switch mechanism.

8. Voltage and Short Circuit Ratings: Match ratings specified for integrated assembly.

9. Momentary Rating: 40kA RMS Asymmetrical.

10. Fault Closing: 40 kA, RMS Asymmetrical {at 25.8 or 38 kV}.

11. Load side live line indicators shall be provided as standard on the mechanism compartment. The live line indicator assembly shall be mounted in the mechanism compartment and shall be an easily removable module containing three neon indicators powered from voltage dividers within the 3 standoff insulators. Incoming line or main bus live line indicators shall be provided as and shall be mounted in the low voltage compartment.

H. Mechanical Interlock: Prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open.

I. Power Fuses: Comply with the following and with applicable requirements in NEMA SG 2:

1. Fuses

a. Fuses shall be expulsion type, fuse holders with replaceable refills or fuse units, complete with muffler exhaust control.
b. Fuses shall be affixed in position in a non-disconnect fuse mounting with provisions for removal and replacement from the front of the gear.
c. Fuse Rating: "E" rated, sized based on manufacturer recommendations based on transformer size.
d. Voltage Class: 15.0 kV.
e. Interrupting Rating: As stated above to achieve the integrated interrupting rating; 40 KA, rms symmetrical.
f. Fuses shall be full range type or general purpose type. Back-up type fuses are not acceptable.

2.4 ACCESSORIES

A. Surge Arresters (metal-oxide type): Standard Distribution class, rated 15 kV, 12.7kV MCOV; one per phase.

B. Incoming Cable Termination: An anti-rotational mounting pad shall have provision for 1single hole cable lugs.

C. Provide mechanical lugs for terminating cables onto the switchgear terminal pads.

D. Provide two 2" short-wavelong-wave infrared inspection windows per vertical section. One window shall be for the lower compartment and the other for the upper compartment.

E. Anti-condensation space heaters{optional for indoor}: For 120VAC from control power transformer, sized by the manufacturer, with thermostats.

F. Pad lock provisions for mechanism covers on the load interrupter switch and grounding switch mechanisms shall be supplied as standard to prevent unauthorized access to the operating

mechanism.

G. Mechanical Interlocks:

1. An interlock shall be provided on the grounding switch mechanism to prevent insertion of the operating handle and operation of the grounding switch when the load interrupter switch is in the closed position. {Include when ground switch is specified}

2. An interlock shall be provided on the load interrupter switch mechanism to prevent insertion of the operating handle and operation of the load interrupter switch when the grounding switch is in the closed position.

3. An interlock shall be provided to prevent the removal of the high voltage access panel with the load interrupter switch closed. To access the high voltage compartment, the load interrupter switch must be opened and the grounding switch must be in the closed position. The interlock must be directly attached to the operating mechanism and should not rely on long cables and linkages.

4. To facilitate cable testing in the high voltage compartment, the grounding switch can be returned to the open position. In this position interlocks are to be provided to prevent replacement of the high voltage access panel and prevent closure of the load interrupter switch. {Include when ground switch is specified}

H. Control Power Transformer Options:

1. A control power transformer bay shall contain a load interrupter with grounding switch.

2. Control Power Transformer, single phase, with primary disconnect fuse, 240/120 VAC secondary, 15 kVA.

3. The width of the unit shall be 20".

2.5 FABRICATION

A. Construction: Indoor Each equipment bay shall be a separately constructed cubicle assembled to form a rigid free standing unit. Minimum sheet metal thickness shall be 11 gauge steel on all exterior surfaces. Adjacent bays shall be securely bolted together to form an integrated rigid structure. Each individual unit shall be braced to prevent distortion.

B. All bus joints shall use Belleville washers. Torque bolts that are used for bus joints or for insulators and direct support of any current carrying parts shall be marked with a bead of highly visible bright orange "torque seal", that will readily show when a bolt has loosened.

C. The high voltage non-disconnect type fuses (when required), shall be accessible only through a separate panel mechanically interlocked with the switch. [Where grounding switches are supplied, access panels shall not be removable unless the grounding switch is in the closed position.] [If grounding switches are defeated, access panels shall not be removable unless the load interrupter switch is in the fully open position.] Screened or penetrable barriers which may allow intentional or inadvertent contact with energized parts shall not be permitted.

D. The duplex switch configuration shall be equipped with a mechanical interlock between the two switches preventing paralleling of the two incoming lines. A single access panel shall be provided to the load side of the duplex configuration requiring that both switches shall be opened [and grounded] prior to accessing the fuses and load cable terminations.

Maximum	Indoor	Outdoor
Voltage	Single/Multiple	Single/Multiple

4.76 & 15.0 kV	90"	99.75"

E. Main bus shall be tin-plated copper, insulated rated 600 amps, and shall be supported directly by the switch.

F. For single bays, include a ground pad with lug. Main bus and ground bus connections shall be designed for easy for future extensions. Cutout areas with removable bolted on covers shall allow for future extension of the main bus. A knock-out shall be removable for the extension of the ground bus.

G. Anti-condensation space heaters: For 120 VAC from control power transformer, sized by the manufacturer, with thermostats

H. The metal-enclosed switchgear shall be fully assembled, inspected and tested at the factory prior to shipment. Large line-ups shall be split to permit normal shipping and handling as well as for ease of rejoining at the job site.

I. Finish: Manufacturer's standard gray finish over rust-inhibiting primer on phosphatizing-treated metal surfaces.

J. Bus Transition Unit: Arranged to suit bus and adjacent units.

K. Incoming-Line Unit: Arranged to suit incoming line.

L. Outgoing Feeder Units: Arranged to suit distribution feeders.

M. Auxiliary Compartments: Arranged to suit house meters, relays, controls, and auxiliary equipment; isolated from medium-voltage components.

N. Key Interlocks: Arranged to effect interlocking schemes indicated.

O. Provisions for Future Key Interlocks: Mountings and hardware required for future installation of locks, where indicated.

2.6 COMPONENTS

A. Main Bus: Copper, silver plated at connection points; full length of switchgear.

B. Ground Bus: Copper, silver plated or copper, tin plated; minimum size 1/4 by 2 inches; full length of switchgear.

C. Bus Insulation: Covered with flame-retardant insulation.

D. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.

2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

E. Surge Arresters: Distribution class, metal-oxide-varistor type. Comply with NEMA LA 1.

1. Install in cable termination compartments in each phase of circuit.

2. Coordinate rating with circuit voltage.

F. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

G. Fungus Proofing: Permanent fungicidal treatment for switchgear interior, including instruments and instrument transformers.

H. Control Power Supply: Control power transformer supplies 120-V control circuits through secondary disconnect devices. Include the following features:

1. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.

2. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

a. Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.
b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.

3. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.

I. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2. Conductors sized according to NFPA 70 for duty required.

2.7 IDENTIFICATION

A. Materials: Refer to Division 16 Section "Identification for Electrical Systems." Identify units, devices, controls, and wiring.

B. Mimic Bus: Continuous mimic bus applied to front of switchgear, arranged in single-line diagram format, using symbols and lettered designations consistent with approved final mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.

2. Medium: Painted graphics, as approved.

3. Color: Contrasting with factory-finish background; selected by Architect.

2.8 SOURCE QUALITY CONTROL

A. Before shipment of equipment, perform the following tests and prepare test reports:

1. Production tests on circuit breakers according to ANSI C37.09.

2. Production tests on completed switchgear assembly according to IEEE C37.20.2.

B. Assemble switchgear and equipment in manufacturer's plant and perform the following:

1. Functional tests of all relays, instruments, meters, and control devices by application of secondary three-phase voltage to voltage circuits and injection of current in current transformer secondary circuits.

2. Functional test of all control and trip circuits. Connect test devices into circuits to simulate operation of controlled remote equipment such as circuit-breaker trip coils, close coils, and auxiliary contacts. Test proper operation of relay targets.

C. Prepare equipment for shipment.

1. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.

2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

2.9 FACTORY FINISHES

A. All non-painted steel parts shall be zinc plated.

B. All painted steel parts shall be cleaned and a zinc- phosphate (outdoor equipment) or iron phosphate (indoor equipment) pre-treatment applied prior to paint application

C. Paint Color shall be ANSI-61 (light gray) TGIC polyester powder, applied electrostatically through air. Following paint application, parts shall be baked to produce a hard durable finish. The average thickness of the paint film shall be 2.0 mils. Paint film shall be uniform in color and free from blisters, sags, flaking and peeling.

D. Adequacy of paint finish to inhibit the buildup of rust on ferrous metal materials shall be tested and evaluated per paragraphs 5.2.8.1-7 of ANSI C37.20.3-1987. Salt spray withstand tests in accordance with paragraph 5.2.8.4 shall be performed on a periodic basis to provide conformance to this corrosion resistance standard of at least 2500 hours minimum (outdoor equipment) or 600 hours minimum (indoor equipment).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Visually inspect switchgear for evidence of damage and verify that surfaces are ready to receive work.

B. Visually inspect to confirm that all items and accessories are in accordance with specifications and drawings

C. Verify field measurements are as shown on Drawings.

D. Verify that required utilities (e.g., control voltage for heater circuits on outdoor switchgear) are available, in proper location, and ready for use.

E. Beginning of installation means installer accepts existing surface conditions.

3.2 INSTALLATION

A. Anchor switchgear assembly to 4-inch, channel-iron sill embedded in concrete base and attach by bolting.

1. Sills: Select to suit switchgear; level and grout flush into concrete base.

2. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 16 Section "Vibration and Seismic Controls for Electrical Systems" for seismic-restraint requirements.

3. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no less than 3 inches in all directions beyond the maximum dimensions of switchgear, unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 16 Section "Hangers and Supports for Electrical Systems."

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchgear units and components.

C. Install in accordance with manufacturer's instructions, applicable requirements of the NEC and in accordance with recognized industry practices.

D. Connect the primary surge arresters if not connected. If required, use jumper cables, as provided by the switchgear manufacturer.

E. Bending of high-voltage cables should be avoided or minimized. All necessary bends should meet at least the minimum radii specified by the cable manufacturer.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Identification for Electrical Systems."

B. Diagram and Instructions:

1. Frame under clear acrylic plastic on front of switchgear.

a. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.

2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

3.4 CONNECTIONS

A. Cable terminations at switchgear are specified in Division 16 Section "Medium-Voltage Cables."

B. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values.

C. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 16 Sections "Low-Voltage Electrical Power Conductors and Cables" and "Medium-Voltage Cables."

3.5 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed by [the installing contractor] [a separate contractor furnished by the owner] under provisions of Section 01400.

B. Visually inspect switchgear for physical damage upon receipt.

C. Perform mechanical operator tests in accordance with manufacturer's instructions.

D. Check torque of all bolted connections, including cable terminations, either by observing the bead of indicating compound to confirm that it is still intact, or with a torque wrench to confirm the joint is tightened to the manufacturer's specifications.

E. Touch-up all chips and scratches with manufacturer-supplied paint and leave remaining paint with Owner.

F. Verify key interlock operation if applicable.

G. Perform insulation resistance test on each phase to ground and phase to phase. Record results for future reference.

H. Perform low-frequency withstand tests according to ANSI/IEEE C37.20.3, paragraph 5.5.

I. Perform contact resistance test across each switch blade; report any contact resistance in excess of 50 micro-ohms

J. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

K. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect switchgear, wiring, components, connections, and equipment installation. Test and adjust components and equipment.

2. Assist in field testing of equipment including pretesting and adjusting of automatic power factor correction units.

3. Report results in writing.

L. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

M. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:

a. Switchgear.
b. Circuit breakers.
c. Protective relays.
d. Instrument transformers.
e. Metering and instrumentation.
f. Ground-fault systems.
g. Battery systems.
h. Surge arresters.
i. Capacitors.

N. Remove and replace malfunctioning units and retest as specified above.

O. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.

2. Instrument: Use an infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes infrared-scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 CLEANING

A. On completion of installation, inspect interior and exterior of switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear. Refer to Division 01 Section "Demonstration and Training."

+ + END OF SECTION + +

SECTION 16361 - SECONDARY UNIT SUBSTATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes indoor and outdoor secondary unit substations, each consisting of the following:

1. Transformer.

2. Secondary distribution section.

B. Related Sections may include the following:

1. Division 16 Section "Medium-Voltage Cables" for requirements of terminating cables in incoming section of substation.

2. Division 16 Section "Overcurrent Protective Device Coordination Study" for short-circuit rating of devices and for setting of overcurrent protective devices.

3. Division 16 Section "Electrical Power Monitoring and Control" for communication features of power distribution system devices.

4. Division 16 Section "Medium-Voltage Compact Load Interrupter Switchgear" for metering and instrument transformers.

5. Division 16 Section "Enclosed Bus Assemblies" for busway connections between transformers and secondary distribution equipment.

6. Division 16 Section "Power Factor Correction Equipment" for capacitors to be located in secondary section.

7. Division 16 Section "Transfer Switches" for transfer switches that may be located in secondary distribution section.

8. Division 16 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" for transient voltage surge suppressors for low-voltage power, control, and communication equipment that may be located in secondary section.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required

clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

2. Dimensioned plans and elevations showing major components and features.

3. One-line diagram.

4. List of materials.

5. Nameplate legends.

6. Size and number of bus bars and current rating for each bus, including mains and branches of phase, neutral, and ground buses.

7. Short-time and short-circuit current ratings of secondary unit substations and components.

8. Ratings of individual protective devices.

C. Time-Current Characteristic Curves: For overcurrent protective devices.

D. Primary Fuses: Submit recommendations and size calculations.

E. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and ground rod locations.

2. Location of structural supports for structure-supported raceways, busways, and seismic bracing.

3. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

F. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Product Certificates: For secondary unit substations, signed by product manufacturer.

H. Qualification Data: For testing agency.

I. Material Test Reports: For secondary unit substations.

J. Factory test reports.

K. Field quality-control test reports.

L. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain secondary unit substation through one source from a single manufacturer.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of secondary unit substations and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

D. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with IEEE C2.

F. Comply with IEEE C37.121.

G. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate delivery of secondary unit substations to allow movement into designated space.

C. Store secondary unit substation components protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

D. Handle secondary unit substation components according to manufacturer's written instructions. Use factory-installed lifting provisions.

1.7 PROJECT CONDITIONS

A. Field Measurements: Indicate measurements on Shop Drawings.

B. Interruption of Existing electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager and Owner no fewer than 14 days in advance of proposed

interruption of electric service.

2. Do not proceed with interruption of electric service without Construction Manager's and Owner's written permission.

C. Service Conditions: IEEE C37.121, usual service conditions, except for the following:

1. Exposure to significant solar radiation.

2. Altitudes above 3300 feet.

3. Exposure to fumes, vapors, or dust.

4. Exposure to explosive environments.

5. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.

6. Exposure to seismic shock or to abnormal vibration, shock, or tilting.

7. Exposure to excessively high or low temperatures.

8. Unusual transportation or storage conditions.

9. Unusual grounding resistance conditions.

10. Unusual space limitations.

1.8 COORDINATION

A. Coordinate layout and installation of secondary unit substations with other construction that penetrates floors and ceilings, or is supported by them, including light fixtures, HVAC equipment, and fire-suppression-system components.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare fuses: Six of each type and rating of fuse and fusible device used, except for medium-voltage fuses and fuses associated with network protector. Include spares for the following:

a. Primary disconnect fuses.
b. Potential transformer fuses.
c. Control power fuses.
d. Fuses and fusible devices for fused circuit breakers.
e. Fuses for secondary fusible devices.

2. Spare Indicating Lights: Six of each type installed.

3. Touchup Paint: Three half-pint containers of paint matching enclosure's exterior finish.

4. Primary Switch Contact Lubricant: One container(s).

5. One set(s) of spare mounting gaskets for bushings, handholes, and the gasket between relief cover and flange of pressure relief device.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; Schneider Electric.

2. Cutler-Hammer.

3. Siemens Energy & Automation, Inc.(except for Air insulated switches)

2.2 MANUFACTURED UNITS

A. Indoor Unit Arrangement: Single assembly or separate secondary distribution equipment connected with busway as per one lines and plans.

B. Enclosure Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.3 INCOMING SECTION

A. Primary Incoming Section: Air Terminal Chamber assembly with adequate space for incoming-cable terminations and surge arresters.

B. Surge Arresters: Comply with IEEE C62.11, Distribution class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.

C. Provide infrared scanning ports for each section as required to allow a full scanner view of all parts requiring thermographic inspection. Window shall comply with IEEE C3T.20.2 and be NEMA 4 rated.

D. Refer to Section 16341 for primary requirements

2.4 TRANSFORMER SECTION

A. Refer to Section 16271.

2.5 SECONDARY DISTRIBUTION SECTION

A. Secondary Terminal Compartment: Bus bars mounted on standoff insulators.

B. Secondary Distribution: Low-voltage switchgear as specified in Division 16, "Low-Voltage Switchgear."

2.6 IDENTIFICATION DEVICES

A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 16 Section "Identification for Electrical Systems."

2.7 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to ANSI C37.51.

B. Factory Tests: Perform the following factory-certified tests on each secondary unit substation:

1. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.

2. Ratios on the rated voltage connection and on tap extreme connections.

3. Polarity and phase relation on the rated voltage connection.

4. No-load loss at rated voltage on the rated voltage connection.

5. Exciting current at rated voltage on the rated voltage connection.

6. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.

7. Applied potential.

8. Induced potential.

9. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class FA rating.

a. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.

10. Owner will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of work.

B. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.

2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit

substation installation.

D. Verify that ground connections are in place and that requirements in Division 16 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at secondary unit substation location.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install secondary unit substations on concrete bases.

1. Anchor secondary unit substations to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 16 Sections "Hangers and Supports for Electrical Systems" and "Vibration and Seismic Controls for Electrical Systems."

2. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.

3. Use 3000-psi 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete ."

4. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.

5. Install epoxy-coated anchor bolts for anchoring equipment to the concrete base.

6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

7. Bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 16 Section "Identification for Electrical Systems."

B. Operating Instructions: Frame printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of secondary unit substation.

3.4 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Testing: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

C. Testing: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

D. Perform the following field tests and inspections and prepare test reports:

1. Perform each visual and mechanical inspection and electrical test according to NETA ATS. Certify compliance with test parameters.

2. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation tested at the specified value or less.

3. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.

4. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

a. Remove and replace malfunctioning units and retest as specified above.

3.7 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.

2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

a. Adjust transformer taps.
b. Rebalance loads.
c. Prepare written request for voltage adjustment by electric utility.

3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.

4. Report: Prepare a written report covering monitoring performed and corrective action

taken.

B. Infrared Scanning: Perform as specified in Division 16 Section "Medium-Voltage Compact Load Interrupter Switchgear."

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems. Refer to Division 01 Section "Demonstration and Training."

+ + END OF SECTION + +

SECTION 16410 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Molded-case switches.
7. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.

2. Current and voltage ratings.

3. Short-circuit current ratings (interrupting and withstand, as appropriate).

4. Include evidence of NRTL listing for series rating of installed devices.

5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

6. Include time-current coordination curves (average melt) for each type and rating of

overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

7. Manufacturer's selective coordination selection tables, where applicable.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

C. Qualification Data: For qualified testing agency.

D. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

4. Test procedures used.

5. Test results that comply with requirements.

6. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Manufacturer's field service report.

F. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NFPA 70.

1.7 PROJECT CONDITIONS

A. Refer to Section 16051 "Common Work Results for Electrical" for Project Conditions.

1.8 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.9 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

2. Fuse Pullers: Two for each size and type.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. Siemens Energy & Automation, Inc.

3. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.

5. Hookstick Handle: Allows use of a hookstick to operate the handle.

6. Lugs: Mechanical type, suitable for number, size, and conductor material.

7. Service-Rated Switches: Labeled for use as service equipment.

8. Accessory Control Power Voltage: Remote mounted and powered; 24V ac.

2.2 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Siemens Energy & Automation, Inc.

4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Double Throw, [600]-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.

4. Hookstick Handle: Allows use of a hookstick to operate the handle.

5. Lugs: Mechanicaltype, suitable for number, size, and conductor material.

6. Accessory Control Power Voltage: Remote mounted and powered; 24-V ac

2.3 SHUNT TRIP SWITCHES [ELEVATOR DISCONNECT SWITCHES]

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton (Cutler-Hammer)

2. Siemens

3. Square "D"

B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98.

C. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and circuit breaker as indicated on drawings; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.

E. Accessories:

1. Oiltight key switch for key-to-test function.

2. Oiltight green ON pilot light.

3. Isolated neutral lug; 100 percent rating.

4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.

5. Form C alarm contacts that change state when switch is tripped.

6. Three-pole, double-throw, fire-safety and alarm relay; 24-V dc coil voltage.

7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

2.4 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; a brand of Schneider Electric.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

3. Siemens Energy & Automation, Inc.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and smaller.

D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings for circuit breaker frame sizes 400A and greater:

1. Instantaneous trip.

2. Long- and short-time pickup levels.

3. Long- and short-time time adjustments.

4. Ground-fault pickup level, time delay, and I^2t response.

F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

G. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

H. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

I. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.

2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.

3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.

4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.

5. Communication Capability: Circuit-breaker-mounted] Integral communication module with functions and features compatible with power monitoring and control system, specified in Division 16 Section "Electrical Power Monitoring and Control."

6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.

7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

8. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

9. Alarm Switch: One NO/ NC contact that operates only when circuit breaker has tripped.

10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

11. Electrical Operator: Provide remote control for on, off, and reset operations.

2.5 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. Siemens Energy & Automation, Inc.

3. Square D; a brand of Schneider Electric.

B. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Features and Accessories:

1. Standard frame sizes and number of poles.

2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.

3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.

4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.

5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic

switch contacts, "b" contacts operate in reverse of switch contacts.

7. Alarm Switch: One NO/ NC contact that operates only when switch has tripped.

8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.

9. Electrical Operator: Provide remote control for on, off, and reset operations.

2.6 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.

2. Outdoor Locations: NEMA 250, Type 3R.

3. Kitchen Wash-Down Areas: NEMA 250, Type 4X stainless steel.

4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.

5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

6. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7 Type 9.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Division 16 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 16 Section "Overcurrent Protective Device Coordination Study".

+ + END OF SECTION + +

SECTION 16415 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.

2. Bypass/isolation switches.

3. Remote annunciation systems.

4. Remote annunciation and control systems.

B. Related Sections include the following:

1. Division 15 Section "Electric-Drive, Centrifugal Fire Pumps" for automatic transfer switches for fire pumps.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: For manufacturer and testing agency.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Features and operating sequences, both automatic and manual.

2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switches, bypass/isolation switches nonautomatic transfer switches, remote annunciators, and remote annunciator and control panels through one source from a single manufacturer. All equipment shall be obtained from its original manufacturer or an authorized distributor thereof. Relabled or repackaged OEM equipment shall not be accepted.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NEMA ICS 1.

F. Comply with NFPA 70.

G. Comply with NFPA 99.

H. Comply with NFPA 110.

I. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.5 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:

1. Notify Architect, Construction Manager, and Owner no fewer than fourteen (14) days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Contactor Transfer Switches:

a. Emerson; ASCO Power Technologies, LP.
b. Russelectric, Inc.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008, without the use of specific fuse or breaker protection (any breaker rating)..

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.

2. Switch Action: Double throw; mechanically held in both directions.

3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.

H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

I. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated,

with an internal heater. Provide thermostat within enclosure to control heater.

J. Battery Charger: For generator starting batteries.

1. Float type rated 10 A.

2. Ammeter to display charging current.

3. Fused ac inputs and dc outputs.

K. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

L. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 16 Section "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.

2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.

3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

M. Enclosures: General-purpose NEMA 250, Type 1 , complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

F. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

G. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

H. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before

transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.

I. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.

J. Automatic Transfer-Switch Features:

1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.

2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.

3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.

5. Test Switch: Simulate normal-source failure.

6. Switch-Position Pilot Lights: Indicate source to which load is connected.

7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

   a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
   b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.

9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.

11. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine

generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
b. Push-button programming control with digital display of settings.
c. Integral battery operation of time switch when normal control power is not available.

K. Power Manager:

1. Furnish Power Managers for each ATS to monitor all functions specified below.

a. The Power Managers shall be listed to UL 3111-1, CSA, CE Mark, and industrially rated for an operating temperature range of -20°C to 60°C.
b. The Power Manager shall be accurate to 1% measured, 2% computed values and display resolution to .1%. Voltage and current for all phases shall be sampled simultaneously to assure high accuracy in conditions of low power factor or large waveform distortions (harmonics).
c. The Power Manager shall be capable of operating without modification at nominal frequencies of 45 to 66 Hz and over a control power input range of 20 – 32VDC.
d. Each Power Manager shall be capable of interfacing with a communications module to permit information to be sent to central location for display, analysis, and logging.
e. The Power Manager shall accept inputs from industry standard instrument trans-formers (120 VAC secondary PTs and 5A secondary CTs.) Direct phase voltage connections, 600 VAC and under, shall be possible without the use of PTs.
f. The Power Manager shall be applied in single, 3-phase, or three & four wire circuits. A fourth CT input shall be available to measure neutral or ground current.
g. All setup parameters required by the Power Manager shall be stored in non-volatile memory and retained in the event of a control power interruption.
h. The Power Managers shall be equipped with a continuous duty, long-life, 4 line x 20 character LCD backlit display to provide local access to the following metered quantitites:

1) Current, per phase RMS and neutral (if applicable)
2) Current Unbalance %
3) Voltage, phase-to-phase and phase-to-neutral
4) Voltage Unbalance %
5) Real power, per phase and 3-phase total
6) Apparent power, per phase and 3-phase total
7) Reactive power, per phase and 3-phase total
8) Power factor, 3-phase total & per phase Frequency
9) Accumulated Energy, (MWH, MVAH, and MVARH)

2. Power Manager Input/Output Options:

a. Provide (8) solid state status inputs.
b. Provide four (4) relay output contacts

3. For ease in operator viewing, the display shall remain on continuously, with no detrimental effect on the life of the Power Manger.

4. Setup for system requirements shall be allowed from the front of the Power Manager. Setup provisions shall include:

   a. CT rating (1200:5)
   b. PT rating (480:120) (if applicable; 24000V maximum)
   c. System type (single; three phase; 3 and 4 wire)
   d. Communication parameters

5. Reset of Real energy (KWH), apparent energy (KVAH) and reactive energy (KVARH) shall be allowed from the front of the Power Manager.

6. All reset and setup functions shall have a means for protection against unauthorized/accidental changes.

2.4 BYPASS/ISOLATION SWITCHES

A. Comply with requirements for Level 1 equipment according to NFPA 110.

B. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:

1. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.

2. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.

3. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.

4. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.

5. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.

6. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.

7. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

C. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

2.5 REMOTE ANNUNCIATOR SYSTEM

A. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:

1. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.

2. Switch position.

3. Switch in test mode.

4. Failure of communication link.

B. Annunciator Panel: LED-lamp type with audible signal and silencing switch.

1. Indicating Lights: Grouped for each transfer switch monitored.

2. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.

3. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.

4. Lamp Test: Push-to-test or lamp-test switch on front panel.

2.6 REMOTE ANNUNCIATOR AND CONTROL SYSTEM

A. Functional Description: Include the following functions for indicated transfer switches:

1. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.

2. Indication of switch position.

3. Indication of switch in test mode.

4. Indication of failure of digital communication link.

5. Key-switch or user-code access to control functions of panel.

6. Control of switch-test initiation.

7. Control of switch operation in either direction.

8. Control of time-delay bypass for transfer to normal source.

B. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.

C. Remote Annunciation and Control Panel: Solid-state components. Include the following features:

1. Controls and indicating lights grouped together for each transfer switch.

2. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.

3. Digital Communication Capability: Matched to that of transfer switches supervised.

4. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.

2.7 SOURCE QUALITY CONTROL

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 16 Section "Vibration and Seismic Controls for Electrical Systems."

B. Floor-Mounting Switch: Anchor to floor by bolting.

1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 16 Section "Hangers and Supports for Electrical Systems."

C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.

D. Identify components according to Division 16 Section "Identification for Electrical Systems."

E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.

2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.

3. Perform each visual and mechanical inspection and electrical test stated in NETA

Acceptance Testing Specification. Certify compliance with test parameters.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

   a. Check for electrical continuity of circuits and for short circuits.
   b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
   c. Verify that manual transfer warnings are properly placed.
   d. Perform manual transfer operation.

5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

   a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
   b. Simulate loss of phase-to-ground voltage for each phase of normal source.
   c. Verify time-delay settings.
   d. Verify pickup and dropout voltages by data readout or inspection of control settings.
   e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
   f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
   g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

   a. Verify grounding connections and locations and ratings of sensors.

D. Testing Agency's Tests and Inspections:

1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

   a. Check for electrical continuity of circuits and for short circuits.
   b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
   c. Verify that manual transfer warnings are properly placed.
   d. Perform manual transfer operation.

4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

   a. Simulate power failures of normal source to automatic transfer switches and of

emergency source with normal source available.

b. Simulate loss of phase-to-ground voltage for each phase of normal source.

c. Verify time-delay settings.

d. Verify pickup and dropout voltages by data readout or inspection of control settings.

e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.

f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

a. Verify grounding connections and locations and ratings of sensors.

E. Coordinate tests with tests of generator and run them concurrently.

F. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

G. Remove and replace malfunctioning units and retest as specified above.

H. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Division 01 Section "Demonstration and Training."

B. Coordinate this training with that for generator equipment.

+ + END OF SECTION + +

SECTION 16441 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.

2. Transient voltage suppression devices.

3. Disconnecting and overcurrent protective devices.

4. Instrumentation.

5. Control power.

6. Accessory components and features.

7. Identification.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.

2. Detail enclosure types for types other than NEMA 250, Type 1.

3. Detail bus configuration, current, and voltage ratings.

4. Detail short-circuit current rating of switchboards and overcurrent protective devices.

5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

6. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

7. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Qualification Data: For qualified Installer and testing agency.

D. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field Quality-Control Reports:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for switchboards and all installed components.

2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and

trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Comply with NEMA PB 2.

G. Comply with NFPA 70.

H. Comply with UL 891.

I. All equipment including circuit breakers shall be procured from an authorized manufacturers' distributor. Proof of purchase in the form of an authorized distributor's invoice shall be required. Reconditioned or brokered equipment will not be acceptable.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and connect factory-installed space heaters to temporary electrical service to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.7 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 104 deg F.
b. Altitude: Not exceeding 6600 feet.

C. Service Conditions: NEMA PB 2, usual service conditions, as follows:

1. Ambient temperatures within limits specified.

2. Altitude not exceeding 6600 feet.

D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager and Owner no fewer than 14 days in advance of proposed interruption of electric service.

2. Indicate method of providing temporary electric service.

3. Do not proceed with interruption of electric service without Construction Manager's, Owner's written permission.

4. Comply with NFPA 70E.

1.8 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; a brand of Schneider Electric.

2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

3. Siemens Energy & Automation, Inc.

B. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.

2. Branch Devices: Panel mounted.

3. Sections front and rear aligned.

C. Front- and Side-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.

2. Branch Devices: Panel mounted.

3. Sections front and rear aligned.

D. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."

E. Indoor Enclosures: Steel, NEMA 250, Type 1.

F. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

G. Barriers: Between adjacent switchboard sections.

H. Cubicle Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point.

2. Space-Heater Power Source: Transformer, factory installed in switchboard.

I. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

J. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

K. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws, for access to rear interior of switchboard.

L. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

M. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.

2. Set back from front to clear circuit-breaker removal mechanism.

3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.

4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.

5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

N. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated, with tin-plated aluminum or copper feeder circuit-breaker line connections.

2. Ground Bus: 1/4-by-2-inch- hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.

4. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise

indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

O. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

P. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

2.2 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Refer to Division 16 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" for requirements.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents. Series rated equipment is not acceptable.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

a. Instantaneous trip.
b. Long- and short-time pickup levels.
c. Long- and short-time time adjustments.
d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. Integrally Fused Circuit Breakers: Not allowed

6. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).

8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
d. Ground-Fault Protection: Integrally mounted relay and trip unit with

adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

e. Communication Capability: Circuit-breaker-mounted Integral communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring and Control."

f. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.4 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; bushing] type; single-secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.

2. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.

3. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Megawatts: Plus or minus 2 percent.
e. Megavars: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.

2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.

3. Cyclometer.

4. Four-dial, totalizing kilowatt-hour register.

5. Positive chart drive mechanism.

6. Capillary pen holding a minimum of one month's ink supply.

7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.

8. Capable of indicating and recording 15 minute integrated demand of totalized system.

2.5 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

D. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

2.7 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

H. Comply with NECA 1.

3.3 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Division 16 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Comply with requirements for terminating cable trays specified in Division 16 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 16 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 16 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 16 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

E. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and rear panels where applicable so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Switchboard will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicate, or as specified in Division 16 Section "Overcurrent Protective Device Coordination Study."

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units, where applicable.

+ + END OF SECTION + +

SECTION 16442 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.

2. Lighting and appliance branch-circuit panelboards.

3. Load centers.

4. Electronic-grade panelboards.

1.3 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. TVSS: Transient voltage surge suppressor.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.

2. Detail enclosure types and details for types other than NEMA 250, Type 1.

3. Detail bus configuration, current, and voltage ratings.

4. Short-circuit current rating of panelboards and overcurrent protective devices.

5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

6. Include wiring diagrams for power, signal, and control wiring.

7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

C. Qualification Data: For qualified testing agency.

D. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field Quality-Control Reports:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

G. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions. Submission of a bid indicates that the Contractor and Manufacturer warrant that the submitted equipment will meet the specification and space requirements.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a

qualified testing agency, and marked for intended location and application.

E. Comply with NEMA PB 1.

F. Comply with NFPA 70.

G. All equipment including circuit breakers shall be procured from an authorized manufacturer's distributor. Proof of purchase in the form of an authorized distributor's invoice shall be required. Reconditioned or brokered equipment will not be acceptable.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.8 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F (plus 40 deg C).
b. Altitude: Not exceeding 6600 feet

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.

2. Altitude not exceeding 6600 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Construction Manager and Owner no fewer than 14 days in advance of proposed interruption of electric service.

2. Do not proceed with interruption of electric service without Construction Manager's and Owner's written permission.

3. Comply with NFPA 70E.

1.9 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

1.11 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.

2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.

3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."

B. Enclosures: Flush- and surface-mounted cabinets, as indicated on drawings and schedules.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1
b. Outdoor Locations: NEMA 250, Type 3R
c. Kitchen or Wash-Down Areas: NEMA 250, Type 4X , stainless steel
d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4 .
e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

3. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.

4. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.

5. Finishes:

a. Panels and Trim: Steel door - indoor construction, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
b. Back Boxes: Same finish as panels and trim.

6. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.

C. Incoming Mains Location: Top or bottom as per Contractor field selection. .

D. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

3. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads. (Where indicated on drawings)

E. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.

2. Main and Neutral Lugs: Mechanical type.

3. Ground Lugs and Bus-Configured Terminators: Mechanical type.

4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

6. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; a brand of Schneider Electric.

2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

3. Siemens Energy & Automation, Inc.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: As indicated on drawings/schedules.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Square D; a brand of Schneider Electric.

2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

3. Siemens Energy & Automation, Inc.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: As indicated on drawings/schedules.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

F. Doors: Door-in-door construction with concealed hinges; secured with flush latch with tumbler lock; keyed alike.

G. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. Siemens Energy & Automation, Inc.

3. Square D; a brand of Schneider Electric.

H. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents. Series rated equipment is not permitted.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and smaller.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip for circuit breaker frame sizes larger than 250A; and the following field-adjustable settings:

   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I^2t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).

7. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
   c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
   d. Ground-Fault Protection: Integrally mounted -relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   e. Communication Capability: Circuit-breaker-mounted, Integral communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring and Control."
   f. Shunt Trip: 24 V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
   g. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
   h. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
   i. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
   j. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
   k. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
   l. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.4 PANELBOARD SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Current Technology; a subsidiary of Danahar Corporation.

2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

3. Liebert Corporation.

4. Siemens Energy & Automation, Inc.

5. Square D; a brand of Schneider Electric.

6. Citel

B. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, solid-state, parallel-connected, non-modular type, with sine-wave tracking suppression and filtering modules, UL 1449, third edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:

1. Accessories:

a. LED indicator lights for power and protection status.
b. Audible alarm, with silencing switch, to indicate when protection has failed.
c. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.

C. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, bolt-on, solid-state, parallel-connected, type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:

1. Accessories:

a. Fabrication using bolted compression lugs for internal wiring.
b. Redundant suppression circuits.
c. Redundant replaceable modules.
d. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
e. LED indicator lights for power and protection status.
f. Audible alarm, with silencing switch, to indicate when protection has failed.
g. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
h. Six-digit, transient-event counter set to totalize transient surges.

2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.

3. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.

a. Line to Neutral: 70,000 A.
b. Line to Ground: 70,000 A.
c. Neutral to Ground: 50,000 A.

4. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

5. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277, 208Y/120-V, three-phase, four-wire circuits shall be as follows:

a. Line to Neutral: 800 V for 480Y/277, 400 V for 208Y/120.
b. Line to Ground: 800 V for 480Y/277, 400 V for 208Y/120.
c. Neutral to Ground: 800 V for 480Y/277, 400 V for 208Y/120.

6. Protection modes and UL 1449 SVR for 240/120-V, single-phase, three-wire circuits shall be as follows:

   a. Line to Neutral: 400 V.
   b. Line to Ground: 400 V.
   c. Neutral to Ground: 400 V.

7. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:

   a. Line to Neutral: 400 V, 800 V from high leg.
   b. Line to Ground: 400 V.
   c. Neutral to Ground: 400 V.

8. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:

   a. Line to Line: 2000 V for 480 V 1000 V for 240 V.
   b. Line to Ground: 1500 V for 480 V 800 V for 240 V.

2.5 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Equipment Mounting: Install panelboards on concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."

   1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.

   2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

   3. Place and secure anchorage devices. Use setting drawings, templates, diagrams,

instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to panelboards.

5. Attach panelboard to the vertical finished or structural surface behind the panelboard.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Comply with mounting and anchoring requirements specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."

E. Mount top of trim 90 inches above finished floor unless otherwise indicated.

F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

H. Install filler plates in unused spaces.

I. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

J. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

K. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 16 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 16 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 16 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as indicated or as specified in Division 16 Section "Overcurrent Protective Device Coordination Study."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.

2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.

3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.

4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

+ + END OF SECTION + +

SECTION 16461 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.

2. Buck-boost transformers.

1.3 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: For testing agency.

E. Source quality-control test reports.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.6 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Products.

2. Power Smiths.

3. Siemens Energy & Automation, Inc.

4. Sola/Hevi-Duty.

5. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.

2. Coil Material: Aluminum

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated, NEMA 250, Type 2.

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: ANSI 49 gray.

F. Taps for Transformers Smaller than 3 kVA: One 5 percent tap above normal full capacity.

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity Two 5 percent taps below rated voltage.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

I. Insulation Class: 220 deg C, UL-component-recognized insulation system with a 150 deg C rise above 40 deg C ambient temperature, unless otherwise indicated on drawings.

J. Energy Efficiency for Transformers Rated 15 kVA and Larger:

1. Transformers shall be provided with minimum efficiency levels at 50% load that meets or exceeds DOE 2010 requirements.

2. Tested according to NEMA TP 2, CSL 3

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.

2. Indicate value of K-factor on transformer nameplate.

L. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.

2. Include special terminal for grounding the shield.

3. Shield Effectiveness:

a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

M. Wall Brackets: Manufacturer's standard brackets.

N. Fungus Proofing: Permanent fungicidal treatment for coil and core.

O. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.4 BUCK-BOOST TRANSFORMERS

A. Description: Self-cooled, two-winding dry type, rated for continuous duty and with wiring terminals suitable for connection as autotransformer. Transformers shall comply with NEMA ST 1 and shall be listed and labeled as complying with UL 506 or UL 1561.

B. Enclosure: Ventilated, NEMA 250, Type 2.

1. Finish Color: ANSI 49 gray [other color specified by Architect].

2.5 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 16 Section "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Division 16 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Brace wall-mounting transformers as specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems.

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions[, seismic codes applicable to Project,] and requirements in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."

3.3 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 16 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: [Owner will engage] [Engage] a qualified testing agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

E. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.

2. Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.

3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

G. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

+ + END OF SECTION + +

SECTION 16491 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600-V ac and less for use in control circuits and enclosed switches.

2. Spare-fuse cabinets.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.

3. Current-limitation curves for fuses with current-limiting characteristics.

4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

5. Coordination charts and tables and related data.

6. Fuse sizes for elevator feeders and elevator disconnect switches.

B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.

2. Current-limitation curves for fuses with current-limiting characteristics.

3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

4. Coordination charts and tables and related data.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.7 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Bussmann, Inc.

2. Ferraz Shawmut, Inc.

3. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.

2. Finish: Gray, baked enamel.

3. Identification: "SPARE FUSES" in 1-1/2-inch-high letters on exterior of door.

4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Service Entrance: Class L, time delay.

2. Feeders: Class RK5, time delay.

3. Motor Branch Circuits: Class RK5,

4. Other Branch Circuits: Class J, fast acting.

5. Control Circuits: Class CC, time delay.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s).

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 16 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

+ + END OF SECTION + +

SECTION 16500 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes all interior luminaires complete with sockets, reflectors, diffusers, shades, holders, lamps, ballasts, protective devices and all other required appurtenances.

B. Requirements of Division16 are applicable, fully or in part to this section as if repeated herein. Provide all basic materials applicable to work in strict accordance with methods specified herein and with manufacturer's recommendations.

C. Include all wiring connections to branch circuits, control switches, and controllers.

1.2 RELATED WORK

A. Division 16, General Electrical Provisions

B. Division 16, Exterior Lighting

C. Division 16, Lighting Control Devices

1.3 REGULATORY AGENCIES

A. Conform to the applicable requirements of the following agencies' most current edition of regulations and standards, unless otherwise stated:

1. American National Standards Institute (ANSI)

2. Illuminating Engineering Society of North America (IESNA)

3. Federal Communications Commission (FCC)

4. Environmental Protection Agency Green Lights Program

1.4 SUBMITTAL AND SAMPLES

A. Submit Shop Drawings and Product Data in accordance with Section 013300.

B. Shop Drawings shall be in the form of standard catalog cuts and/or factory assembly drawings, and shall indicate the following:

1. Luminaire Type

2. Luminaire and Lamp/Ballast/Driver voltage

3. Luminaire and Lamp wattage

4. Luminaire efficiency

5. Luminaire efficacy

6. Complete photometric data

7. Manufacturer's name and catalog number including all fixture options

8. Lamp and ballast/driver types and manufacturer's name

9. Warranty information for lamps and ballasts/ drivers

10. Lamp color temperature (CCT), color rendering index (CRI), and beam spread.

11. Cutsheets for surge protection device, if applicable

C. Submit sample luminaires as directed by Architect/Engineer.

D. Submit application, installation and start up instruction. Submit within 30 days of shop drawing approval to facilitate the commissioning process outlined in Division 01.

E. Submit training information for the Training Plan required per Sections 017900.

F. Submit Operation and Maintenance information, to provide the content of the Operation and Manuals, specified in Sections 017823, relative to systems and equipment of this section. All submittals must be provided in hard copy and electronic copy in Portable Document Format per Section 013300.

G. Submit project specific mounting for luminaires for each ceiling type and location as shown on plans.

1.5 COORDINATION

A. Prior to ordering luminaires, verify exact type of ceiling to be used for each space. Refer to Division 9 and Reflected Ceiling Plans.

B. Coordinate with Division 23 to avoid conflicts between luminaires and Mechanical and Plumbing piping, ductwork, supports, fittings and equipment.

C. Furnish to other trades, plaster frames, trim rings, etc., where required.

1.6 WARRANTY

A. T8 and T5/T5HO Fluorescent lamps shall have a warranty for a minimum of two (2) years from the date of Owner occupancy at project completion, against defects in material or workmanship. Should a lamp fail during the warranty period, a new lamp shall be supplied at no charge. The replacement lamp shall be identical to or an improvement upon the original lamp.

B. Electronic Ballasts shall have a warranty for a minimum of five (5) years, against defects in material or workmanship, from the date of Owner occupancy at project completion. Should a ballast fail during the warranty period, a new ballast shall be supplied to the Owner at no charge, and a labor allowance of $15.00 for each defective ballast shall be supplied to the Owner. The replacement ballast shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

C. Fluorescent Dimming Ballasts: Provide a minimum three (3) year warranty against defects in material or workmanship, from the date of Owner occupancy at project completion. Should a ballast fail during the warranty period, a new ballast shall be supplied to the Owner at no charge, and a labor allowance of $15.00 for each defective ballast shall be supplied to the Owner. The replacement ballast shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

D. Electronic Metal Halide Ballasts: Provide a minimum three (3) years warranty against defects in material or workmanship from the date of Owner occupancy at project completion. Should a ballast fail during the warranty period, a new ballast shall be supplied to the Owner at no charge, and a labor allowance of $25.00 for each defective ballast shall be supplied to the Owner. The

replacement ballast shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

E. LED Luminaire Assembly: Provide a minimum five-year warranty covering maintained integrity and functionality of

1. Luminaire housing, wiring, and connections

2. LED light source(s)

3. LED driver(s)

F. Warranty period shall begin 90 days after date of invoice, or as negotiated by owner such as in the case of an auditable asset management system.

1.7 WORK INSTALLED BUT FURNISHED BY OTHERS

A. Receive, unpack, check, install and lamp luminaires furnished by others and be responsible for them until finally accepted. Maintain a record of all damaged or imperfect luminaires and store same as and where directed.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Luminaires

1. Refer to "Lighting Fixture Schedule" on the Drawings.

B. Incandescent and Halogen lamps

1. Osram-Sylvania

2. Philips

3. General Electric

4. Ushio

C. Fluorescent Lamps

1. Osram-Sylvania

2. Philips

3. General Electric

D. HID Lamps

1. Osram-Sylvania

2. Philips

3. General Electric

4. Venture

E. Tubular Fluorescent Lamp Ballasts

1. Universal Lighting Technologies
2. Advance Transformer Co.
3. Osram-Sylvania
4. General Electric

F. Compact Fluorescent Lamp Ballasts

1. Robertson
2. Advance Transformer Co.
3. Universal Lighting Technologies
4. Osram-Sylvania

G. Magnetic HID Lamp Ballasts

1. Advance Transformer Co.
2. Universal Lighting Technologies
3. Sylvania

H. Metal Halide Electronic Ballasts

1. Aromat Matsushita
2. Advance Transformer Company
3. Sylvania

I. Fluorescent Emergency Battery Ballasts

1. Bodine
2. Iota

J. Tubular Fluorescent Dimming Ballasts, Continuous Dimming

1. Lutron
2. Advance Transformer Co.
3. Lutron

K. Compact Fluorescent Dimming Ballasts, Continuous Dimming from 100%-10% or 5% Light Output

1. Lutron
2. Advance Transformer Co.

3. Philips

4. Energy Savings Inc.

L. LED Drivers

1. OSRAM

2. Thomas Research

3. Phillips Advance

4. Tridonic Transformer Co.

M. LED Dimming Drivers

1. OSRAM

2. Thomas Research

3. Phillips Advance

4. Lutron

N. Substitutions

1. Refer to requirements listed in Division 1. Acceptable alternate manufacturers are listed on Lighting Fixture Schedule. If no equal is shown, only the specified fixture is acceptable.

2.2 FLUORESCENT, INCANDESCENT, LED AND HID LUMINAIRES

A. Unpainted luminaire parts shall be either anodized aluminum, noncorrosive grade stainless steel or an equivalent noncorrosive material.

B. Luminaire housing and door frame shall be fully sealed against light leakage. Light leaks between ceiling trims of recessed luminaires and ceiling will not be acceptable.

C. Alzak parabolic cones shall be guaranteed against fading for a minimum of two (2) years. In the event of premature fading, luminaire manufacturer shall replace cones and pay for both labor and material costs.

D. Luminaires shall have low iridescent reflectors, baffles, and louvers.

E. Adjustable luminaires shall be capable of being locked into position. Aim and adjust all adjustable luminaires to the satisfaction of the Owner and the Architect.

F. Compact fluorescent luminaires shall be manufactured specifically for compact fluorescent lamps with ballasts integral to the luminaire. Providing assemblies designed to retrofit incandescent luminaires is prohibited except when specifically indicated. Luminaires shall use lamps as indicated on Lighting Fixture Schedule.

G. Where plastic lenses, diffusers or shields are specified, provide 100% virgin acrylic, Plexiglas or Lucite. Frameless lenses shall have a minimum thickness of 0.16 inches and shall be guaranteed against undue deflection. Unless otherwise specified, framed" plastic lenses shall be of sufficient thickness to assure rigidity within lens frame and be guaranteed against undue deflection.

H. Luminaires shall bear U.L. or other Nationally Recognized Testing Laboratory (NRTL) inspection

label. Furnish test report on request.

I. All recessed luminaires shall have housing of sufficient size to adequately dissipate heat and shall have mounting yoke and proper ceiling trim.

J. Reflector and lamp positions shall provide highest efficiency and even reflector brightness.

K. Recessed luminaires shall be removable from below to provide access to outlet or prewired luminaire box.

L. All luminaires in wet/damp locations shall be fitted with seals and gaskets to form a weatherproof, watertight assembly, and shall be of rust resistant construction and finish.

M. Unless otherwise noted, all luminaires using metal halide lamps with ANSI rating "E", low voltage "MR" and "AR" lamps, and quartz "Q" single and double-ended lamps, shall be equipped with a clear protective safety glass integral with the luminaire and provided by the luminaire manufacturer.

N. Luminaires used as air handling registers shall meet requirements of NFPA 90A. All fluorescent air handling luminaires shall have air slots that are outwardly identical. Some luminaires shall be air supply type, with dual slots and a single or double side connection with an elbow, others shall be air return type with the same slots as the supply luminaires, and the remaining static luminaires are to have slots which are to be closed off above ceiling. Refer to Division 15 Drawings to determine quantity and exact location of each of the types required. Deliver all air supply, return fittings and back covers to Contractor for Division 15 for installation. Fluorescent air handling troffers to be heat exchange type (air return through lamp chamber).

O. Recessed incandescent luminaires shall be prewired with junction box as an integral part of assembly and equipped with thermal protection as required.

P. Electromagnetic interference filters shall be provided in each fluorescent luminaire where indicated. Filters shall be integral to the luminaire assembly with one filter per ballast and shall suppress electromagnetic interference in the AM radio band from 500 to 1700 kHz.

Q. Type "XL1 THU XL4" directional exit signs shall have directional indicating chevrons pointing in the direction of travel.

R. In each fluorescent luminaire that contains a fluorescent emergency ballast, provide two (2) aluminum 0.005 inch foil warning labels with a permanent type 3M adhesive having a resistance to temperatures ranging from minus 40 degrees F to plus 300 degrees F. These labels shall be placed one on either side of ballast housing cover between lamps so as to be readily seen when servicing luminaire. Labels shall have block lettering, 5/32 inches high, printed on the aluminum foil material and shall read "CAUTION - EMERGENCY LUMINAIRE - LAMP BALLAST ENERGIZED AT ALL TIMES". Suggested label manufacturers, Seton or Specified Products.

S. In each fluorescent luminaire that contains a ballast wired to an emergency source and a ballast wired to a normal source, provide two (2) aluminum 0.005 inch foil warning labels with a permanent type 3M adhesive having a resistance to temperatures ranging from minus 40 degrees F to plus 300 degrees F. These labels shall be placed one on either side of the ballast housing cover between lamps so as to be readily seen when servicing luminaire. Labels shall have block lettering, 5/32 inches high, printed on the aluminum foil material and shall read "CAUTION - BALLAST CONNECTED TO EMERGENCY SOURCE" and "CAUTION - BALLAST CONNECTED TO NORMAL SOURCE" for each respective ballast. Suggested label manufacturers, Seton or Specified Products.

T. In each fluorescent luminaire that contains a fluorescent 277 volt ballast, provide two (2) aluminum 0.005 inch foil warning labels with a permanent type 3M adhesive having a resistance to temperatures ranging from minus 40 degrees F to plus 300 degrees F. These labels shall be placed one on either side of the ballast housing cover between lamps so as to be readily seen when servicing luminaire. Labels shall have block lettering, 5/32 inches high, printed on the

aluminum foil material and shall read "CAUTION - 277 VOLTS. Suggested label manufacturers, Seton or Specified Products.

U. For fluorescent luminaires located in kitchens and food preparation areas, mechanical and electrical rooms, provide a clear polycarbonate protective sleeve over lamp, with 95% minimum light transmission.

V. Auxiliary Instant-on Quartz System: U.L. Listed, relay controlled, automatically switched instant-on 100 150 250 watt quartz lamp. Quartz lamp shall come on when luminaire is initially energized and following a momentary power outage and shall remain on until HID lamp reaches approximately 60% light output. Wiring for quartz lamp shall be internal to the ballast and shall be independent of the incoming line voltage to the ballast.

W. Auxiliary Instant-on Quartz System: U.L. Listed, relay controlled, automatically switched instant-on 150 watt quartz lamp. Quartz lamp shall come on when luminaire is initially energized and following a momentary power outage and shall remain on until HID lamp reaches approximately 60% light output. Wiring for quartz lamp shall be internal to the ballast and shall be independent of the incoming line voltage to the ballast.

2.3 LAMPS

A. Correlated color temperature (CCT), color rendering index (CRI), wattage, bulb type, and beam spread shall be as specified on Lighting Fixture Schedule. Values for CRI are minimum requirements.

B. Tubular Fluorescent Lamps:

1. Average rated life shall be minimum 20,000 hours, is based on three (3) hours of operation per start.

2. All T8 lamps shall be low-mercury type, TCLP-compliant, to meet the U.S. Environmental Protection Agency's (EPA) 1990 Toxic Characteristic Leaching Procedure (TCLP).

C. Compact Fluorescent Lamps:

1. Average rated life shall be minimum 10,000 hours.

2. Lamps shall have a minimum CRI of 82.

D. Metal Halide Lamps:

1. Standard metal halide lamps: Clear (65 CRI at 4000K)Coated (70 CRI at 3900K), for enclosed luminaires, universal burn, mogul base, wattage as indicated in Lighting Fixture Schedule.

2. Low-wattage metal halide lamps: ClearCoated for enclosed luminaires, universal burn, medium base, 70 CRI at 3200K,75 CRI at 3500K,85 CRI at 3000K (available for 70 and 100 watt lamps), wattage as indicated in Luminaire Schedule.

3. Low wattage metal halide lamps for open luminaires: ClearCoated for open or enclosed luminaires, universal burn, 70 CRI at 3200K, wattage as indicated in Luminaire Schedule.

4. Double-ended metal halide lamps: Clear, horizontal burn +/- 45 degrees, 75 CRI at 3000K,75 CRI at 4300K,85 CRI at 3000K, wattage as indicated in Luminaire Schedule.

5. PAR metal halide lamps: 81 CRI at 3000K for PAR 20, PAR 30, PAR 38 lamps,93 CRI at 4000K for PAR 38 lamps, spot; 10 degrees flood; 30 degrees wide flood; 65 degrees.

E. LED Lamps

1. LED's are to be provided by manufacturers with a minimum (8) years' experience and provide minimum (5) years warranty on all electrical parts.

2. LED components and fixtures shall comply with ANSI chromaticity standards, LM79 and IES LM-80 lumen maintenance testing standards.

3. Dimmable LED's will utilize Constant Current Reduction or Pulse Width Modulation controls.

4. White LED luminaires will provide 3500K illumination unless otherwise noted on fixture schedule and with no deviation in color temperature thru full range of dimming.

5. Color changing LED luminaires shall provide full spectrum color changing capability through the use of red, blue, green and white (amber) LED's.

6. LED lighting systems with unmatched drivers and power supplies will not be considered.

F. Incandescent Lamps: Incandescent lamps shall be halogen type unless otherwise noted.

2.4 BALLASTS

A. General: Ballasts for fluorescent and HID luminaires shall be suitable for the electrical characteristics of the supply circuits to which they are to be connected, and shall be suitable for operating the specified lamps.

B. Electronic Fluorescent Ballasts (non-dimming)

1. Unless otherwise indicated in the Luminaire Schedule, ballasts shall be solid-state, full output type (minimum 0.87 ballast factor) for use on all fluorescent lamps (except 2 pin compact fluorescent).

2. All ballasts shall be U.L. listed, Class "P", high power factor, 90% or above.

3. Unless otherwise noted, only single two-lamp, three-lamp, and four-lamp fluorescent ballasts shall be used in any one luminaire. Utilize tandem wiring to accommodate.

4. Ballasts shall have a Class "A" sound rating or better.

5. Total harmonic distortion (THD) shall be less than 20% 10%

6. Ballasts shall have an average lamp current crest factor of less than 1.7.

7. Ballasts shall meet minimum efficiency standards of Public Law No. 100-357, National Appliance Energy Conservation Amendments of 1988, and meet requirements of the FCC regulations Part 18, Governing Electromagnetic and Radio Frequency interference.

8. Ballasts shall have a frequency of 20-40 kHz to minimize interference and operate without visible flicker.

9. Maximum ballast case operating temperature shall not exceed 60 degrees C.

10. Compact fluorescent T2, T4, and T5 lamp ballasts shall include an end of life shutdown circuit.

11. The electronic ballast shall support a sustained short to ground or open circuit of any output leads without damage to the ballast.

12. Starting method shall be rapid or programmed start for all ballasts controlled by occupancy sensors or as noted on Lighting Fixture Schedule.

13. All luminaires of the same type must contain the same ballast from the same manufacturer. No exceptions will be allowed.

C. 2-pin, T4, compact fluorescent lamp ballasts: Provide high power factor type ballast.

D. Fluorescent emergency battery ballasts: Emergency lighting shall be provided by using a standard fluorescent luminaire equipped with an emergency ballast. This emergency ballast shall consist of a high-temperature, maintenance-free nickel cadmium battery, charger and electronic circuitry contained in ballast case. A solid-state charging indicator light to monitor the charger and battery, double-pole test switch, and installation hardware shall be provided or factory installed in the luminaire. Test switch shall be operable from outside of the luminaire, and pilot light shall be visible from outside of the luminaire. The emergency ballast shall be capable of operating at reduced illumination in the emergency mode one or two (2-foot, 3-foot, 4-foot, or U-lamp) T5, T8, or T12 lamps, 36-40 watt T5 twin tube fluorescent lamps, or 9-26 watt compact fluorescent lamps for a minimum of 90 minutes. The ballast shall produce 900 to 3,000 lumens initial emergency light output for T5, T8, or T12 lamps and 475 to 970 lumens initial emergency light output for compact fluorescent lamps. Ballasts shall comply with emergency standards set forth by the current NEC. The emergency ballast shall be U.L. listed for installation either inside or on top of the luminaire.]

E. Tubular fluorescent dimming ballasts:

1. Electronic dimming ballast manufacturer shall provide single, two and three lamp electronic dimming ballasts, as required.

2. Ballast manufacturer shall functionally test each electronic dimming ballast at the low, medium and high end of the dimming range.

3. Ballast manufacturer shall provide a toll-free phone number, with 24-hour access, to specifically service technical and application questions.

4. Dimming range of electronic dimming ballasts shall be from 100% to 10% or 1% illuminance level, as noted on Lighting Fixture Schedule.

5. Electronic dimming ballasts shall not be damaged by miswiring line voltage and control wire inputs.

6. Electronic dimming ballasts shall withstand 4,000 volt surges as specified in ANSI C62.41.

7. Electronic dimming ballast shall preheat lamp cathodes before applying arc voltage to ensure rated lamp life is not diminished.

8. Electronic dimming ballasts shall internally limit inrush current to not exceed three amps at 277 volts or seven amps at 120 volts to avoid computer problems, nuisance circuit breaker trips and control contact malfunctions.

9. Electronic dimming ballast shall have a power factor greater than 0.9, a ballast factor greater than 0.85, total harmonic distortion less than 20% at full light output (magnitude diminishes as dimmed), and a lamp current crest factor less than or equal to 1.7.

10. Electronic dimming ballasts shall be U.L. listed and Class P thermally protected.

11. Light level output shall be continuous, even and flicker free over the entire dimming range.

12. Electronic dimming ballast shall be inaudible in a 27dB ambient throughout the dimming range.

13. Electronic dimming ballast shall be capable of striking lamps at any light level without first flashing to full light.

14. Electronic dimming ballasts must comply with FCC Part 18 regulations for non-consumer RF lighting devices.

15. Electronic dimming ballasts shall have a minimum starting temperature of 50 degrees F.

16. Lead length from electronic dimming ballast to lamp socket shall not exceed seven feet for T8 or three feet for T5 lamps.

17. Ballast shall be controlled by a compatible dimmer.

18. Ballast shall be controllable via a Class 1 or Class 2 low voltage 0-10 VDC circuit.

F. Compact fluorescent dimming Ballasts:

1. Ballasts shall dim 4-pin quad compact fluorescent lamps, T5 long twin tube type fluorescent lamps and 4-pin triple tube lamps as required.

2. Ballasts shall be U.L. listed, Class P and meet ANSI C62.41 (IEEE Publication 587, Category A) standards for surge suppression.

3. Dimming shall be smooth and continuous without flicker down to at least 10% or 5% light output, as noted on Lighting Fixture Schedule.

4. One and two lamp ballasts shall dim evenly when controlled by the same dimmer.

5. Ballast shall be inaudible in a 27dB ambient throughout the dimming range.

6. Ballasts shall be capable of striking lamps at any light level without first flashing to full light.

7. Ballasts must comply with FCC Part 18 regulations and shall not interfere with other properly installed electrical equipment.

8. Ballasts shall be controlled by a compatible dimmer.

G. HID ballasts: Low wattage/heat, high power factor, constant wattage, encased and potted, with "A" sound rating. Voltage rating in accordance with selected lamps, luminaires and available power supply. Integral ballasts on recessed type luminaires shall have built-in thermal protection. Construction shall be such that open circuit operation will not reduce lamp life.]

H. Electronic metal halide ballasts:

1. The metal halide electronic ballast shall not have more than +/- 2% variation in output power with a +/- 10% variation in input line voltage.

2. The metal halide electronic ballast shall not have more than +/- 2% variation in output power within all ranges of accepted ANSI lamp voltages.

3. The metal halide electronic ballast shall have a "square wave" output whose frequency does not exceed 200Hz.

4. The metal halide electronic ballast shall be equipped with a "turn off" safety function to prevent excessive pulsing of failed lamps.

5. The metal halide electronic ballast shall comply with FCC Part 18C, Class A. Furthermore, the manufacturer must show documentation showing that the ballast meets or exceeds the

non-consumer limits for EMI and RFI.

6. The metal halide electronic ballast shall have a total harmonic distortion of less than 10%.

7. The metal halide electronic ballast shall have a lamp current crest factor of less than 1.3.

8. The metal halide electronic ballast shall have a power factor of 0.95 or greater.

9. The metal halide electronic ballast shall have an "A" sound rating.

10. The metal halide electronic ballast shall be thermally protected to shut off when temperatures reach unacceptable levels.

11. The metal halide electronic ballast shall be U.L. and C.U.L. listed or recognized.

2.5 LED

A. Luminaires

1. Luminaires shall be as specified for each type in luminaire schedule

2. Luminaire shall have an external label per ANSI C136.15

3. Luminaire shall have an internal label per ANSI C136.22.

4. Nominal luminaire input wattage shall account for nominal applied voltage and any reduction in driver efficiency due to sub-optimal driver loading.

5. Luminaires shall start and operate in -20°C to +40°C ambient.

6. Electrically test fully assembled luminaires before shipment from factory.

7. Effective Projected Area (EPA) and weight of the luminaire shall not exceed the values indicated in Appendix A.

8. Luminaires shall be designed for ease of component replacement and end-of-life disassembly.

9. Luminaires shall be rated for the ANSI C136.31 Vibration Level indicated in Appendix A.

10. LED light source(s) and driver(s) shall be RoHS compliant.

11. Transmissive optical components shall be applied in accordance with OEM design guidelines to ensure suitability for the thermal/mechanical/chemical environment.

B. Driver

1. Rated case temperature shall be suitable for operation in the luminaire operating in the ambient temperatures indicated

2. Shall accept the voltage or voltage range indicated in Appendix A at 50/60 Hz, and shall operate normally for input voltage fluctuations of plus or minus 10 percent.

3. Shall have a minimum Power Factor (PF) of 0.90 at full input power and across specified voltage range.

4. Control signal interface

a. Luminaire types indicated "Required" in Appendix A shall accept a control signal as specified via separate controls specification referenced in section 1.2 above, e.g., for dimming.
b. Luminaire types indicated "Not Required" in Appendix A need not accept a control signal.

C. Electrical immunity (choose one of the following)

1. Luminaire shall meet the "Basic" requirements in Appendix D. Manufacturer shall indicate on submittal form (Appendix E) whether failure of the electrical immunity system can possibly result in disconnect of power to luminaire.

2. Luminaire shall meet the "Elevated" requirements in Appendix D. Manufacturer shall indicate on submittal form (Appendix E) whether failure of the electrical immunity system can possibly result in disconnect of power to luminaire.

D. Electromagnetic interference

1. Shall have a maximum Total Harmonic Distortion (THD) of 20% at full input power and across specified voltage range.

2. Shall comply with FCC 47 CFR part 15 non-consumer RFI/EMI standards.

E. Electrical safety testing

1. Luminaire shall be listed for wet locations by an OSHA NRTL.

2. Luminaires shall have locality-appropriate governing mark and certification.

F. Painted or finished luminaire components exposed to the environment

1. Shall exceed a rating of six per ASTM D1654 after 1000hrs of testing per ASTM B117.

2. The coating shall exhibit no greater than 30% reduction of gloss per ASTM D523, after 500 hours of QUV testing at ASTM G154 Cycle 6.

G. Thermal management

1. Mechanical design of protruding external surfaces (heat sink fins) for shall facilitate hose-down cleaning and discourage debris accumulation.

2. Liquids or other moving parts shall be clearly indicated in submittals, shall be consistent with product testing, and shall be subject to review by Owner.

H. Minimum Color Rendering Index (CRI): 81 or as noted in schedule. Correlated Color Temperature (CCT)

1. If nominal CCT specified in Appendix A is listed in Table 1 below, measured CCT and Duv shall be as listed in Table 1. ANSI C136.37 adopted this table from an earlier draft of the Model Specification, thereby confirming the suitability of the indoor criteria from ANSI/NEMA/ANSLG C78.377 for use in outdoor applications. Note that if 4000K nominal is specified but 4100K nominal is deemed acceptable, it would be appropriate to specify (in Appendix A) either a range of nominal CCTs or tolerances for the nominal CCT specified.

Table 1. Allowable CCT and Duv (adapted from NEMA C78.377)

Manufacturer-Rated Nominal CCT (K)	Allowable LM-79 Chromaticity Values	
	Measured CCT (K)	Measured Duv

2700	2580 to 2870	-0.006 to 0.006
3000	2870 to 3220	-0.006 to 0.006
3500	3220 to 3710	-0.006 to 0.006
4000	3710 to 4260	-0.005 to 0.007
4500	4260 to 4746	-0.005 to 0.007
5000	4745 to 5311	-0.004 to 0.008
5700	5310 to 6020	-0.004 to 0.008
6500	6020 to 7040	-0.003 to 0.009

2. If nominal CCT specified in Appendix A is not listed in Table 1, measured CCT and Duv shall be as per the criteria for Flexible CCT defined in NEMA C78.377.

I. The following shall be in accordance with corresponding sections of ANSI C136.37

1. Wiring and grounding

a. All internal components shall be assembled and pre-wired using modular electrical connections.
b. Mounting provisions
c. Specific configurations are indicated in Appendix A
d. Terminal blocks for incoming AC lines
e. Photocontrol receptacle
f. Latching and hinging
g. Ingress protection

2.6 LED Dimming Driver

A. The driver shall be provided in accordance with corresponding sections of ANSI C136.37

B. Continuous dimming from 100 percent to 10 percent relative light output

C. Ability to operate with installed or specified building control system

D. Lights automatically return to the setting prior to power interruption.

E. Upon power interruption on 0-10V source, driver shall operate at full light output.

F. No visible change in light output with a variation of plus/minus 10 percent line voltage input.

G. Total Harmonic Distortion less than 20 percent and meet ANSI C82.11 maximum allowable THD requirements

H. In applications with fixture types, all drivers track together with even illumination.

I. Drivers to track evenly across:

1. Multiple fixtures.

2. All light levels.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Do not install reflector cones and visible trim of luminaires until completion of plastering, ceiling tile work, painting, and general cleanup. Installation of reflector cones and visible trim of luminaires shall be carefully coordinated with ceiling openings to prevent light leaks at the ceiling plane. Handle cones and trim carefully to avoid scratching or finger printing. Luminaires shall be completely clean at time of acceptance by Owner.

B. Securely fasten recessed luminaires supported by suspended ceilings to the ceiling framing members with four approved earthquake clips per luminaire. Each clip shall have a capacity of 100% of the luminaire weight acting in any horizontal direction. Install clips as recommended by luminaire manufacturer.

C. Surface mounted luminaires that are supported by the suspended ceiling system shall be securely fastened to the ceiling framing members with two approved earthquake clamping device that completely surround the framing members. Provide a No. 9 gauge safety wire securely fastened to each clamping device and the structure above. Each clamping device shall have a capacity of 100% of the luminaire weight acting in any horizontal direction.

D. Suspended luminaires: Provide hangers capable of supporting twice the combined weight of luminaires supported by hangers. Provide with swivel hangers to ensure a plumb installation. Hanger shall be cadmium-plated steel with a swivel-ball tapped for the conduit size indicated. Hangars shall be shock-absorbing type where indicated. Hangars shall allow luminaires to swing within an angle of 20 degrees. Brace pendants four feet or longer provided in shops or hangers to limit swinging. Single unit suspended fluorescent luminaires shall have twin-stem hangers. Multiple unit or continuous row fluorescent luminaires shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end. Rods shall be a minimum 0.18 inch diameter.

E. Suspended luminaires shall be securely fastened to the structure above each luminaire with No. 9 gauge wire at a minimum of two locations for every four feet of luminaire length. Provide a minimum of two No. 9 gauge wire for each luminaire less than four feet.

F. Acoustical tile suspension ceiling systems will be provided with hanger wires located within six inches of each corner of the luminaire under Section 095123. Where required by local codes, where ceiling systems are not seismically braced or where the weight of luminaires may cause deformation of the suspended ceiling, provide independent seismic restraint supports for luminaires connected to the structure above. The amount of deformation allowed is specified in Section 0952130.

G. Drywall suspension ceiling systems will be provided with supplemental steel stud channels at luminaire locations for supporting luminaires to the ceiling system under Section 092216. Securely fasten recessed and/or surface mounted luminaires to steel channels with approved earthquake clips or clamping devices. Where required by local codes, where ceiling systems are not seismically braced or where the weight of the luminaire may cause deformation of the suspended ceiling, provide independent seismic restraint supports for luminaires connected to the structure above. The amount of deformation allowed is specified in Section 092216.

H. Where MC or AC cable is not used or allowed, connect luminaires to outlet boxes with six foot lengths of flexible conduit (Greenfield) and luminaire wire. Where MC or AC cable is used, provide all recessed luminaires with flexible conduit connection to an accessible outlet box located at the side of the ceiling opening. Locate box so that luminaires can be readily moved into adjacent ceiling modules and to provide access to space above ceiling. Support flexible conduit from structure. Do not lay on ceiling tiles or attach to any other support systems.

I. Properly align all surface type luminaires. Bolt together so that alignment will be permanent.

3.2 LAMP INSTALLATION

A. Do not install lamps for permanent use until operating voltage is verified and established and until luminaires have been washed/cleaned for acceptance by Owner. Burn in all fluorescent lamps for

100 hours prior to acceptance by Owner.

B. Install lamps in accordance with lamp and luminaire manufacturer's instructions.

3.3 BALLAST INSTALLATION

A. Luminaire manufacturer shall install ballasts at factory unless specifically indicated otherwise. Mount on rubber grommets or other sound isolating material to reduce noise transmission to luminaire body.

B. Ballasts and auxiliary equipment not installed as a part of a luminaire assembly shall be enclosed in accessible, permanently installed approved type metal cabinets which must be properly identified with nameplate, see Section 16500.

3.4 WASTE MATERIALS

A. Protection

1. Work Procedure: Furnish labor, materials, services and equipment necessary for the removal of PCB containing lighting ballasts in accordance with local, state, or federal regulations. Package and mark PCB as required by EPA and DOT regulations and dispose of in accordance with EPA, DOT and local regulations at a certified waste disposal site.

2. Special Hazards: PCBs shall not be exposed to open flames or other high temperature sources since toxic decomposition byproducts may be produced.

3. PCB Caution Label: 40 CFR 761, Subpart C. Affix labels to PCB waste containers. Provide label with sufficient print size to be clearly legible, with bold print on a contrasting background, displaying the following: "CAUTION: Contains PCBs (Polychlorinated Biphenyls)".

B. Work Operations: Ensure that work operations or processes involving PCB or PCB-contaminated materials are conducted in accordance with 40 CFR 761 and the applicable requirements of the section, including, but not limited to:

1. Obtaining advance approval of PCB storage sites.

2. Notifying Owner and Architect prior to commencing the operation.

3. Reporting leaks and spills to the Owner and Architect.

4. Cleaning up spills.

5. Inspecting PCB and PCB-contaminated items and waste containers for leaks and forwarding copies of inspection reports to the Owner and Architect.

6. Maintaining inspection, inventory and spill records.

C. PCB Spill Cleanup Requirements

1. PCB Spills: Immediately report to the Owner and Architect any PCB spills on the ground or in the water, PCB spills in drip pans, or PCB leaks.

2. PCB Spill Control Area: Rope off an area around the edges of a PCB leak or spill and post a "PCB Spill Authorized Personnel Only" caution sign. Immediately transfer leaking items to a drip pan or other container.

D. PCB Spill Cleanup

1. 40 CFR 761, Subpart G. Initiate clean-up of spills as soon as possible, but no later than 48 hours of its discovery. Mop up the liquid with rage or other conventional absorbent. The spent absorbent shall be properly contained and disposed of as solid PCB waste.

2. Records and Certifications: Document the cleanup with record of decontamination in accordance with 40 CFR 761, Section 125, and Requirements for OCB Spill Cleanup. Provide certification of decontamination.

3.5 TESTS

A. Completely test entire installation and leave in satisfactory operating condition.

+ + END OF SECTION + +

SECTION 16510 - NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes network lighting components comprising a complete lighting relay control system.

B. Related Sections:

1. Division 16 "Lighting Control Devices" for time clocks, photoelectric sensors, occupancy sensors, and multipole contactors.

2. Division 16 "Modular Dimming Controls" for dimming control components.

1.3 DEFINITIONS

A. BACnet: A networking communication protocol that complies with ASHRAE 135.

B. BAS: Building automation system.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.

E. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

F. PC: Personal computer; sometimes plural as "PCs."

G. Power Line Carrier: Use of radio-frequency energy to transmit information over transmission lines whose primary purpose is the transmission of power.

H. RS-485: A serial network protocol, similar to RS-232, complying with TIA-485-A.

I. UTP: Unshielded twisted pair.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, manual switches and plates, and conductors and cables.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Outline Drawings: Indicate dimensions, weights, arrangement of components, and clearance and access requirements.

3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.

4. Wiring Diagrams: For power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.

1. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.

2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.

B. Field quality-control reports.

C. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.

D. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.

2. Program Software Backup: On a magnetic media or compact disc, complete with data files.

3. Printout of software application and graphic screens.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Electrically Operated, Molded-Case Circuit Breakers: Equal to 10% of amount installed for each size indicated, but no fewer than two circuit breakers.

1.8 QUALITY ASSURANCE

A. Source Limitations: Obtain lighting control module and power distribution components through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a

qualified testing agency, and marked for intended location and application.

C. Comply with 47 CFR, Subparts A and B, for Class A digital devices.

D. Comply with NFPA 70.

1.9 COORDINATION

A. Coordinate lighting control components to form an integrated interconnection of compatible components.

1. Match components and interconnections for optimum performance of lighting control functions.

2. Coordinate lighting controls with BAS. For external control via BAS.

3. Coordinate lighting controls with that in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

B. Coordinate lighting control components specified in this Section with components specified in Section 16442 "Panelboards."

1.10 WARRANTY

A. Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship or from transient voltage surges within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Failure of software input/output to execute switching or dimming commands.
b. Failure of modular relays to operate under manual or software commands.
c. Damage of electronic components due to transient voltage surges.

2. Warranty Period: Five years from date of Substantial Completion.

3. Extended Warranty Period Failure Due to Transient Voltage Surges: Eight years.

4. Extended Warranty Period for Electrically Held Relays: 10 years from date of Substantial Completion.

1.11 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of the software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Lighting- Greengate/Ilumin

2. Acuity Brands Lighting - Synergy

3. Lutron Electronics Co., Inc.- XP Panels

4. Crestron

5. Phillips Lighting Controls - Dynalite

2.2 SYSTEM REQUIREMENTS

A. Expandability: System shall be capable of increasing the number of control functions in the future by 25 percent of current capacity; to include equipment ratings, housing capacities, spare relays, terminals, number of conductors in control cables, and control software.

B. Performance Requirements: Manual switches, an internal timing and control, and external sensors or other control units sends a signal to network-system control module that processes the signal according to its programming and routes an open or close command to one or more electrically operated circuit breakers in the power-supply circuits to groups of lighting fixtures or other loads.

C. BAS Interface: Provide hardware and software to enable the BAS to monitor, control, display, and record data for use in processing reports.

1. Hardwired Points:

a. Monitoring: On-off status for each relay.
b. Control: On-off operation for each relay.

D. Electrolytic capacitors to operate under the component manufacturer's maximum temperature rating when device is under fully-loaded conditions in 40° C (104° F) ambient temperature.

E. Panels: Withstand surges without impairment of performance when subjected to surges of 6,000 volts, 3,000 amps per ANSI/IEEE C62.41 and per IEC 61000-4-5 surge requirements.

F. Other power handling devices: Withstand surges without impairment of performance when subjected to surges of 6,000 volts, 200 amps per ANSI/IEEE C62.41. Power failure memory and dimmer/relay recovery:

G. After power interruption, lighting shall automatically return to same levels (dimmed setting, full on, or off) prior to power interruption.

H. In panels where 3 phases are present, loss of power to any phase should not effect operation or control dimmers on any other phase.

I. The system shall utilize a memory back-up device that is system integrated. The data in RAM shall be protected against power interruptions lasting as long as 30 days.

2.3 NETWORK CONTROL PANELS

A. Control Module (Provided in each relay panel)

1. Description: Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day astronomical timing and control unit. Control units shall be networked and capable of receiving inputs from indicated sensors and hand-held programmer. Output circuits shall be pilot-duty relays compatible with power switching devices. Output circuits

shall include digital circuits arranged to transmit control commands to remote preset dimmers. Modules and their associated control panels shall include the following features

2. Multiple outputs with zones as indicated on control schedule drawings.

3. Capable for a min of 64 programmable addressable inputs per panel. Each relay zone output shall be capable of being programmed from any input on any panel as part of the network.

4. Provide a minimum of two dry contact inputs and outputs per panel/device.

5. Multiple inputs for occupancy sensors, daylight sensors, and dimming systems with associated daylight sensors.

6. Provide dimming profiles to account for the differences of lamp and ballast combinations. Each output shall permit a unique preset or fully configurable option per output. Output profiles shall also include: Minimum Off Level, Minimum & Maximum dimming levels.

7. Provide fully configurable photocell control algorithms. Photocell control shall permit open loop control for daylight or outdoor applications. The controller shall also provide closed loop control for indoor applications. Both control algorithms shall permit adjustments to the upper and lower thresholds. The loops in each controller shall be available to be modified remotely via the programming software.

8. Provide networking between lighting control panels. One network shall support at least 254 control panels. Panels shall permit data sharing for global control. All inputs (no limitation) are transferable over the network to create any switching pattern required.

9. The lighting control system shall be able to log all control events. The controller shall monitor all relay actuations, switch inputs and user intervention. Log reports shall be available for any duration of time the operator chooses through the Software.

10. Provide visible status indication of all relays. The visual indication shall disclose On/Off status and relay number.

11. Programming the controller shall be through the RS-232 port or network connection.

12. Each control panel shall provide a Warn Off (flash the lights) to inform the occupants of an impending Off command. The Warn Off command shall provide an adjustable time duration of 10 second to 99 extra minutes.

13. The controller shall permit lighting to be overridden On for after hours use or cleaning. The controller shall provide optional switch timer assignments or timed overrides. The override choices for various relays shall provide special event occurrences and the controller shall return to the programmed state after the override event. Also, the controller shall provide priority and masking choices to customize the functions of switch inputs, thereby enabling switches to function differently at different times of the day to meet special facility operational requirements. These overrides shall be digital, network, or hard-wired inputs.

B. Relay Control Panels

1. Each relay shall provide circuitry that will ensure switching the load at the optimum time to ensure minimum current flow.

2. Relay Module shall have the ability to measure voltage, current and frequency of each switched load.

3. Each Relay Module shall constantly monitor the connected load and will adapt to the changing circuit characteristics. Switching times are adjusted to maintain minimum current flow regardless of changing factors such as ballast or lamp life.

4. Mechanical:

   a. Meets UL, cUL, and/or CSA Standards specifically for the required loads. Provide evidence of compliance upon request.
   b. Delivered and installed as a factory assembled panel listed to UL508.
   c. Field wiring accessible from front of panel without need to remove dimmer or relay assemblies or other components.
   d. Panels passively cooled via free-convection, unaided by fans or other means.

5. Electrical:

   a. Panel to contain 4 line LCD display controller in each panel

      1) All set up and adjustments of the panel can be made from this device.
      2) USB, RS485, Ethernet, and DMX connections shall be included.
      3) Include Timeclock standard with control of:

         a) Scene selections.
         b) Fade zone to a level.

   b. Real Time Energy Meter per circuit

      1) Electrical device to measure voltage and current within each circuit.
      2) Metered data can be polled via public command string from on board Ethernet input.

6. Replacing relay does not require re-programming of system or processor.

7. Relays: Include diagnostic LED's to verify proper operation and assist in system troubleshooting.

8. Failures on the lighting control system network are localized to the failed product. All other lighting control panels continue to fully function without additional action.

C. Relays

1. Each controller or panel shall come standard with 20amp 120/277VAC electrically held relays. The wire terminations shall be able to accept 10 AWG. relays.

2. The system shall utilize normally open control relays, which are rated to 20 amps at 120/277 VAC. The relays shall be magnetically held.

3. Each relay card shall permit individual override and LED confirmation of relay state. The relays shall be rated for 10 million mechanical operations. The wire terminations shall be able to accept 10 AWG.

D. Overrides

1. The controller shall provide timers for each override. Each override timer shall be capable of 0-999 minutes. Software shall enable or disable overrides based on Priorities, Masks or Time Of Day scheduling.

2. Digital Switch

a. The lighting controller shall support digitally addressable LED annunciated switches. The maximum total number of digital switches that may exist on the lighting control network is 16,256. Each Subnet shall support 64 buttons. The digital switch network requires CAT 5 cable between switches. The digital switches shall control any relay group combination on the lighting control network. Data communications status feedback for system checkout and troubleshooting (transmit and receive LED'S) shall be visible on both the controller and interface.

3. Dry Contact Inputs

a. The control system shall permit 8 dry contacts inputs per panel for override purposes. Momentary 3 wire or 2 wire (toggle) inputs shall be supported. Inputs shall be dry contacts
Verify acceptability of control input with device and panel manufacturers. Provide all required accessories for integration of equipment.

4. Photocell Control

a. The controller shall accept either dry contact or analog ambient light sensors
b. Sensors shall be provided as shown on plans for outdoor, indoor or skylight applications as required.
c. The sensor shall provide either software or user adjustable dead band control. Photocells shall be 0-10 VDC type and available in ranges based on the application for best granularity of control.

5. Network Overrides

a. The controller shall accept network commands issued from other inputs or controllers on the network. The controller shall provide this feature without the need to add extra equipment to the controller. Network overrides can be issued from the Telephone Interface Module (TIM), Modbus® Gateway, DMX Gateway, Photocells, Motion Sensors, Digital or Dry Contact Switches, or other controllers.

6. Service Override & Priority Override

a. The control panel shall provide a three position master-service override for the control unit.
b. The master service override provides a single three-position switch with the option of All Off, Auto, and All On.
c. The system shall report all master service overrides to the controller and shall be accessible via network query. Systems that cannot determine when the service override is in use shall not be acceptable.
d. The system shall remember the last command to the individual relays. Upon returning the master override switch to the Auto position, the relays shall return to the most recent command state.

E. RS-232 port

1. The controller shall provide an RJ-12 connection for RS-232 communications. Programming shall be permitted through a local connection or directly on panel.

F. RS-485 Network

1. The controller shall be able to communicate to other controllers on a daisy chain twisted pair of wires. The RS-485 network shall support 254 controllers with a maximum distance of 4000 feet. Each controller shall be optically isolated on the network. The networked controllers shall provide optical isolation between controller power supplies for true electrical isolation (communication grounds are 100% isolated).

2.4 ETHERNET MODULE

A. Internet Connection Specifications: The control system accessory provides easy access to control panels over a TCP/IP connection by converting sent information into RS-232 communication capable information.

B. Provide all required cabling from controller to Ethernet Interface Modules.

C. Coordinate with owner IT department the IP address, Subnet Mask, Default Gateway, and a TCP Port Number for each Ethernet Interface Module required.

D. Provide a qualified Network Administrator to properly configure the device(s). Refer to demonstration section for all programming requirements.

1. Provide all required Virus Protection Security measures. This includes, but is not limited to, Firewall, Proxy Servers, and Virus Protection Software.

2. Provide a qualified Technician to install and connect the Ethernet Interface Module to the building's LAN and lighting control panel.

3. VPN hardware device accessory: An optional VPN hardware device may be added to your lighting control network and building LAN to ensure security of your building LAN and lighting control network.

E. MODBUS® Gateway

1. The lighting control network network shall permit data protocol translation through a MODBUS® Gateway. The MODBUS® Gateway permits MODBUS® communication to operate individual relays, relay groups and read the status of the coils (status read). The MODBUS® Gateway shall provide data messaging structure to rapidly increase data throughput by employing relay groups directly from the MODBUS® Gateway.

2.5 MANUAL ANALOG SWITCHES AND PLATES

A. Push-Button Switches: Modular, momentary-contact, low-voltage type.

1. Match color specified in Division 16 "Wiring Devices."

2. Integral green LED pilot light to illuminate when zone or scene is on.

3. Internal amber LED locator light to illuminate when zone or scene is.

B. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Section 16140 "Wiring Devices."

C. Wall-Box Dimmers: Comply with Section 16140 "Wiring Devices."

D. Wall Plates: Single and multigang plates as specified in Section 16140 "Wiring Devices."

E. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.6 FIELD-MOUNTED DIGITAL CONTROLS AND PLATES

A. Connection Type: RS-485 protocol, Category 5e UTP cable, using RJ45 connectors. Power shall be from the control unit.

B. Pushbutton Switches: Modular, solid-state, programmable, digital, momentary contact, designed to connect to a microprocessor based control unit as a manual control source.

1. Mounting: Standard single-gang recessed switchbox, using device plates specified in Section 16140 "Wiring Devices."

2. Multi-Gang Mounting: One to six pushbuttons per gang.

2.7 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Section 16120 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cables: Stranded copper, complying with UL 83, multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 16120 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cables: Stranded copper, complying with UL 83, multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 16120 "Low-Voltage Electrical Power Conductors and Cables."

D. Structured Network Digital and Multiplexed Signal Cables: UTP cable with copper conductors, complying with TIA/EIA-568-B.2, Category 6 for horizontal copper cable and with Section 16700 "Communication and Signal System.."

E. RS-485 Cables:

1. Standard Cable: NFPA 70, Type CM or CMG.

a. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
b. PVC insulation.
c. Unshielded.
d. PVC jacket.
e. Flame Resistance: Comply with UL 1581.

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install wiring in raceways. Minimum conduit size shall be 3/4-inch.

1. For power wiring comply with Section 16120 "Low-Voltage Electrical Power Conductors and Cables."

2. For digital data transmission and low-voltage (operating at less than 50 V) remote control and signaling cables, comply with Section 16120 "Low-Voltage Electrical Power Conductors and Cables."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.

F. Identify components and power and control wiring according to Section 16075 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Test for circuit continuity.

2. Verify that the control module features are operational.

3. Check operation of local override controls.

4. Test system diagnostics by simulating improper operation of several components selected by Architect.

E. Lighting controls will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.3 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.4 DEMONSTRATION

A. Provide all required programming, integration with AV and BAS systems, and startup of lighting system for setting each scene and zone as part of the lighting control system.

B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting controls. Training shall be no less than 8 hours at project completion.

C. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Modular Lighting Controls."

D. Provide a follow up visit to modify programming as required by owner/architect 30 days after substantial completion for any modifications requested for zoning or scene control.

+ + END OF SECTION + +

SECTION 16550 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Exterior luminaires with lamps and ballasts.

2. Luminaire-mounted photoelectric relays.

3. Poles and accessories.

4. Luminaire lowering devices.

B. Related Sections:

1. Division 16 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. HID: High-intensity discharge.

D. LER: Luminaire efficacy rating.

E. Luminaire: Complete lighting fixture, including ballast housing if provided.

F. Pole: Luminaire support structure, including tower used for large area illumination.

G. Standard: Same definition as "Pole" above.

H. Driver: drivers and power supplies,

I. LED light source:per IES LM-80 to covers LED package(s), module(s), and array(s).

1.4 SUBMITTALS AND SAMPLES

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.

2. Details of attaching luminaires and accessories.

3. Details of installation and construction.

4. Luminaire materials.

5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.

   a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
   b. Manufacturer Certified Data: Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

6. Photoelectric relays.

7. Ballasts, including energy-efficiency data.

8. Lamps, including life, output, CCT, CRI, lumens, and energy-efficiency data.

9. Materials, dimensions, and finishes of poles.

10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.

11. Anchor bolts for poles.

12. Manufactured pole foundations.

B. Submit Shop Drawings and Product Data in accordance with Section 013300.

C. Shop Drawings shall be in the form of standard catalog cuts and/or factory assembly drawings, and shall indicate the following:

1. Luminaire Type

2. Luminaire and Lamp/Ballast/Driver voltage

3. Luminaire and Lamp wattage

4. Luminaire efficiency

5. Luminaire efficacy

6. Complete photometric data

7. Manufacturer’s name and catalog number including all fixture options

8. Lamp and ballast/driver types and manufacturer’s name

9. Warranty information for lamps and ballasts/ drivers

10. Lamp color temperature (CCT), color rendering index (CRI), and beam spread.

11. Cutsheets for surge protection device, if applicable

D. Submit sample luminaires as directed by Architect/Engineer.

E. Submit application, installation and start up instruction. Submit within 30 days of shop drawing approval to facilitate the commissioning process outlined in Division 01.

F. Submit training information for the Training Plan required per Sections 017900.

G. Submit Operation and Maintenance information, to provide the content of the Operation and Manuals, specified in Sections 017823, relative to systems and equipment of this section. All submittals must be provided in hard copy and electronic copy in Portable Document Format per Section 013300.

H. Submit project specific mounting for luminaires for each ceiling type and location as shown on plans.

I. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.

3. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.

4. Wiring Diagrams: For power, signal, and control wiring.

J. Samples: For products designated for sample submission in the Exterior Lighting Device Schedule. Each Sample shall include lamps and ballasts.

K. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.

L. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

M. Field quality-control reports.

N. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals.

O. Warranty: Sample of special warranty.

1.5 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with IEEE C2, "National Electrical Safety Code."

E. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below ground line.

D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

E. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Luminaires: Five > years from date of Substantial Completion.

2. Warranty Period for Metal Corrosion: Five > years from date of Substantial Completion.

3. Warranty Period for Color Retention: Five years from date of Substantial Completion.

4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

1.8 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: One for every 10 of each type and rating installed. Furnish at least one of each type.

2. Glass and Plastic Lenses, Covers, and Other Optical Parts: One for every 10 of each type and rating installed. Furnish at least one of each type.

3. Ballasts: One for every 10 > of each type and rating installed. Furnish at least one of each type.

4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide product indicated on Drawings

2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

1. LER Tests Incandescent Fixtures: Where LER is specified, test according to NEMA LE 5A.

2. LER Tests Fluorescent Fixtures: Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

3. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.

B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel or aluminum.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.

2. Specular Surfaces: 83 percent.

3. Diffusing Specular Surfaces: 75 percent.

K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

L. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

M. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."

2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As selected from manufacturer's standard catalog of colors.
b. Color: Match Architect's sample of manufacturer's standard color.
c. Color: As selected by Architect from manufacturer's full range.

N. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.

3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

a. Color: As selected by Architect from manufacturers full range.

O. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp and ballast characteristics:

a. "USES ONLY" and include specific lamp type.
b. Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
d. Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.
e. ANSI ballast type (M98, M57, etc.) for HID luminaires.
f. CCT and CRI for all luminaires.

2.3 FLUORESCENT BALLASTS AND LAMPS

A. Ballasts for Low-Temperature Environments:

1. Temperatures 0 Deg F (Minus 17 Deg C) and Higher: Electronic type rated for 0 deg F

(minus 17 deg C) starting and operating temperature with indicated lamp types.

2. Temperatures From Minus 20 Deg F (Minus 29 Deg C) to -1 Deg F (Minus 18 Deg C): Electromagnetic type designed for use with indicated lamp types.

B. Ballast Characteristics:

1. Power Factor: 90 percent, minimum.

2. Sound Rating: Class A

3. Total Harmonic Distortion Rating: Less than20 percent.

4. Electromagnetic Ballasts: Comply with ANSI C82.1, energy-saving, high power factor, Class P, automatic-reset thermal protection.

5. Case Temperature for Compact Lamp Ballasts: 65 deg C, maximum.

6. Transient-Voltage Protection: Comply with IEEE C62.41.1 and IEEE C62.41.2, Category A or better.

C. Low-Temperature Lamp Capability: Rated for reliable starting and operation with ballast provided at temperatures [minus 20 deg F (minus 29 deg C) and higher.

2.4 BALLASTS FOR HID LAMPS

A. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features unless otherwise indicated:

1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.

2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C).

3. Normal Ambient Operating Temperature: 104 deg F (40 deg C).

4. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

B. Auxiliary, Instant-On, Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent of light output.

C. High-Pressure Sodium Ballasts: Electromagnetic type with solid-state igniter/starter and capable of open-circuit operation without reduction of average lamp life. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.

1. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.

a. Restrike Range: 105- to 130-V ac.
b. Maximum Voltage: 250-V peak or 150-V ac rms.

2. Minimum Starting Temperature: Minus 40 deg F (Minus 40 deg C).

2.5 HID LAMPS

A. Metal-Halide Lamps: ANSI C78.43, with minimum CRI 75, and CCT color temperature as indicated on luminaire schedule .

B. Pulse-Start, Metal-Halide Lamps: Minimum CRI 75, and CCT color temperature as indicated on luminaire schedule

C. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 82 , and CCT color temperature as indicated on luminaire schedule

2.6 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

A. Structural Characteristics: Comply withIBC.

1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.

2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.

2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

3. Anchor-Bolt Template: Plywood or steel.

D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

2.7 ALUMINUM POLES

A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.

B. Poles: ASTM B 209 (ASTM B 209M), 5052-H34 marine sheet alloy with access handhole in pole wall.

1. Shape: Refer to luminaire schedule

2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

D. Grounding Electrodes

1. Ground Rods: Copper-clad; 10 feet, 3/4 inch diameter.

E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.

1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.

2. Finish: Same as pole.

F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

G. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.

3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

a. Color: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming

3.2 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:

1. Fire Hydrants and Storm Drainage Piping: 60 inches (1520 mm) >.

2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet (3 m)

3. Trees: 15 feet (5 m) from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.

2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.

3. Install base covers unless otherwise indicated.

4. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.

F. Raise and set poles using web fabric slings (not chain or cable).

3.3 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

A. Install on concrete base with top 2 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.5 GROUNDING

A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.

2. Install grounding conductor pigtail in the base for connecting luminaire to grounding

system.

3.6 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.

1. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):

a. IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
b. IESNA LM-64, "Photometric Measurements of Parking Areas."
c. IESNA LM-72, "Directional Positioning of Photometric Data."

D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

+ + END OF SECTION + +

SECTION 16700 - COMMUNICATION AND SIGNAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The types of systems are as follows:

1. Telephone and Data Empty Raceway System
2. Broadband RF Cabling Systems
3. Security Empty Raceway System

PART 2 - PRODUCTS

2.1 TELEPHONE AND DATA SYSTEM

A. This Contractor shall provide all required accessories and material for complete tele/data raceway system. Division 16 shall be responsible for a raceway system shown on the electrical drawings. The telecommunication cable system portion of this project will be furnished under another contract.

B. Furnish conduit and junction boxes as shown on electrical drawings. Conduits shall be stubbed above nearest accessible ceiling. Note: Examine reflected ceiling plan prior to bid.

2.2 BROAD BAND RF CABLING SYSTEMS

A. This Contractor shall provide all required accessories and material for complete tele/data raceway system. Division 16 shall be responsible for a raceway system shown on the electrical drawings. The telecommunication cable system portion of this project will be furnished under another contract.

B. Furnish conduit and junction boxes as shown on electrical drawings. Conduits shall be stubbed above accessible ceiling. Note: Examine reflected ceiling plan prior to bid.

C. Provide a pull-string in all empty conduits.

2.3 SECURITY EMPTY RACEWAY SYSTEM

A. This Contractor shall provide all required accessories and material for complete security raceway system. Division 16 shall be responsible for a raceway system shown on the electrical drawings. The security system cable portion of this project will be furnished under another contract.

B. Furnish conduit and junction boxes as shown on security drawings. Note: Examine reflected ceiling plan prior to bid.

C. Provide a pull-string in all empty conduits.

D. Security details for scope of conduit work for electrified portions and floor boxes and penetrations.

PART 3 - EXECUTION - NOT APPLICABLE.

END OF SECTION

SECTION 16800 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Air-sampling smoke detectors.
5. Nonsystem smoke detectors.
6. Heat detectors.
7. Notification appliances.
8. Device guards.
9. Firefighters' two-way telephone communication service.
10. Magnetic door holders.
11. Remote annunciator.
12. Graphic annunciator.
13. Addressable interface device.
14. Digital alarm communicator transmitter.
15. Radio alarm transmitter.
16. Network communications.
17. System printer.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

E. PC: Personal computer.

F. VESDA: Very Early Smoke-Detection Apparatus.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.

3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.
12. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.
    d. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' smoke-evacuation system.
    e. Locate detectors according to manufacturer's written recommendations.
    f. Show air-sampling detector pipe routing.

13. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.

C. General Submittal Requirements:

1. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; Level III minimum.
    c. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

E. Shop drawings and submittals shall be produced as many times as necessary to satisfy the requirements of the AHJ.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 SAMPLE WARRANTY

A. For special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in "Operation and Maintenance Data," Specification Section include the following and deliver copies to authorities having jurisdiction:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
g. Record copy of site-specific software.
h. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

i. Manufacturer's required maintenance related to system warranty requirements.
j. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10percent of amount installed, but no fewer than one unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.

3. Smoke Detectors, Fire DetectorsQuantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
5. Keys and Tools: One extra set for access to locked or tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
8. Filters for Air-Sampling Detectors: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
9. Air-Sampling Fan: Quantity equal to one for every five detectors, but no fewer than one unit of each type.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

C. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FM Global-approved alarm company.

1.10 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Construction Manager's written permission.

C. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.11 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Noncoded, UL-certified, FM Global-placarded addressable system, with multiplexed signal transmission and voicestrobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Automatic sprinkler system water flow.
6. Fire-extinguishing system operation.
7. Fire standpipe system.
8. Dry system pressure flow switch.
9. Fire pump running.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances, including voice evacuation notices.
2. Identify alarm and specific initiating device at fire-alarm control unit, off-premises network control panels, and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Activate smoke-control system (smoke management) at firefighters' smoke-control system panel.
9. Activate stairwell and elevator-shaft pressurization systems.
10. Close smoke dampers in air ducts of designated air-conditioning duct systems.
11. Activate preaction system.
12. Recall elevators to primary or alternate recall floors.
13. Activate elevator power shunt trip.
14. Activate emergency lighting control.
15. Activate emergency shutoffs for gas and fuel supplies.
16. Record events in the system memory.
17. Record events by the system printer.
18. Indicate device in alarm on the graphic annunciator.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Elevator shunt-trip supervision.

3. Fire pump running.
4. Fire-pump loss of power.
5. Fire-pump power phase reversal.
6. Independent fire-detection and -suppression systems.
7. User disabling of zones or individual devices.
8. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.
10. Voice signal amplifier failure.
11. Hose cabinet door open.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit, off-premises network control panels, and remote annunciators.
3. Record the event on system printer.
4. After a time delay of 200 seconds , transmit a trouble or supervisory signal to the remote alarm receiving station.
5. Transmit system status to building management system.
6. Display system status on graphic annunciator.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 FIRE-ALARM CONTROL UNIT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Silent Night by Honeywell
2. Edwards Systems Technologies (EST).
3. Siemens Industry, Inc.; Fire Safety Division.
4. SimplexGrinnell LP.

B. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.

a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through

failure of primary and secondary power supplies.

b. Include a real-time clock for time annotation of events on the event recorder and printer.

c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.

d. The FACP shall be listed for connection to a central-station signaling system service.

e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.

3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, three line(s) of 80 characters, minimum.

2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class A.

2. Pathway Survivability: Level 1.

3. Install no more than 50 addressable devices on each signaling-line circuit.

4. Serial Interfaces:

a. One dedicated RS 485 port for central-stationoperation using point ID DACT.

b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).

c. One USBport for PC configuration.

d.

e. One RS 232 port for voice evacuation interface.

E. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.

2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.

3. Record events by the system printer.

4. Sound general alarm if the alarm is verified.

5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

F. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.

2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.

3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the

same field of view, as defined in NFPA 72.

G. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:

   a. Elevator lobby detectors except the lobby detector on the designated floor.
   b. Smoke detector in elevator machine room.
   c. Smoke detectors in elevator hoistway.

2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

   a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

H. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to fire-alarm system.

I. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

J. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

K. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control unit.

1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.

   a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
   b. Programmable tone and message sequence selection.
   c. Standard digitally recorded messages for "Evacuation" and "All Clear."
   d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire-alarm control unit.

2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

L. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

M. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

N. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed, valve-regulated, recombinant lead acid.

O. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.5 MANUAL FIRE-ALARM BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Wheelock.
2. Edwards Systems Technologies (EST).
3. Notifier.
4. Siemens Industry, Inc.; Fire Safety Division.
5. SimplexGrinnell LP.

B. 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.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with attached addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.
3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
4. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.6 SYSTEM SMOKE DETECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Edwards Systems Technologies (EST).
2. Notifier.
3. Siemens Industry, Inc.; Fire Safety Division.
4. SimplexGrinnell LP.

B. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four-wire type.
3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to

restore them to normal operation.

5. Integral Visual-Indicating Light: LED type, indicating detector has operated.
6. Remote Control: Unless otherwise indicated, detectors shall be digital-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.

    a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
    b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units 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.
    c. Multiple levels of detection sensitivity for each sensor.
    d. Sensitivity levels based on time of day.

C. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.7 HEAT DETECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Edwards Systems Technologies (EST).
2. Notifier.
3. Siemens Industry, Inc.; Fire Safety Division.
4. SimplexGrinnell LP.

B. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

C. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

D. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.8 NOTIFICATION APPLIANCES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.

1. Cooper Wheelock.
2. Edwards Systems Technologies (EST).
3. Siemens Industry, Inc.; Fire Safety Division.
4. SimplexGrinnell LP.

B. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

C. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.

D. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

E. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

F. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch high letters on the lens.

1. Rated Light Output:

a. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, white.

G. Voice/Tone Notification Appliances:

1. Comply with UL 1480.
2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
3. High-Range Units: Rated 2 to 15 W.
4. Low-Range Units: Rated 1 to 2 W.
5. Mounting: Flush.
6. Matching Transformers: Tap range matched to acoustical environment of speaker location.

H. Exit Marking Audible Notification Appliance:

1. Exit marking audible notification appliances shall meet the audibility requirements in NFPA 72.
2. Provide exit marking audible notification appliances at the entrance to all building exits.
3. Provide exit marking audible notification appliances at the entrance to areas of refuge with audible signals distinct from those used for building exit marking.

2.9 FIREFIGHTERS' TWO-WAY TELEPHONE COMMUNICATION SERVICE

A. Dedicated, two-way, supervised, telephone voice communication links between fire-alarm control unitand remote firefighters' telephone stations. Supervised telephone lines shall be connected to talk circuits by controls in a control module. Provide the following:

1. Common-talk type for firefighter use only.
2. Selective-talk type for use by firefighters and fire wardens.
3. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously. An indicator lamp shall flash if a phone is disconnected from the talk circuits.
4. Addressable firefighters' phone modules to monitor and control a loop of firefighter phones. Module shall be capable of differentiating between normal, off-hook, and trouble conditions.
5. Audible Pulse and Tone Generator, and High-Intensity Lamp: When a remote telephone is taken off the hook, it causes an audible signal to sound and a high-intensity lamp to flash at the fire-alarm control unit
6. Selector panel controls to provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on the panel front by individual LEDs.
7. Display: Digital to indicate location of caller.
8. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated, factory-standard red finish, with handset.

    a. Install one-piece handset to cabinet with vandal-resistant armored cord. Silk-screened or engraved label on cabinet door, designating "Fire Emergency Phone."
    b. With "break-glass" type door access lock.

9. Remote Telephone Jack Stations: Single-gang, stainless-steel-plate mounted plug, engraved "Fire Emergency Phone."
10. Handsets: push-to-talk-type sets with noise-canceling microphone stored in a cabinet adjacent to fire-alarm control unit.

2.10 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.

3. Rating: 24-V ac or dc.

B. Material and Finish: Match door hardware.

2.11 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.12 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.
2. Operate solenoids for use in sprinkler service.

2.13 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.

4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.14 NETWORK COMMUNICATIONS

A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.

B. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

C. Provide integration gateway using BACnetfor connection to building automation system.

2.15 SYSTEM PRINTER

A. Printer shall be listed and labeled as an integral part of fire-alarm system.

2.16 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by device manufacturer.
2. Finish: Paint of color to match the protected device.

2.17 FIRE ALARM WIRE AND CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC
2. Southwire
3. Vitalink

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.

1. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.

1. Low-Voltage Circuits: No. 16 AWG, minimum.
2. Line-Voltage Circuits: No. 12 AWG, minimum.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.

E. SOURCE QUALITY CONTROL

1. Testing Agency: Engage a qualified testing agency to evaluate cables.
2. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
3. Factory test UTP cables according to TIA/EIA-568-B.2.
4. Factory test multimode optical fiber cables according to TIA-526-14-A and TIA/EIA-568-B.3.
5. Factory sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.
6. Cable will be considered defective if it does not pass tests and inspections.
7. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

1. Connect new equipment to existing monitoring equipment at the supervising station.
2. Expand, modify, and supplement existing control and monitoring equipment as necessary to extend existing control and monitoring functions to the new points. New components

shall be capable of merging with existing configuration without degrading the performance of either system.

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

E. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

F. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

I. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

J. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

L. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 PATHWAYS

A. Pathways above recessed ceilings and in nonaccessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches above the floor shall be installed in EMT.

B. Exposed EMT shall be painted red enamel.

3.4 FIRE ALARM WIRING INSTALLATION

A. Comply with NECA 1 and NFPA 72.

B. Wiring Method: Install wiring in metal raceway according to Section 260533 "Raceways and Boxes for Electrical Systems."

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.

C. Wiring Method:

1. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
2. Fire-Rated Cables: Use of 2-hour, fire-rated fire alarm cables, NFPA 70, Type CI, is permitted.
3. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.

D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

F. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

G. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.

H. Wiring to Remote Alarm Transmitting Device: 1-inch conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.5 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before

making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.
2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
3. Smoke dampers in air ducts of designated HVAC duct systems.
4. Magnetically held-open doors.
5. Electronically locked doors and access gates.
6. Alarm-initiating connection to elevator recall system and components.
7. Alarm-initiating connection to activate emergency lighting control.
8. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
9. Supervisory connections at valve supervisory switches.
10. Supervisory connections at elevator shunt-trip breaker.
11. Data communication circuits for connection to building management system.
12. Supervisory connections at fire-extinguisher locations.
13. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
14. Supervisory connections at fire-pump engine control panel.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 16075 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.7 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.8 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual Inspection: Conduct visual inspection prior to testing.

a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

H. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.9 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.10 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to

adjust, operate, and maintain fire-alarm system.

END OF SECTION

SECTION 16800 - ELECTRICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The purpose of this section is to specify Division 16 responsibilities in the Commissioning (Cx) process which are being directed by the Commissioning Authority (CA).

B. The list of commissioned systems is found in Section 01810, Part 1.10.

C. Commissioning (Cx) requires the participation of Division 16 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01810. Division 16 shall be familiar with all parts of Section 01810 and the Commissioning Plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 RESPONSIBILITIES

A. Electrical Contractor. The commissioning responsibilities applicable to the Electrical Contractor are as follows *(all references apply to commissioned equipment only)*:

Construction and Acceptance Phases

1. Attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the Cx process.
2. Contractor shall provide normal cut sheets and shop drawing submittals of commissioned equipment to the Commissioning Agent (CA).
3. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of start-up checklists and testing procedures.

    a. Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner/Owner's Rep. to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the CA.
    b. The CA may request further documentation necessary for the commissioning process.
    c. This data request may be made prior to normal submittals.
4. Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CA for review and comments.
6. Electrical Contractor shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, wiring diagrams or equipment documentation is not sufficient for writing start-up checklists and procedures.
7. Provide assistance to the CA in preparation of the specific test procedures. Electrical Contractor shall review test procedures to ensure feasibility, safety and equipment protection during the tests.
8. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the pre-functional checklists from the CA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures to the CA for review.
9. During the startup and initial checkout process, execute and document the electrical-related portions of the pre-functional checklists provided by the CA for all commissioned equipment.
10. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.
11. Provide skilled technicians to execute starting of equipment and to execute the pre-functional start-up tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests and adjustments.
12. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA and retest the equipment.
13. During construction, maintain as-built red-line drawings for all drawings and final as-builts for contractor-generated coordination drawings. Update after completion of commissioning (excluding

deferred testing). Prepare red-line as-built drawings for all drawings and final as-builts for contractor-generated coordination drawings.

14. Provide training of the Owner's operating personnel as specified.
15. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

1. Execute deferred start-up and performance testing, witnessed by the CA, according to the specifications.
2. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any deferred testing.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Division 16 shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 01810 for additional Division 16 requirements.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. Division 16 shall provide submittal documentation relative to commissioning to the CA as requested by the CA. Refer to Section 01810 for additional Division 16 requirements.

3.2 STARTUP

A. The Electrical Contractor shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section. Division 16 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and pre-functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the Commissioning Authority or the Owner/Owner's Rep.

B. Pre-functional testing is intended to begin upon completion of a system. Pre-functional testing may proceed prior to the completion of systems, or sub-systems at the discretion of the CA. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre-functional checklists as soon as possible.

3.3 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Refer to Section 01810 for specific details on pre-functional and functional performance testing.

3.4 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Division 16 shall compile and prepare documentation for all equipment and systems covered in Division 16 and deliver to the CM.

B. The CA shall receive a preliminary copy of the O&M manuals for review. Refer to section 01810 for specific details.

3.5 TRAINING OF OWNER'S PERSONNEL

A. Division 16 shall be responsible for necessary training for all equipment and systems covered in Division 16.

B. The CA shall be responsible for reviewing the content and adequacy of the training of the Owner's personnel for commissioned equipment. Refer to section 01810 for specific details.

3.7 WRITTEN WORK PRODUCTS

A. Written work products of the Electrical Contractor will consist of the filled out initial checkout/installation, start-up and functional testing forms.

END OF SECTION 16800

SECTION 17000 – INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Differential Pressure Switches

B. Pressure and Temperature Sensor Wells & Sockets

C. Automatic Control Valves

D. Automatic Control Dampers

E. Venturi Airflow Control Valves

1.2 WORK PROVIDED UNDER OTHER DIVISIONS

A. General

1. When equipment is supplied by the BAS Contractor to be installed by other trades, pay any shipping expenses to deliver the material as directed by the appropriate Division such as the Mechanical Contractor or the Electrical Contractor.

2. Upon receipt of any material from another Division for installation by the BAS Contractor inspect the material for damage before acceptance. Store and protect the material after acceptance.

B. The following is the Mechanical Contractor, Electrical Contractor and BAS Contractor Coordination Table.

BC=BAS Contractor; EC=Electrical Contractor(s); MC=Mechanical Contractor(s)

ITEM	FURNISHED BY	INSTALLED BY	POWER BY	CONTROL BY	MONITOR BY	OTHER/COMMENTS
Fire Damper	MC	MC	N/A	N/A	N/A	
Variable Frequency Drives	MC	EC	EC	MC, BC	MC, BC	Mechanical Contractor will provide BACnet MS/TP for interface to BAS.
Smoke Detectors/Fan Shutdown for Fire/Smoke Alarm	EC	MC	EC	EC	EC, BC	EC provides FAS addressable relays for fan shutdown and duct detector status. BC shall provide interlock wiring from FAS fan shutdown relays to fan motor starters or variable frequency drives. BC shall monitor FAS duct detectors status relays for duct detectors status inputs to BAS.
VAV/CAV Terminal Units	MC	MC	See Below	BC	BC	VAV/CAV terminal unit manufacturer will factory mount and wire 2nd tier controller and control damper actuator

ITEM	FURNISHED BY	INSTALLED BY	POWER BY	CONTROL BY	MONITOR BY	OTHER/COMMENTS
						supplied by BC. BC shall field wire control valve, space temperature sensor and 2nd tier controller communications.
Control Power to VAV/CAV Terminal Units	EC	EC, BC	EC, BC	N/A	N/A	EC will supply primary power to BAS panels (VAV/CAV terminal units' power supplies or BAS panels) as indicated on project plans. BC shall supply secondary power from VAV/CAV terminal units power supplies to VAV/CAV controller and perform all necessary installation thereof.
Laboratory Airflow Control System	BC	MC, BC	See Below	BC	BC	Specified in this Specification Section. MC installs all venturi airflow control valves.
Control Power To Laboratory Airflow Control System	EC	EC, BC	EC, BC	N/A	N/A	EC will supply primary power to BAS panels (venturi airflow control valves' power supplies or BAS panels) as indicated on project plans. BC shall supply secondary power from venturi airflow control valves power supplies to venturi airflow control valves controls as required
Unit Heater	MC	MC	EC	BC	N/A	
Fan Coil Units / Blower Coil Units	MC	MC	EC	BC	BC	
Water Differential Pressure Switches	BC	MC	BC	N/A	BC	BC responsible to wire water differential pressure switch into HVAC equipment safety circuit and to wire to BAS input.
Flow Meters (air)	MC	MC	BC	N/A	BC	
Flow Meters (water)	MC	MC	BC	N/A	BC	
Power Monitoring System	EC	EC	EC	EC	EC, BC	Electrical Contractor provides Modbus TCP/IP for interface to BAS.
Lighting Control System	EC	EC	EC	EC	EC, BC	Electrical Contractor provides BACnet/IP for interface to BAS.
Energy Recovery Wheels Control Panels	MC	MC	EC	MC, BC	MC, BC	Mechanical Contractor provides BACnet MS/TP for interface to BAS.

ITEM	FURNISHED BY	INSTALLED BY	POWER BY	CONTROL BY	MONITOR BY	OTHER/COMMENTS
Fume Hood Monitors	Fume Hood Manu.	Fume Hood Manu.	EC	N/A	N/A	
Automatic Control Valves	BC	MC	BC	BC	N/A	Automatic control valve actuators provided and mounted by control valves manufacturer(s).
Automatic Control Dampers	BC	MC	BC	BC	N/A	Automatic control damper actuators provided and mounted by BC.

C. The designated Division shall provide the following incidental work:

1. The Mechanical Contractor will:

   a. Install all automatic control valves and all separable wells.
   b. Provide all:

      1) Pressure taps and shutoff valves.
      2) Water drain and overflow connections and piping.
      3) Valve bypass assemblies (manual throttling valves and associated piping).
      4) Gages for local fluid temperature and pressure indication.

   c. Provide all necessary piping connections required for all flow devices, wells, temperature sensors, pressure indicators, etc.
   d. Install all automatic control dampers furnished by BAS Contractor and:

      1) Provide necessary blank-off plates (safing) required to install control dampers that are smaller than duct size.
      2) Assemble multiple section control dampers with required interconnecting linkages and extend required number of shafts through duct for external mounting of control damper motors.

   e. Provide access doors or other approved means of access through ducts for service to control equipment.
   f. Install all airflow and static pressure sensing stations in ductwork.
   g. Install all fluid flow meters (water, air) and provide all thredolets, manual valves, etc. required for proper installation.
   h. Install duct-mounted smoke detectors.
   i. Install all venturi airflow control valves, all CAV/VAV terminal units, and associated accessories.
   j. Provide all transitions from airflow control valves to ductwork.

2. The Electrical Contractor will:

   a. Provide one dedicated 120 VAC, 20 amp power circuit for each LACS power supply, each VAV/CAV terminal units power supply and each BAS panel as indicated on project plans.
   b. Provide all duct smoke detectors.
   c. Install all fire alarm system wiring.

3. BAS Contractor shall:

   a. Provide all electrical work from VAV/CAV terminal units' power supplies to BAS 2nd tier controller locations.

b. Provide all electrical work from LACS power supplies to DDC controllers' locations.
c. Provide hardwired interlocks between fire alarm addressable relay mounted by the Electrical Contractor in motor starter and/or equipment motor starters; input wiring from duct detectors to controllers.
d. Provide all hardwired interlocks from safety and permissive devices such as freezestats and end switches from the device to motor starters and to the BAS.
e. Provide all hardwired interlocks between motor starters and between variable frequency drives.
f. Provide all control wiring for the Mechanical Contractor devices such as unit heater thermostats.

1.3 DEFINITIONS

A. Advanced Application Controller (AAC): A fully programmable control module. This control module may be capable of some of the advanced features found in Building Controllers (storing trends, initiating read and write requests, etc.) but it does not serve as a master controller. Advanced Application Controllers may reside on either the Ethernet/IP backbone or on a subnet.

B. AE - Ballinger.

C. Application Specific Controller (ASC): A pre-programmed control module which is intended for use in a specific application. ASCs may be configurable, in that the user can choose between various pre-programmed options, but it does not support full custom programming. ASCs are often used on terminal equipment such as VAV/CAV terminal units or fan coil units. In many vendors' architectures ASCs do not store trends or schedules but instead rely upon a Building Controller to provide those functions.

D. BACnet/IP: An approved BACnet network type which uses an Ethernet carrier and IP addressing. BACnet IP uses a standard UDP/IP stack to send and receive messages (see definition of UDP/IP below). For the most part, the same packet that would be found on an MS/TP link is encapsulated in a UDP/IP packet and called BACnet IP. Devices use IP addresses and Ethernet MAC addresses just like other UDP/IP network devices. There is no concept of master/slave token passing since Ethernet is automatically peer to peer in nature. Devices simply transmit to their intended recipient at will, and let Ethernet deal with packet collisions and retries as needed.

E. BACnet MS/TP: An approved BACnet network type which uses a Master-Slave Token Passing configuration. MS/TP networks are unique to BACnet and utilize EIA485 twisted pair topology running at 9600 to 76,800 bps. Each device on the link is considered the "master" when it has the token. If it does not have immediate need to use the token, it is required to pass the token along to the next device. This is the "token passing" part. All devices on the link which do not currently have the token are regarded as slaves, and are expected to listen to any messages the current master may have for it. Because all devices take turns being master, the link is effectively peer to peer.

F. BACnet over ARCNET: An approved BACnet network type which uses an ARCNET (attached resource computer network) carrier. ARCNET is an industry standard that can utilize several speeds and wiring standards. The most common configuration used by BACnet controllers is an EIA485 twisted pair topology running at 156,000 bps.

G. Building Automation System (BAS): Building automation describes the functionality provided by the control system of a building. A building automation system (BAS) is an example of a distributed control system. The control system is a computerized, intelligent network of electronic devices, designed to monitor and control the mechanical and/or lighting systems in a building.

H. Building Controller (BC): A fully programmable control module which is capable of storing trends and schedules, serving as a router to devices on a subnet, and initiating read and write requests to other controllers. Typically this controller is located on the Ethernet/IP backbone of the BAS. In many vendors' architectures a Building Controller will serve as a master controller, storing schedules and trends for controllers on a subnet underneath the Building Controller.

I. Controls Manufacturer - Company that manufactures the BAS equipment.

J. CM - Construction Manager/Owner's representative managing the project.

K. Direct Digital Control (DDC): A control system in which a digital computer or microprocessor is directly connected to the control valves, control dampers, and other actuators which control the system, as opposed to indirectly controlling a system by resetting setpoints on an analog pneumatic or electronic controller.

L. Furnish or Furnished: The act of supplying a device or piece of equipment as required meeting the scope of work specified.

M. Input/Output (I/O):

1. AI = Analog Input. A physical input to the control module.

2. AO = Analog Output. A physical output from the control module.

3. AV = Analog Value. An intermediate (software) point that may be editable or read-only. Editable AVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only AVs are typically used to display the status of a control operation.

4. BI = Binary Input. A physical input to the control module.

5. BO = Binary Output. A physical output from the control module.

6. BV = Binary Value. An intermediate (software) point that may be editable or read-only. Editable BVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only BVs are typically used to display the status of a control operation.

7. Sched = Schedule. The control algorithm for this equipment shall include a user editable schedule.

8. Trend. The control system shall be configured to collect and display a trend log of this object. The trending interval shall be no less than one sample every 5 minutes. (Change of Value rending, where a sample is taken every time the value changes by more than a user-defined minimum, is an acceptable alternative.)

9. Alarm. The control system shall be configured to generate an alarm when this object exceeds user definable limits, as described in the Sequence of Operation.

   Note: If the specifications require use of the BACnet protocol, all of the above shall be provided as BACnet objects.

N. Install or Installed: The physical act of mounting, piping or wiring a device or piece of equipment in accordance with the manufacturer's instructions and the scope of work as specified. All costs required to complete the installation are borne by the division specified to include labor and any ancillary materials.

O. Interface: The physical device required to provide integration capabilities from an equipment vendor's product to the control system. The equipment vendor most normally furnishes the interface device. An example of an interface is the chilled water temperature reset interface card provided by the chiller manufacturer in order to allow the control system to integrate the chilled water temperature reset function into the control system.

P. Integrate: The physical connections from a control system to all specified equipment through an interface as required to allow the specified control and monitoring functions of the equipment to be performed via the control system.

Q. KW Demand Limiting: An energy management strategy that reduces energy consumption when a system's electric power meter exceeds an operator-defined threshold. When power consumption exceeds defined levels, the system automatically adjust setpoints, de-energizes low priority equipment, and takes other pre-programmed actions to avoid peak demand charges. As the demand drops, the system restores loads in a predetermined manner.

R. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

S. Occupant Override Switch or Timed Local Override: A control option that allows building occupants to override the programmed HVAC schedule for a limited period of time. When the override time expires, the zone returns to its unoccupied state.

T. Occupant Setpoint Adjustment: A control option that allows building occupants to adjust - within limits set by the HVAC control system - the heating and cooling setpoints of selected zones. Typically the user interface for this function is built into the zone sensor.

U. Optimal Start-Up: A control strategy that automatically starts an HVAC system at the latest possible time yet ensures comfort conditions by the time the building becomes occupied. In a typical implementation, a controller measures the temperature of the zone and the outside air. Then, using design heating or cooling capacity at the design outside air temperature, the system computes how long a unit must run at maximum capacity to bring the zone temperature to its occupied setpoint. The optimal start algorithm often includes a self-learning feature to adjust for variations from design capacity. A distributed system must use Run on Request with Optimal Start (See below).

V. Owner: Owner of property/building(s) where work is being performed.

W. Proportional plus Integral plus Derivative (PID): A generic control loop feedback mechanism (controller) widely used in industrial control systems. A PID controller attempts to correct the error between a measured process variable and a desired setpoint by calculating and then outputting a corrective action that can adjust the process accordingly and rapidly, to keep the error minimal.

X. Protocol Implementation Conformance Statement (PICS): A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device.

Y. Provide or Provided: To both furnish and install a device or piece of equipment as required meeting the scope of work specified and making that device or equipment operational. All costs required to provide the specified device or equipment and make it operational are borne by the division specified to be responsible for providing the device or equipment.

Z. Requested, or Run on Request: A control strategy that optimizes the runtime of a source piece of equipment that supplies one or more receiving units - such as an air handling unit supplying zone terminal units with heating, cooling, ventilation, or similar service. Source equipment runs only when needed, not on a fixed schedule. The source equipment runs when one or more receiving units request its services. An operator determines how many requests are required to start the source equipment. For example, if all the zones in a building are unoccupied and the zone terminal units do not need heating or cooling, the AHU will shut down. However, if a zone becomes occupied or needs cooling, the terminal unit will send a run request to the AHU to initiate the start-up sequence. If this AHU depends on a central chiller, it can send a run request to the chiller. The run on request algorithm also allows an operator to schedule occupancy for individual zones based on the needs of the occupants without having to adjust the schedules of related AHUs and chillers

AA. Resistance Temperature Detector (RTD): A Resistance Temperature Detector (RTD) is a device with a significant temperature coefficient (that is, its resistance varies with temperature). It is used as a temperature measurement device, usually by passing a low-level current through it and measuring the voltage drop. A thermistor is a common type of RTD.

BB. Terminal equipment - HVAC equipment conditioning an individual space or small group of rooms.

Examples of terminal equipment are VAV/CAV terminal units, Fan Coil Units, Unit Ventilators, Unit heaters.

CC. Trim and Respond, or Setpoint Optimization: A control strategy that optimizes the setpoint of a source piece of equipment that supplies one or more receiving units - such as an air handling unit supplying zone terminal units with heating, cooling, ventilation, or similar service. The source unit communicates with receiving units to determine heating, cooling, and other requirements, and then adjusts its setpoint. For example, if all zones are comfortable and do not request cooling, the AHU will gradually increase (trim) its supply air setpoint. When a zone requests cooling, the AHU responds by dropping its setpoint. The more zones that request cooling, the more it drops the setpoint. The AHU repeats this process throughout the day to keep zones cool, but with a supply air setpoint that is no cooler than necessary.

DD. Web Services: Web services are a standard method of exchanging data between computer systems using the XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services can be used at any level within a Building Automation System (BAS), but most commonly they are used to transfer data between BAS using different protocols or between a BAS and a non-BAS system such as a tenant billing system or a utility management system.

1.4 DESCRIPTION

A. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and a web-based operator interface. Depict each mechanical system and building floor plan by a point-and-click graphic. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.

B. The system shall directly control HVAC equipment as indicated on the BAS Drawings Sequence of Operations. Each zone controller shall provide occupied and unoccupied modes of operation by individual zone. Furnish energy conservation features such as optimal start and stop, night setback, request-based logic, and demand level adjustment of setpoints as specified in the sequence.

C. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. I/O points, schedules, setpoints, trends, and alarms indicated on the BAS Drawings shall be BACnet objects.

1.5 BAS CONTRACTOR SCOPE OF WORK

A. Provide a complete direct digital control (DDC) Building Automation System (BAS), capable of integrating building functions including equipment supervision and control, alarm management, energy management, network monitoring and control and all hardware and software operator interface utilities.

B. The BAS is one of a number of individual control and monitoring systems, which together comprise an overall Integrated Building Control System (IBCS). Details of the scope of overall integration.

C. The BAS shall consist of the following as detailed in this Specification. This is intended to describe in general what is to be provided. Reference this Specification Part 2 (Products) for specific product requirements of each item listed below. Also, reference this Specification Section Part 3 (Execution) for a complete description of the mechanics of providing the overall system, the BAS Drawings for BAS Points Lists for the systems points lists, the BAS Drawings for BAS Sequence of Operations, and this Specification Section for Laboratory Airflow Control System (LACS). Provide whatever is necessary, even if not spelled out below, for a complete and working system as spelled out in this Specification Section:

1. 1st and 2nd tier DDC controllers as required to meet requirements spelled out in this Specification Section. Minimum of one 1st tier controller.

2. All automatic control valves, control valve actuators, control valve linkages and required miscellaneous items and materials.

3. All automatic control dampers, control damper actuators, linkages, end switches, mounting brackets, extension shafts and miscellaneous items and materials.

4. All input, output and electric or electronic devices as required.

5. All conduits, wire, communication cable, connectors, enclosures, fittings, miscellaneous equipment and materials and associated labor to install for a complete system. All installation work shall be per NEC and any local or state code requirements.

6. Monitor and control all I/O points necessary to perform all functions as identified in the BAS Drawings sequence of operations and the BAS Drawings BAS points lists, including all software points required for any processing, systems integration, data logging and storage, graphics, calculations or report generation related to the field I/O points.

7. The system specified herein shall be capable of expansion to a minimum three times the initial overall point capacity, with no limitations on the types of points and without requirement for future board/chip/firmware upgrade.

8. Provide a minimum of 10% spare Input/Output (I/O) control point capacity at each 1st tier controller/ panel. The controller power supply shall accommodate a fully module loaded controller.

9. Provide all VAV/CAV terminal unit mounted devices such as 2nd tier controllers, temperature sensors, velocity sensors, control damper actuators and control valves with actuators. 2nd tier controllers and control damper actuators shall be shipped with approved wiring diagrams to the VAV/CAV terminal unit manufacturer for factory mounting and wiring.

10. Provide all gateways, routers, bridges, network cards, card racks, power supplies, drivers, etc. for facilitating 1st tier and 2nd tier communication per manufacturers' recommendation, to interface with the site network backbone and to facilitate any communication to other building systems. This shall include installation of connectors on all communication cables, final terminations and testing. The BAS Contractor is responsible for the proper operation of any networks used in the BAS.

11. Provide color graphic displays per this Specification Section 2.3. Provide trend logs, schedules, floor plans, sequence of operation and reports for each system per Specification Section.

D. Provide all necessary engineering, project management, field technical support, material, labor and interface necessary to provide a complete BAS. At a minimum, provide controls for the following:

1. Air handling unit, its associated energy recovery systems, and its associated heating coil freeze protection pump.

2. Exhaust fans.

3. Chilled water system including chiller, plate and frame heat exchanger, primary chilled water pumps, variable frequency drives, and accessories.

4. Chilled beams chilled water system including plate and frame heat exchanger, chilled beams chilled water pumps, variable frequency drives, and accessories.

5. Heating hot water system including boilers, heating hot water pumps, variable frequency drives, and accessories.

6. Commercial grade constant air volume terminal units and variable air volume terminal units.

7. Variable air volume venturi air valves and constant air volume venturi air valves.

8. Complete laboratory airflow control system including venturi air valves; space temperature sensors; venturi air valves low static pressure switches; chilled beams controls; condensation sensors; laboratory airflow control system cabling; routers; repeaters; laboratory airflow control system server; laboratories temperature and airflow control with integration from the laboratory airflow control system to the BAS.

9. Active chilled beams and their associated controls.

10. Fan coil units.

11. Blower coil units.

12. Finned tube radiation.

13. Airflow measuring stations monitoring.

14. Electrical power monitoring system monitoring.

15. Electrical circuit breakers monitoring.

16. Lighting control system monitoring.

17. Electric unit heater.

18. Plumbing systems monitoring including sump pumps; domestic water booster pump; and domestic hot water heaters.

19. Monitoring points, drivers and hardware interface for communication to equipment, including all gateways, drivers, cabling, etc. to all BAS to communicate with the other systems.

20. Power wiring to BAS I/O devices (including any BAS panels required but not shown on floor plans) and terminal/application specific (2nd tier) controllers.

E. Provide submittals, design, installation, workstation user interface, programming, start up, testing and commissioning of the BAS, instruction of Owner's representative on maintenance and operation of the BAS, as built documentation and system warranty.

F. Provide services and manpower necessary for commissioning of system in coordination with the Mechanical Contractor Balancing effort and Owner's Representative.

1. Coordinate set-up and calibration of all airflow measuring and control instrumentation with the Mechanical Contractor air balancing effort.

2. The BAS Contractor shall work directly with the air and water balancing Subcontractor(s) to provide calibration of all fluid flow stations for water and other such flows and all airflow measuring devices such as static pressure, airflow station and VAV/CAV terminal unit airflow.

3. Provide complete system hardpoint and functional (software) testing as spelled out in this Specification Section Article 3.16 (Control System Checkout and Testing).

G. Provide all signal, control, data transmission, low voltage and power wiring except where otherwise

specified, incidental to the installation of the BAS.

H. Coordination with all trades.

1. Locate all sensors, controls, peripherals, conduits, 1st and 2nd tier controllers, workstations, networking equipment and other materials to result in proper operation of the various systems to avoid conflicts with the work of other trades and with the installation by the Mechanical Contractor or the Electrical Contractor. Obtain required location approval in time to allow uninterrupted progress. Check layouts of equipment with shop drawings of all trades to determine rough-in requirements. Do not use scaled drawings as sole method of locating system components. Exercise proper judgment to secure a neat arrangement of equipment and to overcome local interferences to best advantage of the project.

2. Where physical interferences cannot be resolved readily, consult with the Construction Manager and prepare dated, dimensioned drawings correcting the interferences. Obtain written approval from the CM and AE for such changes and distribute the drawings to all interested parties as directed by the CM.

3. Locate switches and other manually operated devices in a location easily accessible and convenient to operating personnel. If any such devices are mounted in a location deemed inaccessible or impractical, relocate devices.

4. Ensure that the location and wiring of all devices are in accordance with these Specifications and manufacturer's requirements.

5. Provide direction to the Mechanical Contractor regarding installation of automatic control valves. Communicate any special considerations related to the proper performance of, or manufacturers recommendations for installation of the control valve and/or actuator to the Mechanical Contractor prior to installation.

I. Provide all cutting and patching incidental to the installation of the BAS. Use patching materials that are the same as the surrounding materials and/or are commonly used materials for such patching and provide finish to match surrounding as directed by CM/Owner. Patching must maintain all fire rating or other building code related properties of material being patched.

1.6 APPROVED CONTROL SYSTEMS

A. The BAS basis of design is Automated Logic Corporation WebCTRL. The following are approved control system suppliers, manufacturers, and product lines:

Supplier	Manufacturer	Product Line
Advanced Power Control, Inc.	Alerton Controls	Alerton BACtalk Building Suite 3
Radius Systems, LLC	Automated Logic	Automated Logic WebCTRL
Honeywell Branch Office	Honeywell	Honeywell Enterprise Buildings Integrator
Johnson Controls Branch Office	Johnson Controls	Johnson Control Metasys with NAE Architecture
Schneider-Electric Branch Office	Schneider-Electric	Schneider-Electric Andover Continuum
CM3 Building Solutions	Schneider-Electric	Schneider-Electric I/A Series
Tri-M Building Automation Systems	Schneider-Electric	Schneider-Electric Andover Continuum

B. Control systems shall comply with the terms of this specification.

1. The BAS Contractor shall use only operator workstation software, controller software,

custom application programming language, and controllers from the corresponding manufacturer and product line unless Owner approves use of multiple manufacturers.

2. Other products specified herein (such as sensors, control valves, control dampers, and actuators) need not be manufactured by the above manufacturers.

1.7 CODES AND STANDARDS

A. All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local and state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications. As a minimum, the installation shall comply with current editions in effect 90 days prior to receipt of bids of the following codes. All products of the BAS shall be provided with the following agency approvals. With the submittal documents, verification that the approvals exist for all submitted products, shall be provided. Systems or products not currently offering the following approvals are not acceptable.

1. National Electric Code, UL-916 (File # E71385 Category PAZX) Energy Management Systems, UL, ULC listed to Canadian Safety Standard (CAN/CSA C22.2), FCC, Part 15, subpart J, Class B Computing Devices, Canadian Department of Communications, Class B, and European Community-EMC Directive EN55022 (Emissions, Class A).

2. All products shall be labeled with the appropriate approval markings. System installation shall comply with NFPA, NEMA, Local and National codes.

3. The BAS manufacturer shall provide documentation supporting compliance with ISO-9000 certification mark from applicable registrar.

4. All products shall comply with surge immunity standards ANSI C62.41 (IEEE-587, Category A & B), EN6100-4 Surges per EN50082-1.

5. International Building Code (IBC)

a. Section 719 Ducts and Air Transfer Openings
b. Section 907 Fire Alarm and Detection Systems
c. Section 909 Smoke Control Systems
d. Chapter 28 Mechanical

6. International Mechanical Code (IMC)

7. Instrument Society of America (ISA)

8. DDC system control components shall be based upon BACnet™ ASHRAE Standard 135 Conformance level 3.

9. National fire Protection Association (NFPA)

10. Occupational safety and Health Act (OSHA)

11. Underwriters' Laboratories, Inc. (UL)

1.8 INTENT OF DOCUMENTS

A. Consider the Drawings and Specifications as supplementing each other. Work specified but not shown, or shown but not specified, shall be performed or furnished as though mentioned in both Specifications and Drawings.

B. Provide minor items, accessories or devices as necessary for completion and proper operation of any system whether or not they are specifically called for by Specifications or Drawings.

C. Provide all labor, material, equipment and service necessary and reasonably incidental to proper completion of all systems as shown on Drawings and as specified.

D. Coordinate the work and equipment in this Division with the work and equipment specified elsewhere in order to assure a complete installation.

E. The General Conditions shall be considered as forming a part of the Specifications and shall be carefully examined before proposals for any work are submitted. Unless the Specifications contain statements that are more definitive, or more restrictive, than those contained in the General Conditions, the Specifications shall not be interpreted as waiving or overruling any requirements expressed in the General Conditions.

1.9 SYSTEM PERFORMANCE

A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems):

1. Graphic Display. The system shall display a graphic with 20 dynamic points with all current data within 10 seconds.

2. Graphic Refresh. The system shall update a graphic with 20 dynamic points with all current data within 8 seconds.

3. Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be less than 5 seconds. Analog objects should start to adjust within 5 seconds.

4. Object Scan. All changes of state and change of analog values will be transmitted over the high-speed network such that any data used or displayed at a controller or workstation will have been current within previous 60 seconds.

5. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 20 seconds.

6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. The BAS Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.

7. Performance. Programmable controllers shall be able to execute DDC PID control loops at a selectable frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.

8. Configuration and Tuning Screens: Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.

9. Multiple Alarm Annunciation. All workstations on the network must receive alarms within 5 seconds of each other.

10. Reporting Accuracy. The system shall report all values with an end-to-end accuracy as listed as or better than those listed in Table 1.

11. Stability of Control. Control loops shall maintain measured variable at set point within the tolerances listed in Table 2.

Table 1
Reporting Accuracy

Measured Variable	Reported Accuracy

Space Temperature	±1ºF
Ducted Air	±1ºF
Outside Air	±1ºF
Dew Point	±2ºF
Water Temperature	±1ºF
Delta-T	±0.25ºF
Relative Humidity	±2% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±0.1 in. w.g.
Air Pressure (space)	±0.01 in. w.g.
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 3)

Note 1: Accuracy applies to 10% - 100% of scale
Note 2: For both absolute and differential pressure
Note 3: Not including utility-supplied meters

Table 2
Control Stability and Accuracy

Controlled Variable	**Control Accuracy**	**Range of Medium**
Air Pressure	±0.2 in. w.g. ±0.01 in. w.g.	0-6 in. w.g. -0.1 to 0.1 in. w.g.
Air Flow	±10% of full scale	
Space Temperature	±1.0ºF	
Duct Temperature	±1ºF	
Humidity	±2% RH	
Fluid Flow	+/- 2% of flow velocity	0 to 30 FPM
Fluid Pressure	±1.5 PSI ±1.0 in. w.g.	1-150 PSI 0-50 in. w.g. differential

1.10 SUBMITTALS

A. Technical Proposal

1. Submit a technical proposal for the Owner's evaluation as a part of the bid documents.

2. Design the proposal to define the details of the system proposed. Clarify areas of compliance and non-compliance with the requirements and intent of this Section Specification paragraph by paragraph. State the reason for non-compliance and explain the proposed alternative.

3. Review the installation requirements with the Mechanical Contractor and the Electrical Contractor and certify that the system proposed meets the requirements.

4. Provide the technical proposal in binder, tabbed for easy reference. All drawings included shall be reduced to A- or B-size (if legible at this size - if not, provide smallest drawings possible that provide adequate clarity) and folded to fit in the proposal. Tabbed sections of the technical proposal shall be as follows:

a. Overall description of scope of work proposed.
b. Product cut sheets for primary and secondary DDC components.
c. List of 5 customer references, 2 of which are for projects of similar size and

scope over the past 3 years.

d. List of Subcontractor(s) (name, phone number, primary contact name) and what portion of the work they shall perform.

e. 3rd party integration – communication and software/driver method for each interface, BAS hardware required for the interface, 2-way data available for each interface, BACnet PICS (if utilizing BACnet) and physical method of connection to BAS.

f. Company information - brief company history, organizational chart for the team who shall work on this project (all personnel) what each person's role shall be and a resume for each project team member.

5. Review of the submitted technical proposal shall not be construed as approval of the system and shall not relieve the system BAS Contractor of fulfilling the requirements of the Specifications in total.

B. Submittal

1. Submit all data to the AE. Six submittal copies are required, unless specified otherwise elsewhere in this specification. Submittal shall include the following:

a. Riser diagram showing 1st tier controllers, 2nd tier controllers, BAS servers, BAS workstations, UPS, external batteries, modems and other peripheral devices, control panels, switches, routers and all trunk wiring. Diagram shall show all 1st and 2nd tier communication cabling linking these items, phone line requirements, all power wiring (240 VAC, 120 VAC, 24 VAC, etc.) requirements to each and wire types and terminations for communication buses. This shall include all specific wire runs, wire type and terminations for all open protocol interfaces. In addition, all dryers, filters, pressure reducing stations, primary air distribution piping shall be shown.

b. Schedule of hardwired input and output (I/O) points per 1st tier and 2nd tier controller (one I/O schedule per controller). Each controller I/O schedule shall include for each input and output its channel, I/O device used, range, software address (point name) and the drawing number(s). Each controller I/O schedule shall also contain the controller name, location, part number, firmware version and the current revision date/description. In addition, the 2nd tier controller I/O schedules shall contain the name of the 1st tier controller to which they are wired.

c. Sequence of operation, detailing all DDC and non-DDC control sequences.

d. System graphics that shall be part of the front end user interface (typicals only). At a minimum, graphics shall be provided for (1) each piece of controlled equipment (including terminal equipment); (2) each building floor plan (NOTE - floor plans are to be broken down into smaller sections as required to be legible and fit all required data); (3) building riser/cross-section; (4) chart summarizing terminal equipment per air handling unit or floor plan section). Equipment graphics shall include a flow diagram of the equipment, all monitored and controlled data points, all setpoints and targets, all animations and all buttons/links to other graphics (at a minimum, provide links to related equipment, the building riser, floor plans, charts, sequence of operation, schedules, reports and trend logs). Floor plans shall include room name/number, space temperatures, space temperature setpoint, links to terminal equipment, link to riser and links to air handling unit or other primary equipment located on the floor plan. Building riser shall include a cross-section of the building with links to primary equipment and floor plans. Charts shall include tag/label of equipment, all pertinent setpoints/ inputs/outputs, link to riser and links to air handling unit or other primary equipment associated with this type of equipment.

e. Technical specification data sheets of all system components such as BAS equipment, BAS servers, BAS workstations, I/O devices, software, control valves, control dampers, actuators, and miscellaneous components. Provide technical specification data sheets of all system components such as BAS equipment, I/O devices, software, control valves, control dampers, actuators, and miscellaneous components. Mark data sheets with arrows pointing to the specific

model number chosen. All product data sheets submitted should contain the VA draw of the equipment with arrows pointing to the specific model number chosen. All product data sheets submitted should contain the VA draw of the equipment.

f. Control valve schedule showing at a minimum – quantity, tag, type (2-way, 3-way), configuration (mixing, diverting), fluid type (chilled water, hot water, etc.), failure state (N.O., N.C.), spring return (y/n), GPM or #/hour, actuator type (electric, electronic), actuator range, pressure drop, flow coefficient, manufacturer and part number.

g. Control damper schedule showing at a minimum – quantity, tag, type (opposed, parallel), configuration (single section, multi-section), failure state (N.O., N.C.), spring return (y/n), airflow (CFM), actuator type (electric, electronic), actuator range, width, height, shaft arrangement, manufacturer and part number.

h. Wiring diagrams for each typical piece of controlled equipment. These diagrams shall include but not be limited to the following:

1) Flow diagram showing all HVAC equipment components, all control devices and all wiring end-to-end from control device to control panel.
2) All power supply, transformer and 120 VAC wiring and connections.
3) All wiring to motor starters and all motor starter interconnect terminations.
4) All wiring interconnects details for interface to equipment supplied by others.
5) Bill of material showing quantity, device designation, manufacturer and part number of all equipment supplied related to each control enclosure.
6) Ladder-style wiring diagrams showing all end- to-end wiring and specific terminations (from controller input or output to the specific terminations at the monitored or controlled device), including all terminal numbering inside the control enclosure. This shall include but not be limited to wiring to temperature sensors, pressure sensor, humidity sensors, relays, contactors, photocells, solenoids, PE switches, flow meters, control damper actuators and control valve actuators.
7) List of labels to be supplied inside and outside the control enclosure.

i. System Testing and Commissioning procedures and forms. See Section 1.06 for submittal requirements.

j. Submit for record: Final as-built shop drawings of all submittals, control enclosures and components incorporating all field modifications made prior to Owner acceptance.

k. Licensing agreement for each licensed software module (one copy to be executed by the Owner prior to software delivery).

2. Quantities of items submitted shall be reviewed by the Engineer and Owner, but are the responsibility of the BAS Contractor.

3. Provide and submit for review and acceptance all report formats and checklists to be used in "Control System Demonstration and Acceptance" to the Engineer and Owner. Include any additional information or data that is deemed necessary to determine compliance with these specifications or which is deemed valuable in documenting the control system to be installed.

4. If applicable provide a BACnet™ Protocol Implementation Conformance Statement (PICS) for each type of controller and operator interface included in the submittal.

5. Description of process, report formats, and checklists to be used in this Specification Section Article 3.17 (Control System Demonstration and Acceptance).

C. Schedules

1. Schedule of work provided within one month of contract award, indicating:

a. Intended sequence of work items
b. Start date of each work item
c. Duration of each work item
d. Planned delivery dates for ordered material and equipment and expected lead times
e. Milestones indicating possible restraints on work by other trades or situations

2. Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.

D. Project Record Documents: Upon completion of installation, submit three (3) copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and shall include:

1. Project Record Drawings. These shall be as-built versions of the submittal shop drawings. One set of magnetic media including .CAD, .DWG, .VSD or .DXF drawing files also shall be provided.

2. Testing and Commissioning Reports and Checklists. Provide completed versions of all reports and checklists used to complete the requirements of this Specification Section Article 3.17 (Control System Demonstration and Acceptance).

3. System Testing and Commissioning procedures and forms**.** See Section 1.10 for submittal requirements.

4. Operation and Maintenance (O & M) Manual. This shall include as-built versions of the submittal product data. In addition to the information required for submittals, the O & M manual shall include:

a. Names, addresses, and 24-hour telephone numbers of BAS Contractor's installing equipment, and the control systems and service representatives of each.
b. Operators Manual with procedures for operating the control systems, including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.
c. Programming Manual with a description of the programming language (including syntax), statement descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the editor.
d. Engineering, Installation and Maintenance Manual(s) that explain how to design and install new points, panels, and other hardware; preventive maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.
e. A listing and documentation of all custom software created using the programming language, including the point database. One set of magnetic media containing files of the software and database also shall be provided.
f. One set of magnetic media containing files of all color graphic screens created for the project.
g. A list of recommended spare parts with part numbers and suppliers.
h. Complete original issue documentation, installation and maintenance information for all third-party hardware provided, including computer equipment and sensors.
i. Complete original issue diskettes for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
j. Licenses, guarantee, and warranty documents for all equipment and systems.
k. Recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions.

E. Training Manuals: The BAS Contractor shall provide a course outline and training manuals for all

training classes at least six weeks prior to the first class. The Owner reserves the right to modify any or all of the training course outline and training materials. Review and approval by Owner and Engineer shall be completed at least three weeks prior to the first class.

1.11 QUALITY ASSURANCE

A. Reference Standards:

1. All systems, devices etc. shall be per applicable provisions of the following:

a.	ISA	Instrument Society of America
b.	NEC	National Electrical Code
c.	OSHA	Occupational Safety and Health Act
d.	UL	Underwriters' Laboratories, Inc.
e.	NFPA	National Fire Protection Assoc.

B. Requirements of Regulatory Agencies

1. Provide material and equipment and execute the work, including test and inspections, per applicable provision of Federal, State and Local Government laws and ordinances and referenced codes and standards and per applicable Owner's standard. Governing laws, ordinances, codes and standards constitute minimum requirements.

C. Source Quality Control

1. Perform manufacturer's standard shop tests for each component to ensure compliance with intent of these Specifications.

2. Materials and equipment shall be the products of manufacturer's regularly engaged in the manufacture of such products, shall essentially duplicate equipment that has been in satisfactory service at least 2 years prior to issue date of the contract.

D. Installer and Manufacturer Qualifications

1. Installer shall have an established working relationship with Control System Manufacturer.

2. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

3. Bids by wholesalers, contractors or franchised dealers or any other firm whose principal business is not that of manufacturing and installing automatic temperature control systems shall not be acceptable.

4. All products used in this installation shall be new, currently under manufacture, and have been applied in similar installations for a minimum of 2 years. This installation shall not be used as a test site for any products unless explicitly approved by the Engineer in writing.

5. Mechanical equipment manufacturers desiring to provide DDC type controls as factory mounted equipment, shall provide a separate bid for their products less all controls, actuators, control valve assemblies and sensors, which are specified to be provided by the BAS Contractor.

E. Electrical Installer Qualifications

1. Electrical installer shall at a minimum hold an electrical license in the state where the work is being performed. Additional licensing required by the city, county, township, or other municipality is the responsibility of the BAS Contractor and its Subcontractor(s).

2. Electrical installer is responsible for obtaining and paying for any permits, licenses, or other business fees related to the performance of this work.

3. Electrical installer shall use on this project personnel who regularly install systems of the size and scope of this project.

4. Electrical installer shall provide a foreman on site at all times to direct its work crew(s).

5. Installer shall have been in business a minimum of 5 years and shall have installed 2 projects of a similar size and scope in the past 3 years.

F. BAS Manufacturer and BAS Contractor Qualifications

1. The 1st tier and 2nd tier DDC controllers specified herein shall, with exception to certain components where specified, be the product of one building automation system manufacturer. The components shall be designed, programmed, installed, tested and calibrated by personnel regularly employed in such work and who specialize in BAS instrumentation engineering, installation and startup.

2. The BAS manufacturer shall have been regularly engaged in the manufacture and installation of controls and control systems for the last ten years.

3. Total bid price by the BAS Contractor cannot be greater than 50% of the prior calendar year's total revenue.

4. The BAS Contractor shall have engineered, installed, startup and commissioned and serviced at least 2 systems of similar size and scope in the past 3 years and have an office within a 50 mile radius of the project site.

5. The following minimum qualifications apply to each project team member:
   a. Project Manager, Project Engineer/Designer, Applications/Software Engineer - 5 years experience at current position and experience doing 2 projects of similar dollar amount, building type and project scope.
   b. Lead startup technician - 10 years BAS startup experience and experience doing 3 projects of similar size and type.

6. The BAS Contractor shall have an office that is staffed with factory trained engineers who shall provide system design, program, training, workstation and software setup and installation and oversee all engineering work on the project. Staff shall also include factory-trained technicians fully capable of providing system checkout and startup, instruction and routine maintenance/repair service and emergency service on all system components.

7. The BAS Contractor shall also have a demonstrated ability and existing internal systems in place to provide emergency service 24 hours/day 7 days/week, with 1 hour response time by phone and 4 hour response time on-site. Emergency technicians shall be trained and experienced in system troubleshooting, programming and workstations to troubleshoot and solve any system malfunction either via the Internet through the Owners firewall or at the site via direct-connected laptop computer.

8. The BAS Contractor shall maintain at its office software language manuals, system troubleshooting manuals and as-built documentation manuals in order to support any system additions, modifications and troubleshooting.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

H. Comply with ASHRAE 135 for DDC system components.

I. Source Quality Control

1. Perform manufacturer's standard shop tests for each component to ensure compliance with intent of these Specifications.

2. Materials and equipment shall be the products of manufacturer's regularly engaged in the manufacture of such products, shall essentially duplicate equipment that has been in satisfactory service at least 2 years prior to issue date of the contract.

1.12 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

C. Provide secure on-site storage for materials and tools including those of Subcontractor(s).

1.13 WARRANTY REQUIREMENTS

A. Warrant work as follows:

1. All components, system software, and parts supplied by the BAS Contractor shall be guaranteed against defects in materials and workmanship for one year from acceptance date. The BAS Contractor at no charge shall furnish Labor to repair, reprogram, or replace components during the warranty period. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The BAS Contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours.

2. At the end of the final startup, testing and commissioning phase, if equipment and systems are operating satisfactorily to the Owner’s Authorized Representative and Engineer, the Owner’s Authorized Representative shall sign certificates certifying that the control systems’ operation has been tested and accepted in accordance with the terms of this specification.

3. Operator workstation software, project-specific software, graphic software, database software, and firmware updates which resolve known software deficiencies as identified by the BAS Contractor shall be provided to the Owner at no charge during the warranty period. Any upgrades or functional enhancements associated with the above mentioned items also can be provided during the warranty period for an additional charge to the Owner by purchasing an in-warranty service agreement from the BAS Contractor. Written authorization by the Owner must, however, be granted prior to the installation of any of the above mentioned items.

4. The BAS Contractor shall send a letter to the Owner with copies to CM and AE notifying them of the commencement of warranty, which starts upon acceptance of the system. Date of acceptance shall begin warranty period. Acceptance date shall be defined as follows:

   a. All pre-requisites for Owner training have been met (see this Specification Section Article 3.19).
   b. All operators training have occurred.

5. Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve BAS Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without

Owner's written authorization.

6. Update corrective software modifications made during warranty service periods on all user documentation and on user and manufacturer archived software disks. Save all software changes to the system at the office of the BAS Contractor for remote reload, as well as at the site. Provide remote or on-site reloads of controller programming during the warranty period.

7. Exception: BAS Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer's acceptance.

8. Provide warranty service in accordance with the warranty section of this specification. In addition provide scheduled maintenance on all control system apparatus including control valves, control dampers, linkages, control panels, interfaces, direct digital control systems, GUI's, PC's, Software and application programs. Maintenance shall consist of:

   a. Scheduled p.m. visit twice a year to audit system performance. Each p.m. visit will include exercising each control Loop and control sequence for performance. A log of each loop tested and each control sequence verified shall be reviewed with the Owner.
   b. Provide emergency service for parts and labor on an as needed basis. Response to an emergency call shall be 4 hours maximum on Mon.-Fri. and 8 hours maximum on holidays and weekends.
   c. Provide remote service diagnostic monitoring from the nearest service location. At the request of the Owner, a service diagnostic call will be made to troubleshoot and resolve (if possible) any reported system complaints. The Owner will provide a dedicated telephone line for connection to the system.
   d. Provide a separate written quotation with the submittal for extension of the maintenance for years 2, 3, 4, and 5.

1.14 OWNERSHIP OF PROPRIETARY MATERIAL

A. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software. All project developed software and documentation shall become the property of the Owner. These include, but are not limited to:

   1. Project graphic images
   2. Record drawings
   3. Project database
   4. Project-specific application programming code
   5. All documentation
   6. System technical manuals
   7. Programming tools
   8. Graphic editing tools
   9. Database configuration tools.

PART 2 - PRODUCTS

2.1 MATERIALS

A. This Specification Section defines the minimum required specifications for all products used which shall make up the BAS. Provide any devices not specified but required for a complete and working system. The quality, accuracy and operability of system components shall be equivalent or better than the components specified in this Specification Section.

B. All products used in this project installation shall be new, currently under manufacture, and shall be applied in similar installations for a minimum of 2 years. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner's Representative in writing. Spare parts shall be available for at least 5 years after completion of this contract.

2.2 COMMUNICATION

A. Control products, communication media, connectors, repeaters, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2010, BACnet.

B. Install new wiring and network devices as required to provide a complete and workable control network.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.

2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies indicated on the BAS Drawings. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

E. Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.

F. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

G. System shall support Web services data exchange with any other system that complies with XML (extensible markup language) and SOAP (simple object access protocol) standards specified by the Web Services Interoperability Organization (WS-I) Basic Profile 1.0 or higher. Web services support shall as a minimum be provided at the workstation or web server level and shall enable data to be read from or written to the system.

1. System shall support Web services read data requests by retrieving requested trend data or point values (I/O hardware points, analog value software points, or binary value software points) from any system controller or from the trend history database.

2. System shall support Web services write data request to each analog and binary object that can be edited through the system operator interface by downloading a numeric value to the specified object.

3. For read or write requests, the system shall require user name and password authentication and shall support SSL (Secure Socket Layer) or equivalent data encryption.

4. System shall support discovery through a Web services connection or shall provide a tool available through the Operator Interface that will reveal the path/identifier needed to allow a third party Web services device to read data from or write data to any object in the system which supports this service.

2.3 OPERATOR INTERFACE

A. Operator Interface. Vendor shall provide all graphics, trends, alarms, global demand limiting, and other functions required under this section.

B. Vendor must include with bid all software for owner to create new or edit existing graphics, trends, schedules, reports, alarms, system database, or any other functions included with the front end software. The intent is for the owner to be capable of being fully autonomous once the system installation is complete.

C. Communication. Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135-2010, BACnet Annex J.

D. Hardware. Each workstation or web server shall consist of the following:

1. Hardware Base. Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times specified in this Specification Section Article 1.9. Hard disk shall have sufficient memory to store system software, one year of data for trended points indicated on the BAS Drawings, and a system database at least twice the size of the existing database at system acceptance. Configure computers and network connections if multiple computers are required to meet specified memory and performance. Web server or workstations shall be IBM-compatible PCs with a minimum of:

a. Intel Pentium 2.66 GHz processor
b. 1 GB RAM
c. 40 GB hard disk providing data at 100 MB/sec
d. 48x CD-ROM drive
e. Serial, parallel, and network communication ports and cables required for proper system operation

E. Operator Functions. Operator interface shall allow each authorized operator to execute the following functions as a minimum:

1. Log In and Log Out. System shall require user name and password to log in to operator interface.

2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.

3. View and Adjust Equipment Properties. Operators shall be able to view controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls, and sensor calibration.

4. View and Adjust Operating Schedules. Operators shall be able to view scheduled operating hours of each schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.

5. View and Respond to Alarms. Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms.

6. View and Configure Trends. Operators shall be able to view a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data

from multiple trended points.

7. View and Configure Reports. Operators shall be able to run preconfigured reports, to view report results, and to customize report configuration to show data of interest.

8. Manage Control System Hardware. Operators shall be able to view controller status, to restart (reboot) each controller, and to download new control software to each controller.

9. Manage Operator Access. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system access and of functions they can perform while logged in. Operators shall be able to add operators, to delete operators, and to edit operator function authorization. Operator shall be able to authorize each operator function separately.

F. System Software.

1. Operating System. Web server shall have an industry-standard professional-grade operating system. Acceptable systems include Microsoft Windows XP Pro, Red Hat Linux, or Sun Solaris.

2. System Graphics. Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.

a. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.
b. Animation. Graphics shall animate by displaying different image files for changed object status.
c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).

G. System Tools – The BAS Contractor shall include all software tools (at no additional cost) and any required training to allow the owner to be fully autonomous in creating new, editing/changing the system being provided. This will include all tools for creating/editing/changing:

1. Databases.
2. Adding input, output, or any other type of points.
3. Trend intervals, view durations.
4. Which points are trended.
5. Reports.
6. Schedules.
7. Alarms.
8. Programming for any controller throughout the entire system.
9. Graphics – editing, adding/removing points from existing, creating new.

H. System Administration - System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs

with no limit on the number of copies that can be installed under the system license.

1. Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.

2. Controller Memory Download. Operators shall be able to download memory from the system database to each controller.

3. System Configuration. Operators shall be able to configure the system.

4. Online Help. Context-sensitive online help for each tool shall assist operators in operating and editing the system.

5. Security. System shall require a user name and password to view, edit, add, or delete data.

    a. Operator Access. Each user name and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object. Authorized operators shall be able to vary and deny each operator's accessible functions based on equipment or geographic location.
    b. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.
    c. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.

6. System Diagnostics. System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).

7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as indicated in the BAS Drawings Sequence of Operations. Alarms shall be BACnet alarm objects and shall use BACnet alarm services.

8. Alarm Messages. Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.

9. Alarm Reactions. Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.

10. Alarm Maintenance. Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms, and to archive closed alarms to the workstation or web server hard disk from each workstation or web browser interface.

11. Trend Configuration. Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall archive data to the hard disk for a minimum of two years. Configure trends as indicated in the BAS Drawings Sequence of Operations. Trends shall be BACnet trend objects.

12. Object and Property Status and Control. Operator shall be able to view, and to edit if

applicable, the status of each system object and property by menu, on graphics, or through custom programs.

13. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.

14. Standard Reports. Furnish the following standard system reports:

    a. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
    b. Alarm Summary. Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
    c. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:

        1) Alarm History.
        2) Trend Data. Operator shall be able to select trends to be logged.
        3) Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

15. Custom Reports. Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. Reports shall be launched from the operator interface.

16. Graphics Generation. Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system. Operator shall be able to add analog and binary values, dynamic text, static text, and animation files to a background graphic using a mouse.

17. Graphics Library. Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, control valves, piping, control dampers, and ductwork. Library graphic file format shall be compatible with graphics generation tools.

18. 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. At a minimum create color graphic floor plan displays and system schematics for each piece of controlled equipment listed in the table below. In general, each graphic shall include the inputs, outputs, setpoints, targets and other pertinent calculated values. In addition, graphic shall include links/buttons to access trend logs, schedules, floor plans, sequence of operation and reports for that system, as well as links/buttons for the system riser and related equipment. These buttons/links are required even if not specifically spelled out in the table below.

CATEGORY	DESCRIPTION	SPECIAL FEATURES	TABLE GRAPHIC REQD FOR EACH	PICTURE/ DIAGRAM GRAPHIC REQD FOR EACH
General	Site plan and series of floor and roof plans covering the entire facility locating all equipment monitored or controlled by the BAS including	Equipment or devices to serve as clickable links to their individual graphic. Show air		X

CATEGORY	DESCRIPTION	SPECIAL FEATURES	TABLE GRAPHIC REQD FOR EACH	PICTURE/ DIAGRAM GRAPHIC REQD FOR EACH
	VAV/CAV terminal units with temperature sensors located and location of all other sensors and control devices. Floor plans must be broken down into quadrants or smaller sections as necessary to show all equipment, sensors and sensor values.	handling units, VAV/CAV terminal units (all clickable links to associated graphics), hot water system, chilled water system, exhaust fans, etc. Indicate room #'s and function.		
Air Handling System	Air handling unit with associated energy recovery wheels and all associated exhaust fans. Show all air handling unit fans, energy recovery coils, coils, control dampers control valves, BAS I/O devices and values, BAS target and setpoint values. Setpoint values shall be changeable from graphic display.	Provide buttons on graphic for AHU schedule, AHU sequence of operation, AHU trend log, riser and associated floor plan(s).	X	X
VAV/CAV Terminal Units	VAV/CAV terminal units organized by air handling unit. Chart to display VAV/CAV terminal unit number, room(s) served, CFM, CFM target, minimum design CFM value, maximum design CFM value, heating setpoint, cooling setpoint, space temperature. Setpoint values shall be changeable from graphic display.	Indicate sum of terminal unit CFMs per air handling unit. Include buttons on graphic for riser, sequence of operation, associated AHU, schedule, trend log for each VAV/CAV.	X	X
Fan Coil Units / Blower Coil Units	Graphic to display FCU/BCU terminal unit number, room(s) served, heating setpoint, cooling setpoint, space temperature, fan command, fan status and control valves position. Setpoint values shall be changeable from graphic display.	Include buttons on graphic for riser, sequence of operation, schedule, and trend log for each FCU/BCU.	X	X
Laboratories	Graphic per laboratory, showing all input and output values, minimum and maximum design flows, heating and cooling setpoints, and space temperature. Setpoint values shall be changeable from graphic display.	Indicate design minimum and maximum CFM values for each air valve, actual return/exhaust airflow and actual supply airflow.	X	X
VFD	Variable Frequency Drive – include monitored data from point list in chart form. Group VFDs by type (i.e. – supply fans; chilled water pumps; hot water pumps.	Provide buttons/links on graphics for associated system (i.e. – AHU, chiller), sequence and riser.	X	
Exhaust Fans	Show all input and output values, setpoints associated with each system. Setpoint values shall be changeable from graphic display.	Include buttons/links on graphic for riser, floor plan, trend log, associated AHU and sequence of operation.	X	
Power Monitoring System	Single line diagrams – display all data as indicated on BAS drawings. Coordinate BAS graphics, BAS Reports, BAS Trending and BAS Archiving requirements with Owner.	Equipment or devices shown to serve as clickable links to other graphics (i.e. substation, main switchgear, ATS, Emergency Generator).		X

CATEGORY	DESCRIPTION	SPECIAL FEATURES	TABLE GRAPHIC REQD FOR EACH	PICTURE/ DIAGRAM GRAPHIC REQD FOR EACH
		Provide additional links to riser and associated floor plan.		
Lighting Control System	Display all data as indicated on BAS drawings. Coordinate BAS graphics, BAS Reports, BAS Trending and BAS Archiving requirements with Owner.	Equipment or devices shown to serve as clickable links to other graphics (i.e. substation, main switchgear, ATS, Emergency Generator). Provide additional links to riser and associated floor plan.	X	
Chilled water systems	Chilled water system, including complete flow diagram, all BAS I/O devices and values, chiller, plate and frame heat exchanger, pumps, control valves, temperature targets and setpoints. Setpoint values shall be changeable from graphic display.	Equipment or devices shown to serve as clickable links to other graphics. Include buttons/links for air handling unit, site plan, chilled water systems trend logs and chilled water systems sequence of operation.	X	X
Chilled beams chilled water system	Chilled beam chilled water system, including complete flow diagram, plate and frame heat exchanger, all BAS I/O devices and values, pumps, control valves, temperature targets and setpoints. Setpoint values shall be changeable from graphic display.	Equipment or devices shown to serve as clickable links to other graphics. Include buttons/links for air handling unit, site plan, chilled beams chilled water system trend logs and chilled beams chilled water system sequence of operation.	X	X
Heating hot water system	Heating hot water system, including boilers, heat exchanger, pumps, control valves, BAS I/O devices and values, temperature targets and setpoints. Setpoint values shall be changeable from graphic display.	Equipment or devices shown to serve as clickable links to other graphics. Include buttons/links for air handling unit, site plan, hot water system trend logs and hot water system sequence of operation.	X	X
Miscellaneous	Outdoor Conditions – show on each graphic.		X	
Miscellaneous	Show all miscellaneous inputs and output points, grouped as shown on points list.	Links to riser, trend log and sequence of operation.	X	

19. Custom Application Programming. Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

    a. Language. Language shall be graphically based and shall use function blocks

arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.

b. Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.

c. Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.

d. Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.

e. Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

f. Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.

g. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.

1) Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.

2) System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

I. BACnet. Web server or workstation shall have demonstrated interoperability during at least one BMA Interoperability Workshop and shall substantially conform to BACnet Operator Workstation (B-OWS) device profile as specified in ASHRAE/ANSI 135-2010, BACnet Annex L.

2.4 CONTROLLER SOFTWARE

A. Building and energy management application software shall reside and operate in system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.

B. All controllers throughout the entire system shall use the same programming language, and use the same programming tool. Programming tool(s) required for creating and editing programs will be provided with the system.

C. System Security. See Paragraph 2.3.H.5 (Security) and Paragraph 2.3.H.5.a (Operator Activity).

D. Scheduling. See Paragraph 2.3.E.4 (View and Adjust Operating Schedules). All schedules will be stored locally within each controller. System shall provide the following schedule options as a minimum:

1. Weekly. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).

2. Exception. Operator shall be able to designate an exception schedule for each of the next 365 days. After an exception schedule has executed, system shall discard and replace exception schedule with standard schedule for that day of the week.

3. Holiday. Operator shall be able to define 24 special or holiday schedules of varying length on a scheduling calendar that repeats each year.

E. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

F. Binary and Analog Alarms. See Paragraph 2.3.H.7 (Alarm Processing).

G. Alarm Reporting. See Paragraph 2.3.H.9 (Alarm Reactions).

H. Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, system shall use a modem connection.

I. Demand Limiting.

1. System shall monitor building power consumption from building power meter pulse generator signals or from building feeder line watt transducer or current transformer.

2. When power consumption exceeds adjustable levels, system shall automatically adjust setpoints, de-energize low-priority equipment, and take other programmatic actions to reduce demand as indicated in the BAS Drawings Sequence of Operations. When demand drops below adjustable levels, system shall restore loads as specified.

J. Maintenance Management. System shall generate maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as indicated in the BAS Drawings Sequence of Operations.

K. Sequencing. Application software shall sequence chillers, boilers, and pumps as indicated in the BAS Drawings Sequence of Operations.

L. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs.

M. Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

N. Energy Calculations.

1. System shall accumulate and convert instantaneous power (kW) or flow rates GPM to energy usage data.

2. System shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.

O. Anti-Short Cycling. Binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

P. On and Off Control with Differential. System shall provide direct- and reverse-acting on and off algorithms with adjustable differential to cycle a binary output based on a controlled variable and setpoint.

Q. Runtime Totalization. System shall provide an algorithm that can totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as indicated in the BAS Drawings Sequence of Operations.

R. Trending. All points in the system (inputs, outputs, setpoints, etc. will be capable of being trended down to a minimum of every 1 second. All points will initially be set for trending on 5 minute intervals.

2.5 CONTROLLERS

A. General. Provide Building Controllers (BC), Advanced Application Controllers (AAC), and Application Specific Controllers (ASC) as required to achieve performance specified in this specification Section Article 3.15 (System Setup/Performance). Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135-2010, BACnet Annex L.

B. BACnet.

1. Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2010, BACnet Annex L and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.

2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2010, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.

3. BACnet Communication.

a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
c. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
d. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
e. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.

C. Communication.

1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.

2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.

3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.

4. Stand-Alone Operation. Each piece of equipment specified in this Specification Section Appendix A shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be

integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

D. Environment. Controller hardware shall be suitable for anticipated ambient conditions.

1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -20°F to 140°F.

2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 32°F to 120°F.

E. Keypad. Provide a local keypad and display for each BC and AAC. Operator shall be able to use keypad to view and edit data. Keypad and display shall require password to prevent unauthorized use. If the manufacturer does not normally provide a keypad and display for each BC and AAC, provide the software and any interface cabling needed to use a laptop computer as a Portable Operator's Terminal for the system.

F. Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.

G. Serviceability.

1. Controllers shall have diagnostic LEDs for power, communication, and processor.

2. Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.

3. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

H. Memory.

1. Controller memory shall support operating system, database, and programming requirements.

2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.

3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

I. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.

J. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

K. Trending. Controllers will be have memory capacity to trend all points within the controller at 5 minute intervals for storage of up to 4 days' worth of data. Additionally, each controller will automatically upload its trend data on a user defined interval to the user interface software to ensure continuity and long-term data trending.

2.6 INPUT AND OUTPUT INTERFACE

A. Hardwired inputs and outputs may tie into the system through Building, Custom, or Application Specific Controllers.

B. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller. Inputs and outputs shall be arranged on interchangeable modules or circuit boards to allow the replacement of a damaged module or board without replacing the entire controller.

C. Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices, and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

D. Pulse accumulation input points. This type of point shall conform to all the requirements of binary input points, and also accept up to 10 pulses per second for pulse accumulation.

E. Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with — and field-configurable to — commonly available sensing devices. To prevent thermal loading, RTDs and thermistors shall be scanned rather than have continuous power applied.

F. Inputs shall be electrically isolated from their associated field points.

G. Readings of any analog input point shall be repeatable within 0.1% of range; drift of readings shall be less than 0.2% of range per year. (see accuracy table)

H. Binary outputs shall provide for ON/OFF operation, or a pulsed low- voltage signal for pulse width modulation control. Outputs shall be selectable for either normally open or normally closed operation.

I. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC or a 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

J. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV/CAV terminal units, duct-mounted heating coils, and zone control dampers.

K. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

L. System Point Capacity: The system size shall be expandable to at least 2 times the number of input/output points required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.7 POWER SUPPLIES AND LINE FILTERING

A. Control transformers shall be UL and CSA Listed. Furnish Class 2 current-limiting type, or furnish over-current protection in both primary and secondary circuits for Class 2 service per NEC requirements.

1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0-% line and load combined with 100 microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be

able to withstand a 150% current overload for at least 3 seconds without trip-out or failure.

a. Unit shall operate between 32°F and 120°F. EM/RF shall meet FCC Class B.
b. Line voltage units shall be UL Recognized and CSA or ETL Approved.

2. Accepted Manufacturer: Functional Devices.

B. Power Line Filtering

1. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:

a. Dielectric strength of 1,000 volts minimum.
b. Response time of 10 nanoseconds or less.
c. Transverse mode noise attenuation of 65 dB or greater.
d. Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.

2.8 STATIC PRESSURE SENSING ELEMENTS - AIR DUCT

A. Static pressure sensing elements for air ducts having horizontal or vertical dimension of 36 inches or greater shall be the traverse probe type. Probe shall be constructed of extruded aluminum or stainless steel and shall contain multiple static pressure sensing points connected to an averaging manifold to produce a non-pulsating signal with an accuracy of +/- 1%.

1. Provide static pressure traverse probes manufactured by Air Monitor, Cambridge, Brandt or Ultratech.

B. Static pressure sensing elements for air ducts having horizontal or vertical dimension of less than 36 inches shall be single probe type, with rounded tip, mounting flange and extended connection. Construction shall be extruded aluminum or stainless steel.

1. Provide single point static pressure sensing elements manufactured by Cambridge, Brandt or Ultratech.

2.9 WIRING AND RACEWAYS

A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 16.

B. Insulated wire shall use copper conductors and shall be UL listed for 200°F minimum service.

C. Provide all conduit, wiring, connectors, hangers, enclosures, junction terminal units, transformers, as described under Division 16 unless otherwise specified. If installation materials required for this contract are not specified under this Specification Section or in Division 16, provide materials of consistent quality to those specified.

D. Ensure that all communication cables installed meet the specification requirements put forth by the manufacturer of the control system. This extends to wire types used for any open protocol interfaces.

2.10 FIBER OPTIC CABLE SYSTEM

A. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.

B. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic

ferrules and metal bayonet latching bodies.

2.11 NAMEPLATES

A. Provide engraved phenolic nameplates with white lettering on black background, for all field mounted devices on ductwork, air handling units, piping or mechanical appurtenances, control valves, control dampers, control panels, control panels gages/switches/etc. on exterior and all equipment mounted within control panels.

B. Nameplates for field or sub-panel mounted devices shall bear the device tag corresponding to the BAS control diagrams. Nameplates for devices mounted on control panel faces shall bear the device function, operating signal range and units and fail position of operated end device. Minimum letter size shall be 3/16 inch.

C. Nameplates describing control panel designation shall have minimum letter size of 1/2 inch.

D. Provide individual labeling for each control component in each control panel (excluding terminal/unitary control panels), as well as on field mounted control devices (excluding space temperature and humidity sensors). Labels shall be either engraved plastic or laminated printed labels.

2.12 MISCELLANEOUS DEVICES

A. Provide all the necessary devices such as relays and transformers to make a complete and operable system.

2.13 PHOENIX LABORATORY AIRFLOW CONTROL SYSTEM

A. General

1. Description

a. A laboratory airflow control system shall be furnished and installed to control the airflow into and out of the laboratory rooms. The laboratory airflow control system shall vary the amount of make-up/supply air into the room to operate the laboratory at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates, and maintain room pressurization in relation to adjacent spaces (positive or negative). The laboratory airflow control system shall be capable of operating as a standalone system or as a system integrated with the Building Automation System (BAS).

b. Airflow control valves and associated control devices specified in this section are to be furnished by the BAS Contractor. The Mechanical Contractor will install the airflow control valves. All wiring or installation of any other components associated with the lab monitoring and control are by the BAS Contractor. Airflow control valves and control components shall be furnished and installed to control the airflow into and out of the laboratories.

c. The plans and specifications for the LACS are based on systems and equipment manufactured by Phoenix Controls Corporation Traccel low pressure venturi air valves. Tek-Air Systems, Inc. SmartLab System with Tek-Air AccuValves and TSI, Inc. with TSI Venturi Air Valves are also acceptable bidders.

B. Submittal Requirements

1. The LACS supplier shall submit 5 complete sets of submittal documentation for approval prior to the start of installation. The submittal documentation shall include:

a. Manufacturer's product data sheets including technical specifications of all LACS components including air terminals, sensors, actuators, control units, local monitors, etc. Where applicable the specifications shall include minimum and maximum flow rates, sound ratings, measurement device accuracies, operational ranges, etc.

b. A tabulation of all air terminals including types, sizes, air capacities, sound ratings, etc.

c. A comprehensive list of all LACS input/output point functions including all alarm and monitoring points.

d. Detailed descriptions of all LACS operational sequences.

e. Shop drawings showing LACS control unit configuration and wiring connection diagrams covering all LACS input/output interconnections and termination details.

f. Room schedule sheet(s) that include the following data for each room: Room number, component description, component function, model code, product catalog number, component tag number, minimum CFM, maximum CFM and room offset. Organize room schedule sheet(s) so that components for each room are listed together.

g. Zone balance worksheet(s) that include the following data for each room: Room number, room offset, minimum ventilation, maximum cooling, minimum CFM for each supply air valve, maximum CFM for each supply air valve, minimum CFM for each exhaust air valve, maximum CFM for each exhaust air valve, minimum CFM for each return air valve, maximum CFM for each return air valve, and CFM for each constant volume exhaust air valve. Zone balance worksheet(s) show indicate all modes of operation (such as MinCool/MinExh, MaxCool/MinExh, MaxCool/MaxExh, MinCool/MaxExh) and it shall demonstrate that the room offset shall be maintained during all operating modes.

C. Phoenix Controls Products

1. System Performance Requirements

a. Each laboratory shall have dedicated laboratory airflow control system. Each dedicated laboratory airflow control system shall support a minimum of 20 network controlled airflow devices.

b. The laboratory airflow control system shall maintain specific airflow (± 5% of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change, airflow change or quantity of airflow control devices on the manifold (within 0.3" to 3.0" W.C.).

c. The laboratory airflow control system shall use volumetric offset control to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions such as rapid changes in duct static pressure.

d. The laboratory airflow control system shall maintain specific airflow (± 5% of signal) with a minimum 16 to 1 turndown to insure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.

2. Airflow Control Sound Specifications

a. Unless otherwise specified, the airflow control device shall not exceed the sound

power levels in Table 1, Table 2 and Table 3.

b. If the airflow control device cannot meet the sound power level specification, a properly sized silencer or sound attenuator must be used. All silencers must be of a packless design with a maximum pressure drop at the device's maximum rated flow rate not to exceed 0.20 inches of water.

c. All proposed airflow control devices shall include discharge, exhaust, return and radiated sound power level performance.

TABLE 1.
EXHAUST AIRFLOW CONTROL DEVICE SOUND POWER LEVEL

EXHAUST AND RETURN SOUND POWER LEVEL IN DB (RE: 10^{-12} WATTS)						
Octave Band Number	2	3	4	5	6	7
Center Frequency Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1000-50 CFM Device						
800 CFM @ 0.3" W.C.	63	55	52	54	50	49
200 CFM @ 0.3" W.C.	46	42	38	37	32	25
800 CFM @ 3.0" W.C.	73	70	64	66	65	60
200 CFM @ 3.0" W.C.	51	52	51	50	52	51
1500-100 CFM Device						
1200 CFM @ 0.3" W.C.	65	58	53	56	52	52
400 CFM @ 0.3" W.C.	50	45	38	39	37	31
1200 CFM @ 3.0" W.C.	72	70	62	65	64	60
400 CFM @ 3.0" W.C.	55	57	55	53	56	55
3000-200 CFM Device						
2400 CFM @ 0.3" W.C.	63	56	55	58	54	55
800 CFM @ 0.3" W.C.	51	45	41	42	39	34
2400 CFM @ 3.0" W.C.	75	71	65	68	67	63
800 CFM @ 3.0" W.C.	58	58	56	56	59	58

TABLE 2.
SUPPLY AIRFLOW CONTROL DEVICE SOUND POWER LEVEL
(DISCHARGE)

DISCHARGE SOUND POWER LEVEL IN DB (RE: 10-12 WATTS)						
Octave Band Number	2	3	4	5	6	7
Center Frequency Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1000-50 CFM Device						
800 CFM @ 0.3" W.C.	62	57	54	58	54	51
200 CFM @ 0.3" W.C.	45	46	42	44	40	34
800 CFM @ 3.0" W.C.	72	71	67	75	72	68
200 CFM @ 3.0" W.C.	53	56	54	58	56	54
1500-100 CFM Device						
1200 CFM @ 0.3" W.C.	63	59	55	60	54	53
400 CFM @ 0.3" W.C.	53	49	44	49	45	39
1200 CFM @ 3.0" W.C.	72	73	69	77	72	68
400 CFM @ 3.0" W.C.	58	63	61	63	60	57
3000-200 CFM Device						
2400 CFM @ 0.3" W.C.	64	60	58	63	56	56
800 CFM @ 0.3" W.C.	52	48	47	52	46	41
2400 CFM @ 3.0" W.C.	75	75	72	78	73	70
800 CFM @ 3.0" W.C.	59	62	62	66	62	60

TABLE 3.
SUPPLY AIRFLOW CONTROL DEVICE SOUND POWER LEVEL (RADIATED)

RADIATED SOUND POWER LEVEL IN DB (RE: 10-12 WATTS)						
Octave Band Number	2	3	4	5	6	7
Center Frequency Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1000-50 CFM Device						
800 CFM @ 0.3" W.C.	44	41	45	41	36	34
200 CFM @ 0.3" W.C.	33	28	31	29	26	20
800 CFM @ 3.0" W.C.	53	53	56	57	55	53
200 CFM @ 3.0" W.C.	41	38	41	39	39	37
1500-100 CFM Device						
1200 CFM @ 0.3" W.C.	47	53	40	42	38	36
400 CFM @ 0.3" W.C.	35	39	31	34	33	26
1200 CFM @ 3.0" W.C.	52	60	54	60	59	53
400 CFM @ 3.0" W.C.	42	44	43	46	46	42
3000-200 CFM Device						
2400 CFM @ 0.3" W.C.	58	56	45	47	43	42
800 CFM @ 0.3" W.C.	45	43	36	39	37	29
2400 CFM @ 3.0" W.C.	69	68	60	65	63	57
800 CFM @ 3.0" W.C.	54	53	48	51	50	48

3. Airflow Control Device – General

a. The airflow control device shall be a venturi valve. The airflow control device shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifolded system.

b. The airflow control device shall maintain accuracy (within ± 5% of signal) over an airflow turndown range of no less than 16 to 1. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.

c. The airflow control device shall be constructed of one of the following three types:

1) Class A - The airflow control device for non-corrosive airstreams such as supply, exhaust, and return shall be constructed of 16-gauge aluminum. The device's shaft and shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure independent springs shall be a spring grade stainless steel. All shaft bearing surfaces shall be made of a Teflon, polyester or PPS (polyphenylene sulfide) composite. Sound attenuating devices used in conjunction with exhaust, return or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. No sound absorptive materials of any kind shall be used.

2) Class B - The airflow control device for corrosive airstreams such as fume hoods and biosafety cabinets shall have a baked-on corrosion resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of a Teflon or PPS (polyphenylene sulfide) composite.

3) Cass C - The airflow control device for Class C - The airflow control device for highly corrosive airstreams shall be constructed as defined in Paragraph D. 3. b. and in addition, shall have no exposed aluminum or stainless steel components. Shaft support brackets, pivot arm, internal mounting link, and pressure independent springs shall have a baked on corrosion resistant phenolic coating in addition to the materials defined in paragraph D. 3. b. The internal nuts, bolts, and rivets shall be titanium or phenolic coated stainless steel. Only devices clearly defined as "High Corrosion Resistant" on project drawings shall require this construction.

d. A UL 916 listed electronic actuator shall be factory mounted to the valve.

e. The controller for airflow control devices shall be microprocessor based and operate using peer-to-peer control architecture. The room-level airflow control devices shall function as a standalone network.

f. The room-level control network shall utilize a LonTalk communications protocol.

g. There shall be no reliance on external or building-level control devices to perform room-level control functions. Each laboratory control system shall have the capability of performing fume hood control, pressurization control, temperature control, humidity control, and implement occupancy and emergency mode control schemes.

h. The laboratory airflow control system shall digitally integrate into the BAS.

4. Certification

a. Each airflow control device shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of at least ± 1% of signal over the entire range of measurement. Electronic airflow control devices shall be further calibrated and their accuracy verified to ± 5% of signal at a minimum of 48 different airflows across the full operating range of the device.

b. All airflow control devices shall be individually marked with device specific, factory calibration data. As a minimum, it should include: tag number, serial number, model number, eight point characterization information (for electronic devices), and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation.

5. Exhaust and Supply Airflow Device Controller

a. The airflow control device shall be a microprocessor-based design and shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.

b. The airflow control device shall store its control algorithms in non-volitle, re-writable memory. The device shall be able to standalone or be able to network with other room-level digital airflow control devices using an industry standard protocol.

c. Room-level control functions shall be embedded in and carried out by the airflow device controller using distributed control architecture. Critical control functions shall be implemented locally; no room-level controller shall be required.

d. The airflow control device shall use industry standard 24 VAC power.

e. The airflow control device shall have provisions to connect a notebook PC

commissioning tool and every node on the network shall be accessible from any point in the system.

f. The airflow control device shall have built-in integral input/output connections that address temperature control, humidity control, occupancy control, emergency control, and non-network sensors, switches and control devices. At a minimum, the airflow controller shall have:

1) 3 universal inputs capable of accepting 0 to 10 VDC, 4 to 20 mA, 0 to 65 K ohms, or Type 2 or Type 3 10 K ohm @ 25 degree C thermistor temperature sensors.
2) 1 digital input capable of accepting a dry contact or logic level signal input.
3) 2 analog outputs capable of developing either a 0 to 10 VDC or 4 to 20 mA linear control signal.
4) 1 Form C (SPDT) relay output capable of driving up to 1 A @ 24 VAC/VDC.

g. The airflow control device shall meet FCC Part 15 Subpart J Class A, and be UL916 listed.

6. Phoenix Controls Supervisor

a. Phoenix Controls Supervisor software is used to visualize data from critical environments using Phoenix Controls airflow control systems, sensors, and monitors. Real-time data is collected from Phoenix Controls. MacroServersTM. Data can also be pulled from any third party device on a facility's BACnet® network.

b. The information is graphically displayed as dashboard web pages on a standard HTML5 enabled web browser. Dashboard pages include energy management, safety, compliance monitoring, and equipment maintenance and diagnostics. Functions such as centralized data logging, historical data trending, alarming, and optional archiving to enterprise class databases are also included in this software. Dashboard displays can be customized to the facility, including creating views based on individual users. The dashboards supplement building automation system (BAS) information and provide more data than is typically integrated to the BAS.

c. Features

1) Standard dashboard web pages for energy management, safety monitoring, and equipment maintenance.
2) HTML5 web-based graphical user interface.
3) Can display up to 1,000 dashboard points.
4) Individual users can customize dashboards to their own views.
5) Displays real-time as well as historical data.
6) Non-invasive, flexible installation with existing or new integrations.
7) Smart import for MacroServers for quick job startup.
8) Integrates with BACnet IP or BACnet Ethernet.
9) Supports visualization of third-party BACnet devices.
10) Native functions include centralized data logging, historical data trending and reporting package.
11) Enterprise-level information exchange using an SQL database and HTTP/HTML/XML text formats.
12) Security and password protection using standard Java authentication and encryption techniques.
13) Optional security via an external LDAP connection.
14) Exports archived trend and alarm data to SQL.
15) Supports standard Niagara objects and feature set components.

D. Phoenix Laboratory Sequence Of Operations

1. Introduction

a. The airflow control devices shall utilize peer-to-peer, distributed control architecture to perform room-level control functions. Control functions shall include at a minimum, pressurization, temperature, humidity control as well as respond to occupancy and emergency control commands.

2. Pressurization Control

a. The laboratory control system shall control supply and auxiliary exhaust airflow devices in order to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure. This offset shall be field adjustable and represents the volume of air, which shall enter (or exit) the room from the corridor of adjacent spaces.

b. The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriate controlled devices to new setpoints to maintain the desired offset. The offset shall be adjustable.

c. The pressurization control algorithm shall consider both networked devices, as well as:

1) Up to 3 non-networked devices providing a linear analog flow signal.
2) Any number of constant volume devices where the total of supply devices and the total exhaust devices may be factored into the pressurization control algorithm.

d. The pressurization control algorithm shall support the ability to regulate the distribution of total supply flow across multiple airflow control devices in order to optimize air distribution in the space.

3. Temperature Control

a. The laboratory control system shall regulate the space temperature through a combination of volumetric thermal override and control of chilled beams. The laboratory control system shall support up to 4 separate temperature zones for each pressurization zone. Each zone shall have provisions for monitoring up to 5 temperature inputs and calculating a straight-line average to be used for control purposes. Separate cooling and heating setpoints shall be writeable from the BAS, with the option of local offset adjustment.

b. Temperature control shall be implemented through the use of primary cooling and heating control functions, as well as an auxiliary temperature control function, which may be used for either supplemental cooling or heating. Cooling shall be provided as a function of thermal override of conditioned air with both supply and exhaust airflow devices responding simultaneously so as to maintain the desired offset.

c. The auxiliary temperature control function shall offer the option of either heating or cooling mode and to operate as either a standalone temperature control loop, or staged to supplement the primary temperature control loop.

4. Humidity Control

a. The laboratory airflow control system shall have an embedded humidity control function, which allows the monitoring and control of the relative humidity level in the pressurized zone. Using peer-to-peer control, the airflow devices shall have

the ability to monitor the relative humidity level of the space and, based on a BAS writeable setpoint, develop a control signal to drive one or the other humidification or dehumidification control circuits.

b. The humidity control loop(s) shall share a common setpoint, with a configurable deadband adjustment to prevent the humidification and dehumidification control functions to operate at the same time.

5. Occupancy Control

a. The laboratory control system shall have the ability to change the minimum ventilation and/or temperature control setpoints, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state shall be set by the BAS as a scheduled event.

b. The laboratory airflow control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to occupied for a predetermined interval. The override interval shall be configurable for 1 to 1,440 minutes. The local occupancy sensor/switch or bypass button shall be given priority over a BAS command.

6. Emergency Mode Control

a. The laboratory airflow control system shall provide a means of overriding temperature and pressurization control in response to a command indicating an emergency condition exists and airflow control devices are to be driven to a specific flow setpoint. The system shall support up to 4 emergency control modes. The emergency control modes may be initiated either by a local contact input or BAS command.

b. Once an emergency mode is invoked, pressurization and temperature control are overridden for the period that the mode is active. Emergency modes shall have a priority scheme allowing a more critical mode to override a previously set condition.

7. Local Alarm Control

a. The laboratory control system shall provide the means of summing selective alarm activity at the room-level network and generating a local alarm signal. The local alarm signal may be directed to any available output, as well as to the BAS. The alarm mask may be configured differently for each room-level system.

8. Diversity Alarm

a. The laboratory control system shall have the ability of monitoring the airflow values for the pressurized space and generating an alarm signal in the event the total exhaust flow exceeds a predetermined threshold. The diversity alarm is intended to allow the user to take diversity in the design and generate an alarm condition in the event the diversity threshold is compromised. This function must be available in either an integrated or standalone system.

9. Miscellaneous

a. The laboratory airflow control system shall be segregated into subnets to isolate network communications to ensure room-level control functions and BAS communications are carried out reliably. Each laboratory space or pressurization zone shall be its own LACS subnet. Commercially available routers shall be used to provide this isolation.

b. The laboratory airflow control system shall support at least 20 networked devices in each pressurized zone.

c. All points shall be available through the interface to the BAS for trending, archiving, graphics, alarm notification and status reports. Laboratory airflow control system performance (speed, stability and accuracy) shall be unaffected by the quantity of points being monitored, processed or controlled.

d. Refer to the Drawings for the required input/output summary for the necessary points to be monitored and/or controlled.

E. Interface To Building Automation System

1. The laboratory airflow control system network shall digitally interface with the BAS. The required software interface drivers shall be developed and housed in a dedicated interface device furnished by the laboratory airflow control system supplier.

2. All room-level points shall be available to the BAS for monitoring or trending. The gateway shall maintain a cache of all points to be monitored by the BAS. The room-level airflow control devices shall update this cache continuously. Provide BAS Contractor with PICs statements and schedule of all point names/addresses so the BAS vendor can map points to their system.

3. The building-level network shall be a high speed LonTalk (1.25 mbps) communications protocol. The building-level network shall support up to 100 subnets or pressurization zones, or 6000 data points.

4. A commercially available interface card shall be provided with the dedicated interface device in order to connect to the building-level network.

5. The BAS Contractor is responsible to make connection to Phoenix supplied BACnet connection, and run communication wire to BAS.

F. Execution

1. Installation

a. The BAS Contractor shall install all routers and repeaters in an accessible location in or around the designated laboratory room.

b. The BAS Contractor shall install the wall-mounted power supplies (as required) in accessible locations in the designated laboratory rooms.

c. The BAS Contractor shall install appropriately sized and fused 24 VAC transformers suitable for NEC Class II wiring.

d. All cable shall be furnished and installed by the BAS Contractor. The BAS Contractor shall terminate and connect all cables as required. The BAS Contractor shall utilize cables specifically recommended by the LACS supplier.

e. The Mechanical Contractor will install all airflow control devices in the ductwork and shall connect all airflow control valve linkages.

f. The Mechanical Contractor will provide and install all transitions.

g. The Mechanical Contractor will provide and install insulation as required.

h. The BAS Contractor shall provide for each pressurization zone a dedicated,

single-phase primary circuit or secondary circuits disconnect.

2. System Startup and Training

a. System startup shall be provided by a factory-authorized representative of the laboratory airflow control system manufacturer. Startup shall provide electronic verification of airflow (fume hood exhaust, supply, exhaust), system programming and integration to the BAS.

b. The TAB Contractor will be responsible for final verification and reporting of all airflows.

c. The LACS supplier shall furnish a minimum of 8 hours of Owner training by factory trained and certified personnel. The training shall provide an overview of the project specific airflow control components, general procedures for verifying airflows of air valves and general troubleshooting procedures.

d. Operation and maintenance manuals, including as-built wiring diagrams and components lists, shall be provided for each training attendee.

G. Warranty

1. Warranty shall commence upon the date of substantial completion and extend for a period of twelve months whereupon any defects in materials or LACS performance shall be repaired 24 hours/day 7 days/week by the supplier at no cost to the Owner. At a minimum, the BAS Contractor shall warranty all material and labor to repair/adjust the lab control system for a period of twelve months from the date of acceptance.

2.14 AUXILIARY CONTROL DEVICES

A. Motorized Control Dampers

1. Type. Control dampers shall have linear flow characteristics and shall be parallel- or opposed-blade type as specified below or as scheduled on drawings.

a. Outdoor and return air mixing control dampers and face-and-bypass control dampers shall be parallel blade and shall direct airstreams toward each other.
b. Other modulating control dampers shall be opposed-blade.
c. Two-position shutoff control dampers shall be parallel blade with blade and side seals.

2. Frame. Control damper frames shall be 13 gauge galvanized steel channel or 1/8 in. extruded aluminum with reinforced corner bracing.

3. Blades. Control damper blades shall not exceed 8 in. in width or 48 in. in length. Blades shall be suitable for medium velocity 2000 FPM performance. Blades shall be not less than EC gauge.

4. Shaft Bearings. Control damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze, or better.

5. Seals. Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Side seals shall be spring-loaded stainless steel. Blade seals shall leak no more than 10 CFM per ft2 at 4 in. w.g. differential pressure. Blades shall be airfoil type suitable for wide-open face velocity of 1500 FPM.

6. Sections. Control damper sections shall not exceed 48 in. - 60 in. Each section shall have at least one control damper actuator.

7. Linkages. Control dampers shall have exposed linkages.

8. Accepted Manufacturer: Ruskin.

9. Provide any technical information and field direction necessary for the installation of control dampers. Provide all automatic control dampers where shown on the mechanical drawings.

10. Coordinate control damper sizes with the Mechanical contractor.

11. Control damper construction specifications herein are minimum. In all cases, control damper static pressure ratings shall meet or exceed the rating of the ductwork or system in which they are installed.

12. Provide control damper actuators of sufficient torque to ensure smooth operation under all design loading conditions. Actuators shall be capable of providing 125% of the required maximum opening torque.

13. Control Dampers - 0" to 2" W.C. Service

    a. Control damper construction shall meet the following minimum criteria:

        1) Blades: EC gage galvanized steel, V-grooved, maximum length 48 inches, maximum width 6 inches. Axles shall be 1/2" diameter plated steel.
        2) Blade edge seals: EPM or dual durometer vinyl.
        3) Bearings: oil impregnated bronze.
        4) Frame: EC gage galvanized steel high hat channel
        5) Bearings: oil impregnated bronze.
        6) Frame: EC gage galvanized steel high hat channel.
        7) Jamb seals: flexible steel compression type.

    b. Leakage rate shall not exceed 1% of maximum flow or 10 CFM, whichever is less, at 2" W.C. differential.
    c. Operating temperature limits shall be -10° F. to +150° F. minimum.
    d. Accepted Manufacturers: Ruskin CD-36 or Tamco Series 1000.

14. Control Dampers - 2" to 6" W.C. Service

    a. Control damper construction shall meet the following minimum criteria:

        1) Blades: EC gage galvanized steel, airfoil type double skinned, maximum length 48 inches, maximum width 6 inches. Axles shall be 1/2" diameter plated steel.
        2) Blade edge seals: extruded vinyl or neoprene.
        3) Bearings: oil impregnated bronze.
        4) Frame: 12 gage galvanized steel high hat channel.
        5) Jamb seals: stainless steel compression type.
        6) Leakage rate shall not exceed 3% of maximum flow or 12 CFM, whichever is less, at 6" W.C. differential.
    b. Operating temperature limits shall be -10° F. to +150° F. minimum.
    c. Accepted Manufacturer: Ruskin CD-60 or Tamco Series 1500.

15. Exterior Wall Control Dampers – Insulation Type

    a. Provide insulation type control dampers where control dampers are called for on exterior walls.
    b. Control damper construction shall meet the following minimum criteria:

        1) Blades: EC gage galvanized steel, airfoil type double skinned, maximum

length 48 inches, maximum width 6 inches. Axles shall be 1/2" diameter plated steel.

2) Blade edge seals: PVC coated polyester fabric mechanically locked into blade edge or polyurethane.
3) Bearings: oiltite bronze or synthetic.
4) Frame: EC gage galvanized steel high hat channel.
5) Jamb seals: flexible metal, compression type or polyurethane.
6) Insulation: Styrofoam.

c. Leakage rate shall not exceed 3% of maximum flow of 12 CFM, whichever is less, at 6" W.C. differential. Leakage rate shall not exceed 1% of maximum flow or 10 CFM, whichever is less, at 2" W.C. differential.
d. Operating temperature limits shall be -10°F to +150°F minimum.
e. Accepted Manufacturer: Ruskin IL-35 or Tamco Series 9000.

B. Electric Control Damper and Control Valve Actuators

1. Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.

2. Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).

3. Signal and Range. Proportional actuators shall accept a 0-10 VDC or a 0-20 mA control signal and shall have a 2-10 VDC or 4-20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications).

4. Wiring. 24 VAC and 24 VDC actuators shall operate on Class 2 wiring.

5. Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 60 in.-lb torque capacity shall have a manual crank.

6. Housing. Actuator housings shall be molded or die-cast zinc or aluminum. Exception: Actuator housings for terminal unit zone control dampers or control valves may be of high-impact plastic construction with a minimum ambient temperature rating of 50°F-140°F.

7. Selection. Size actuators suitable for intended application and in accordance with manufacturer's recommendations.

a. Actuators shall have sufficient reserve power to operate related control damper or control valve with smooth modulating or two-position action.
b. Actuators shall have proper response speed at design velocity and pressure.
c. Actuator close-off force shall effectively seal control damper or control valve at maximum design system pressure. At design flow and pressure actuator shall modulate smoothly.

8. Fast-response Control Damper Actuators – Provide for use on stair tower pressurization fan isolation control dampers, exhaust fan isolation control dampers.
a. Actuators shall be two position.
b. Actuators shall be separately powered from a 120V or 24V source, extended from the local control panel. Provide 120/24 VAC step-down transformer as needed to power actuators.
c. Actuators shall be spring return N.C. on power/signal failure.
d. Actuators shall have adequate stroke to provide the full travel of the control damper from 0 to 100% and shall have the available torque to provide closing of the end element to the specified leakage rating. Timing for the full stroke angle of

rotation shall be no more than 25 seconds.

e. Actuators shall be direct-coupled to the control damper shaft. Attachment of actuator to control damper shaft shall be by U-bolt and V-shaped tooth cradle or similar method for maximum holding strength. Single bold or set screw type fasteners are not acceptable.

f. Accepted Manufacturers: Belimo, Johnson Controls or Schneider Electric.

9. General Use Electric Control Damper Actuators

a. Actuators shall allow continuous positioning of a control damper assembly between full open and full closed positions, in response to a current (4-20 mA) or voltage (0-10VDC) output signal. Floating Point type actuator is only acceptable for use on CAV terminal unit control dampers;

b. Actuators shall be separately powered from a 120 VAC or 24 VAC source, extended from the local control panel. Provide 120/24 VAC step-down transformer in the local control panel as needed to power actuators.

c. Current or voltage signal actuators shall be spring return on power/signal failure, either normally open (N.O.) or normally closed (N.C.). Floating point actuators shall fail to last commanded position.

d. Actuators shall have adequate stroke to provide the full travel of the control damper from 0 to 100% and shall have the available torque to provide closing of the end element to the specified leakage rating. Timing for the full stroke angle of rotation shall be no more than 90 seconds.

e. Actuators shall have the following accessories:

1) Auxiliary switches (adjustable)
2) Feedback potentiometer

f. Actuators shall be direct-coupled to the control damper shaft. Attachment of actuator to control damper shaft shall be by U-bolt and V-shaped tooth cradle or similar method for maximum holding strength. Single bold or set screw type fasteners are not acceptable.

g. For high torque applications where direct-coupling is not recommended by actuator manufacturer, provide all linkages and mounting brackets for control dampers/actuators as required for the installation. Provide the number of actuators required to meet torque requirements and end-to-end accuracy.

h. Accepted Manufacturers: Belimo, Johnson Controls or Schneider Electric.

10. General Use Electric Control Valve Actuators

a. Actuators shall be separately powered from a 24 VAC source, extended from the location of the 2nd tier controller. Provide 120/24 VAC step-down transformer at the 2nd tier controller location as needed to power actuators.

b. Current or voltage signal actuators shall be spring return on power/signal failure, either normally open (N.O.) or normally closed (N.C.). Floating point actuators for reheat control valves shall fail to last commanded position.

c. Actuators shall have adequate stroke to provide the full travel of the control valve from 0 to 100% and shall have the available torque to provide closing of the end element to the specified leakage rating. Timing for the full stroke angle of rotation shall be no more than 90 seconds.

d. Provide linkages for control valves as required for the installation. Provide the number of actuators required to meet torque requirements and end to end accuracies.

e. Actuators shall be integrally mounted by the supplied linkage to the control valve as a single unit. The actuator and linkage shall be capable of operation in an ambient temperature of -40°F to 120°F.

f. Actuators for hot water control valves shall be installed per manufacturers' recommendations regarding angle of deflection from direct vertical mounting to avoid heat damage to actuator.

g. Accepted Manufacturers: Belimo, Johnson Controls, Schneider Electric or Valve Solutions, Inc.

C. Industrial Grade Actuators

1. Provide industrial grade actuators for all control valves 4” and above.

2. Actuators shall be integrally mounted to the control valve as a single unit. The actuator and linkage shall be capable of operation in an ambient temperature of -40°F to 120°F.

3. The actuator shall be housed in a NEMA 4 enclosure. The motor insulation shall be Class F with Class B wiring insulation.

4. The actuator shall have visual mechanical indication, showing output shaft and control valve position. Provide a manual handwheel worm gear for manual override.

5. The actuator shall have an integral terminal strip. The actuator shall have a self-locking gear train which has been permanently lubricated.

6. The actuator shall have two adjustable mechanical torque limit switches and four configurable limit switches. The motor shall be equipped with thermal overload protection.

7. The actuator shall mount directly on the control valve with no connecting linkages. All exposed materials shall be weatherproofed.

8. The actuator shall have an integral self-locking manual positioner. Levers or latches shall not be required to engage or disengage the actuator.

9. Provide the actuator with anti-condensation and low temperature heaters when used outdoors.

10. Provide the actuator with feedback potentiometer.

11. Signal input shall be compatible directly or by way of signal converter with the system controller. Provide signal converter if required.

12. Actuators for hot water control valves should be installed per manufacturers’ recommendations regarding angle of deflection from direct vertical mounting to avoid heat damage to actuator.

13. Approved Manufacturer(s): Bray, Dezurik, Cameron or Valve Solutions, Inc.

D. Control Valves.

1. General. Select body and trim materials in accordance with manufacturer's recommendations for design conditions and service shown.

2. Control valves shall be sized to meet the heating and cooling flows as specified. Control valve pressure drop at design flow conditions in water systems shall be based upon pressure drop of the controlled equipment or system.

   a. Control valves used in system differential pressure control shall be sized using 50-60% of total system resistance, at design flow rate, as a pressure drop value.

3. Control Valve ratings, materials and construction set forth herein are a minimum. Body pressure rating and connection type shall conform to pipe schedules in the Mechanical plans and specifications. Actuators shall shutoff valves tightly against 120% of maximum system pressure in both fail open and fail closed positions.

4. Control valves sized for pressure drops in excess of 25 PSI at design flow (water) shall be furnished with cage guided trim.

5. Control valves shall be quiet in operation and arranged to fail-safe in the open or closed position in the event of power failure or control air failure.

6. All chilled water control valves shall be 150 PSIG bodies minimum with the ability to open and close against a differential pressure of 40 PSIG minimum and not less than each pumps shutoff head pressure at full motor speed. This requirement may require industrial grade control valves at the larger control valves.

7. Type. Provide two- or three-way control valves for two-position or modulating service as shown.

8. Water Control Valves. Control valves providing two-position service shall be quick opening. Two-way control valves shall have replaceable disc or ball.

   a. Close-off (Differential) Pressure Rating. Control valve actuator and trim shall provide the following minimum close-off pressure ratings.

      1) Two-way: 150% of total system (pump) head.
      2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

   b. Ports. Control valves providing modulating service shall have equal percentage ports.
   c. Sizing.

      1) Two-position service: line size.
      2) Two-way modulating service: select control valve assembly such that the pressure drop across the control valve is greater than or equal to the pressure drop across the associated coil and not to exceed 9 PSIG.
      3) Three-way modulating service: select control valve assembly such that the pressure drop across the control valve is greater than or equal to the pressure drop across the associated coil and not to exceed 9 PSIG.
      4) Coordinate control valves flow rates with final, approved equipment submittals prior to sizing the control valves assemblies and before submission to the A/E.

   d. Fail Position. Water control valves shall fail normally open or closed as follows unless otherwise specified.

      1) Water zone control valves: as scheduled or as required by sequences of operation.
      2) Heating coils in air handling units: normally open.
      3) Chilled water control valves: normally closed.
      4) Other applications: as scheduled or as required by sequences of operation.

9. Control Valves - Water, less than 4" line size

   a. Body:

      1) Up to 2" line size; bronze, ANSI 125 lb rating, NPT connections.
      2) 2-1/2" to 3" line size; cast iron, ANSI 250 lb rating, flanged connections.

   b. Packing:

      1) Teflon cone or Teflon V-ring.

   c. Trim (2-way control valves):

      1) Stainless steel stem, bronze plug with equal percentage characteristic,

brass seat, Teflon or composition disc.

d. Trim (3-way control valves, mixing or diverting):

1) Up to 2" line size; stainless steel stem, bronze plug with linear characteristic, brass seat, Teflon or Teflon composite packing.
2) For 2 1/2" to 3" line sizes; stainless steel stem, bronze-skirted plug with linear characteristic, bronze cage type seat, Teflon or Teflon composite packing.

10. Control Valves - Water, 4" line size and above High Performance (Butterfly)

a. Body: Water type, lugged end connection, carbon steel, ANSI 150 lb. rating.

b. Packing, Seat: PTFE (TC, TMD) packing material. PTFE/Titanium (RT and TT) seat.

c. Disc/Shaft/bearing material: 3EC stainless steel disc, 3EC stainless steel shaft, BC-4 PH stainless steel bearings.

d. Control valve shall be capable of bubble-tight shutoff at minimum 285 PSI differential.

e. Three-way butterfly control valves shall be furnished as a complete assembly, consisting of two two-way control valves factory-mounted on a cast iron tee, including actuator, all necessary linkages and accessories, e.g. end switches, etc. mounted and mechanically connected.

f. Modulating control valves shall be sized to provide equal flow characteristics (% of flow vs. % open) through the full range of operation.

g. Accepted Manufacturer(s): Dezurik BHP high performance butterfly control valves, Cameron high performance butterfly control valves, Bray Series 41 high performance butterfly control valves with Bray Series 70 electric actuators or Valve Solutions, Inc. Series V-Ball (for modulating service only through 6”).

E. Local Control Panels

1. Indoor control panels shall be fully enclosed NEMA 1 construction with hinged door key-lock latch and removable subpanels. A common key shall open each control panel.

2. Prewire internal and face-mounted device connections with color-coded stranded conductors tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring.

3. Each local panel shall have a control power source power disconnect switch (on-off) with overcurrent protection. At a minimum, the primary power into each panel shall be fused and the primary of each transformer in each control panel shall be fused.

4. Control panels shall be installed with a duplex 120 VAC outlet. The disconnect switch shall disconnect the 120 VAC power after the 120 VAC outlet and remove power from all other devices within the panel.

5. All controllers, relays, switches, transducers, gages, etc. that are part of the BAS and not required to be mounted on the HVAC equipment shall be mounted in enclosed NEMA 1 control panels.

6. Control panel shall be minimum 14AWG steel, painted gray, white, or neutral color, with piano hinge and latch. Removable subpanel shall be minimum of 12AWG steel painted

gray, white, or neutral color.

7. All control devices for each panel shall be pre-mounted and tested at the BAS Contractor qualified panel fabricating facility prior to installation at the site.

8. Control panels are to be vented or heated as required by the heat generated inside the panel or by heat/cold of the surrounding space.

9. Provide nameplates for all control panels.

10. Accepted Manufacturer: Hoffman.

F. Binary Temperature Devices.

1. Low-Voltage Space Thermostats. Low-voltage space thermostats shall be 24 V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, 55°F-85°F setpoint range, 2°F maximum differential, and vented ABS plastic cover.

2. Line-Voltage Space Thermostats. Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 55°F-85°F setpoint range, 2°F maximum differential, and vented ABS plastic cover.

G. Condensation Sensor (CS)

1. The condensation sensor shall have the following characteristics:

a. Supply voltage: 24 VAC/VDC +/-20%
b. Power consumption: Maximum 1 VA
c. Relays contacts: 6 amps @ 250 VAC/VDC
d. Operating temperature: -5… +50°C

2. Accepted Manufacturer: Siemens, model number QXA2000.

H. Current Transmitters (CSE)

1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.

3. Unit shall be split-core type for clamp-on installation on existing wiring.

4. Accepted Manufacturers: Veris Industries, Senva, Automation Components, Inc., or Functional Devices.

I. Current Switches (CSW)

1. Current operated switches shall be self-powered, solid-state with adjustable trip current. Current switch shall be UL Listed. Select switches to match application current and DDC system output requirements.

2. For proof-of-run applications on VFDs that are supplied with a bypass, the current switch

shall be placed on the load side of the VFD on common conductors leaving the VFD so as to measure current whether the VFD is in normal or bypass mode.

3. Accepted Manufacturers: Veris Industries, Senva, Automation Components, Inc., or Functional Devices.

J. Current Transformers

1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.

2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.

3. Use split-core transformers only.

4. Accepted Manufacturer: Kele and Associates.

K. Differential Pressure Sensors/Transmitters (DPSE) – Water

1. Differential pressure transmitters shall be diaphragm operated and shall output a linear 4-20 mA signal over the transmitter span.

a. Transmitter range shall be selected for the application and shall exceed the nominal system working pressure by 50% minimum.
b. Differential pressure transmitters shall meet the following performance standards as a minimum:

1) Accuracy: +/- 0.2% of calibrated span.
2) Hysteresis: +/- 0.05% of calibrated span.
3) Linearity: +/- 0.1% of calibrated span.
4) Damping: Adjustable time constant.
5) Calibration: Zero point and span adjustable to within +/-0.5% of full span.
6) Wetted Parts: 316 SS, monel or nickel-chrome.
7) Housing: Carbon steel or aluminum, NEMA 4.
8) Zero Suppression: 100% of span.
9) Overrange Limit: 200% of transmitter range.

c. Transmitters shall be furnished with 3-valve balancing manifold, as a complete assembly.

2. Accepted Manufacturer: Rosemount.

L. Differential Pressure Sensors/Transmitters (DPSE) - Low Range Air

1. Differential pressure transmitters shall measure pressure signals from space or duct probes and shall output a linear 4-20 mA or DC voltage signal.

a. Transmitter range shall be selected for the application and shall exceed the nominal system working pressure by 50%.
b. Low range differential pressure transmitters shall meet the following performance standards as a minimum:

1) Accuracy: Overall +/- 2% of span.
2) Hysteresis: +/- 0.2% of span.
3) Linearity: +/- 0.2% of span.
4) Overrange Protection: 500% of range.

5) Calibration: Zero point and span adjustable to within +/-0.1% of full span.

c. Provide auto zeroing or install with bypass valving to allow for manual zeroing in readily accessible location (not above ceilings).

2. Accepted Manufacturers: Ashcroft, Setra, or Modus.

M. Differential Pressure Sensor/Transmitter (DPSE) - Variable Water Volume Pumping Systems

1. Complete, self-contained, variable capacitance type with no internal mechanical linkages. Wiring terminals and electronics in separate compartments so that electronics remain sealed during installation. Provide reverse polarity protection to keep wiring mishaps from damaging the transmitter.

2. Minimum accuracy of +/- 0.25% of calibrated span, including combined effects of linearity, hysteresis and repeatability.

3. Stability shall be +/- 0.25% of upper range limit for six months.

4. Design range as required by system. External zero and span adjustments, overpressure to 2,000 psi and no humidity effects.

5. Accepted Manufacturer: Rosemount.

N. Differential Pressure Switches (DPSW)

1. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

2. Differential Pressure Switches 0" to 10" W.C. – Air (DPSW)

a. Switch shall be diaphragm actuated SPDT, minimum rating 5 amps resistive 120 VAC, enclosed in NEMA 1 housing. Maximum deadband shall be 0.30 inches W.C. Setpoint shall be fully adjustable over switch range.
b. Diaphragm material shall be silicone rubber or BUNA-N. Actuator assembly enclosure shall be entirely of aluminum or steel. Switches mounted outdoors, within panels located outdoors, or within ducts or plenums, shall be provided with NEMA 4 enclosures. Pressure connections shall be NPT.
c. Accepted Manufacturers: Dwyer, Barksdale or Mercoid.

3. Low Differential Pressure Switches - 0" to 1" W.C. Air Systems (DPSW)

a. Low differential pressure switches shall incorporate differential pressure gage and switch set point indicator or continuous pressure and set point indication. Unit shall be diaphragm operated. Switch output shall be by photocell controlled relay. Setpoint shall be by front knob with red dial indicator.
b. Accepted Manufacturer: Dwyer Photohelic, Series 3000.

4. Differential Pressure Switches – Water (DPSW)

a. Switch shall be SPDT, minimum 4 amp inductive rating at 250 VAC. Switch may be diaphragm or bourdon tube actuated, with adjustable setpoint and maximum switch deadband of 1.5 PSI. Working pressure shall be 150 PSI differential.
b. Differential pressure switch shall be suitable for the flow and pressure of each system.
c. Accepted Manufacturers: United Electric, Model 25.

O. End Switches (ES)

1. End switches shall have minimum rating of 2 amps resistive at 120 VAC. End switches consist of an encapsulated mercury switch mounted on a ½" diameter crank arm. End switches mount on control damper control shaft to give an indication of opened or closed control damper position.

2. End switch contacts are normal when cable end of the switch is horizontal or above. The switches make when cable end drops more than 15° below horizontal.

3. Accepted Manufacturer: Kele and Associates, Model TS-470 Series.

P. Flow Switches - Water Systems (FSW)

1. Verification/proof of actual water flow shall be provided by paddle-type insertion flow switch. Flow switch shall be equipped with stainless steel paddle and SPDT switch with minimum rating of 7 amps resistive at 120 VAC.

2. Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).

3. Switch assembly shall be fully enclosed and shall be isolated from the pipeline fluid.

4. Switch enclosure shall be suitable for the location and shall be minimum NEMA 1.

5. Stainless steel paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.

6. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

7. Accepted Manufacturer(s): Magnetrol, McDonnell Miller FS4-3; Mercoid, Kele model FD61 or FS1-6.

Q. Humidity Sensors (HS-Room, HD-Duct, HO-Outdoor).

1. Humidity sensor shall utilize thin film polymer capacitor sensing, over a minimum range of 10% to 90% R.H. output shall be temperature compensated. Sensor housing shall incorporate a terminal strip for lead wire connection.

2. Humidity transmitters shall meet the following performance standards as a minimum:

   a. Accuracy: +/- 2% R.H. over entire range.
   b. Hysteresis: +/- 0.3% R.H., maximum.
   c. Linearity: +/- 0.7% R.H. over entire range.
   d. Output range: 4-20mA.

3. Humidity transmitters shall be enclosed in NEMA 1 housing minimum. Transmitters in outdoor air or on outdoor air intake plenums or ducts shall be enclosed in NEMA 3R housing. In addition, transmitters in outdoor air shall be housed within a baffled aluminum or stainless steel rain shield.

4. All humidity sensors shall have replaceable sensor tips.

5. Accepted Manufacturer: Vaisala.

R. Electric Low Limit Thermostats (LTS)

1. Electric Low Limit Thermostats (LTS). Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 20 ft long. Element shall sense temperature in each 1 ft section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.

2. Electric low limit thermostats shall have the following characteristics:

   a. Switch: Snap acting, adjustable between 30 deg. f. and 60 deg. F.; electrical rating shall be minimum 2 amps inductive at 240 VAC. Switch shall be manual reset only, SPST or DPST as required and shall be housed in NEMA 1 enclosure.
   b. Sensing Element: UL listed, vapor pressure type. Gas filled capillary, minimum length of 20 feet, substantially mounted by mechanical clips. Capillary shall be serpentined vertically across the leaving face of the protected coil.
   c. Switch shall respond to the lowest temperature along any one-foot section of the capillary. Averaging type thermostats are not acceptable.

3. Provide one 20' capillary low limit thermostat for each 20 square feet or fraction thereof, of coil face area. Where there are multiple coils, provide 1 low limit thermostat per coil. Assure that the bottom 6” of each coil is protected by a low limit thermostat.

4. Low limit thermostats shall be wired to their respective monitoring panel (for alarm) and, separately, hardwired to shut down the fan at the motor starter or variable frequency drive. Where electric low limit thermostats are used to deenergize equipment, hardwire contacts from electric low limit thermostats directly to the motor starters or VFDs.

5. Accepted Manufacturers: Honeywell, Johnson Controls, and Siemens.

S. Occupancy Sensors (OS)

1. Wall Mount – Is to be utilized in place of standard light switch and has the following features:

   a. Utilize passive infrared (PIR) technology.
   b. Adjustable motion sensitivity.
   c. On-time delay adjustable from 30 seconds to 30 minutes.
   d. Integrated light level sensor with ambient light level adjustment from 2.7 to 200 foot candles.
   e. Compatible with fluorescent ballasts and incandescent lighting.
   f. 120-370 VAC power input.
   g. Up to 800 Watt incandescent or ballast load at 120 VAC; Up to 1200 Watt ballast load at 220/240/277 VAC; Up to 1500 Watt load at 347 VAC/ .167 Hp.
   h. UL and CUL listed.
   i. Integral Auto/Off switch.
   j. LED motion/activation indicator.
   k. 180° coverage, up to 900 square feet.
   l. 5-year warranty.
   m. Accepted Manufacturer(s): Kele and Associates or WattMaster.

2. Ceiling Mount – has the following features:

   a. Utilize passive infrared (PIR) technology.
   b. Adjustable motion sensitivity.
   c. On-time delay adjustment - 30 seconds, 10 minutes, 20 minutes, or 30 minutes.
   d. Integrated light level sensor with ambient light level adjustment from 2.5 to 430 foot candles.
   e. 24 VAC or 24 VDC power input.
   f. Isolated relay contacts rated for 1 Amp @ 24 VDC, ½ Amp @ 120 VAC, for interface to power pack or direct to BAS input.

g. Power pack - Up to 20 Amp ballast @ 120/277 VAC; Up to 15 Amp ballast @ 240 VAC; Up to 13 Amp incandescent @ 120 VAC; Up to 1 HP motor @ 120/220/240 VAC.
h. UL and CUL listed.
i. LED motion/activation indicator.
j. 360° coverage, up to 1200 square feet.
k. 5-year warranty.

3. Accepted Manufacturers: Kele and Associates or WattMaster.

T. Control Relays (RE)

1. Control relays shall be plug-in type or RIB type, UL listed, and shall have dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application. All plug-in type relays shall be minimum 2-pole. RIB type relays can be single pole.

2. Control relay contacts shall be rated for no less than 110% of the switched load, or a minimum continuous rating of 10 amps at 120 VAC. Relay coils shall be rated for continuous duty at 100% +/- 10% of the nominal coil pilot voltage.

3. Relays mounted within enclosures, within Motor Control Centers, within Motor Starters or within VFDs may be plastic encapsulated socket mounted type, or modular design with multiple convertible contacts, as required.

4. Relays located outside of enclosures shall be housed in enclosures rated for the intended location.

5. Start/stop relay module shall provide either momentary or maintained switching action as appropriate for the motor being started. All relays shall be plugged in, interchangeable, mounted on a circuit board and wired to numbered terminal strips.

6. Accepted Manufacturers: Relays: Allen Bradley, Cutler Hammer, IDEC, Omron, Function Devices, and Potter Brumfield.

U. Smoke Detectors (SD)

1. Furnished by the Electrical Contractor and installed by the Mechanical Contractor with contact for use by the BAS Contractor.

2. Where detectors are used to deenergize equipment, hardwire contacts from detector directly to the motor starters or VFD.

V. Temperature Sensors (TD-Duct, TW-Immersion, TA-Averaging, TO-Outdoor Air, TS-Room, TSSA-Room w/ Setpoint Adj., TSSW-Room w/ Setpoint Adj. & Override).

1. Type. Temperature sensors shall be 10K type II thermistor.

2. Duct Sensors. Duct sensors shall be single point or averaging as shown. Single point sensors shall be a minimum 9” length, unless otherwise limited by duct size. Averaging sensors shall be used where duct area is 14 square feet or greater, where duct dimension is 60 inches or greater in either width or depth, or where specified or shown. Thermistor sensors for air duct application shall be highly stable precision thermistor material accurate to within ±0.36°F.

a. Thermistor sensors for air duct application shall be a rugged point sensitive, waterproof sensor housed in a 304 stainless steel probe with ½" NPT male NPT brass fitting.
b. A minimum of 4 sensing elements shall be used for averaging elements of 12' or

less and a minimum of 9 sensing elements shall be used for averaging elements of 25' or less. The sensing elements are sealed in a 3/16" soft-drawn copper coiled tube, attached to a standard junction box with mounting bracket attached. Coil tube shall be firmly supported by a system of mechanical clips.

3. Immersion Sensors. Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities. Well and probe length should extend to the center of the pipe. Sensors used in liquid measuring applications shall be installed with thermal compound. Thermistor sensors for liquid application shall be highly stable precision thermistor material accurate to within ±0.36°F.

   a. Thermistor sensors for liquid application shall be a rugged point sensitive, waterproof sensor housed in a 304 stainless steel probe with ½" NPT male NPT brass fitting.

4. Space Sensors. Space sensors shall have setpoint adjustment, override switch, display to indicate current room temperature, and communication port to allow plug-in of local operator terminal allowing full access to all controllers in the BAS.

   a. Space sensors shall utilize a thermistor sensing element and have an integral override pushbutton. The sensor shall have the following specifications:

      1) Temperature monitoring range: 20 to 120°F.
      2) Output signal: Variable resistance
      3) Accuracy: +/- 0.36°F.

   b. Each office area space sensor shall have an integral pushbutton for overriding unoccupied periods. The pushbutton shall be set via the BAS workstation to provide up to 8 hours (adjustable) of override.
   c. Conference room space sensors only shall have a setpoint adjustment slider, to provide a configurable (from BAS workstation) number of degrees of adjustment to the VAV/CAV box room temperature setpoint. This shall initially be set to +/- 3°F.

5. Room Temperature Sensors – Laboratories

   a. The temperature sensor shall be equipped with an integral space temperature adjustment that allows room setpoint adjustment from 55°F to 75°F.
   b. The temperature sensor shall have a thermistor sensing element with the following characteristics:

      1) Temperature monitoring range: 20 to 120°F.
      2) Output signal: Variable resistance or 4-20mA DC.
      3) Accuracy: +/- 0.36°F.

   c. Sensor housing shall be constructed of stainless steel plate that shall be flush mounted in the wall at the location of the room light switches. Pushbutton override and temperature setpoint adjustment shall be mounted in the face of the plate, with labels that clearly define their purpose and scale. Proposed labels to be submitted along with sensor submittal.
   d. Accepted Manufacturers: Phoenix Controls.

W. Temperature Transmitters (TT)

1. Temperature transmitters for RTD elements shall output a 4-20 mA linear signal over the specified range. Zero point and span shall be adjustable over a minimum of 75% of range.

2. Temperature transmitters shall meet the following performance standards as a minimum:

1) Accuracy: +/- 0.5% of span.
2) Linearity: +/- 0.2% of span.
3) Isolation: Input to output, 600 VDC or VAC peak.

3. Housings for transmitters mounted on supply ducts or in non-hazardous spaces shall be NEMA 1. Housings for transmitters in outdoor air, on outdoor air plenums or intake ducts, or in spaces whose ambient temperature is below 55 deg. F, shall be gasketed die-cast aluminum, NEMA 3R minimum.
4. Transmitter range shall suit the application and shall be 0°F-100°F for preheat discharge air, 30°F-80°F for chilled water, 0°F-100°F for mixed air, and 32°F-212°F for hot water.
5. Provide approved sun shields for transmitters in outdoor air.
6. Accepted Manufacturer: Minco.

X. Voltage (Potential) Transducers.

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.

2. Adjustable full-scale unit ranges shall be 100-130 VAC, 200-250 VAC, 250-330 VAC, and 400-600 VAC. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 VAC rating.

4. Accepted Manufacturer: Kele and Associates PVM Series.

Y. Voltage Transformers.

1. AC voltage transformers shall be UL/CSA recognized, 600 VAC rated, and shall have built-in fuse protection.

2. Transformers shall be suitable for ambient temperatures of 40°F-130°F and shall provide ±0.5% accuracy at 24 VAC and 5 VA load.

3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

4. Accepted Manufacturer: Kele and Associates.

PART 3 - EXECUTION

3.1 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

B. The BAS Contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts or omissions shall be reported to the Engineer for resolution before rough-in work is started.

C. The BAS Contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate - or if any discrepancies occur between the plans and the BAS Contractor's work, and the plans and the work of others - the BAS Contractor shall report these discrepancies to the Engineer and shall obtain written instructions for any changes necessary to accommodate the BAS Contractor's work with the work of others.

3.2 PROTECTION

A. The BAS Contractor shall protect all work and material from damage from its work or employees, and shall be liable for all damages thus caused.

B. The BAS Contractor shall be responsible for its work and equipment until finally inspected, tested and accepted. The BAS Contractor shall protect any material that is not immediately installed. The BAS Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 COORDINATION

A. Site.

1. Where the mechanical work will be installed in close proximity to, or will interfere with work of other trades, the BAS Contractor shall assist in working out space conditions to make a satisfactory adjustment. If the BAS Contractor installs its work before coordinating with other trades, so as to cause any interference with work of other trades, the BAS Contractor shall make the necessary changes in its work to correct the condition without extra charge.

2. Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.

B. Submittals. See this Specification Section Article 1.10 (Submittals).

C. Test and Balance.

1. The BAS Contractor shall furnish all tools necessary to interface to the control system for test and balance purposes.

2. The BAS Contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.

3. In addition, the BAS Contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.

4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.

D. Life Safety.

1. Duct smoke detectors required for air handling unit shutdown are supplied under Division 16. The BAS Contractor shall interlock smoke detectors to air handling units for shutdown as indicated on the BAS Drawings.

E. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the controls system specified in this section. These controls shall be integrated into the system and coordinated by the BAS Contractor as follows:

1. All communication media and equipment shall be provided as specified in this Specification Section.

2. Each supplier of a control product is responsible for the configuration, programming, startup and testing of that product to meet the sequences of operation indicated on the BAS Drawings.

3.4 GENERAL WORKMANSHIP

A. Install equipment, piping and wiring raceway parallel to the building lines (i.e., horizontal, vertical and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electric Code (NEC).

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation and wiring shall comply with acceptable industry specifications and standards for performance, reliability and compatibility and be executed in strict adherence to local codes and standard practices.

3.5 FIELD QUALITY CONTROL

A. All work, materials and equipment shall comply with the rules and regulations of applicable local, state and federal codes and ordinances as identified in this Specification Section Article 1.7 (Codes and Standards).

B. BAS Contractor shall continually monitor the field installation for code compliance and quality workmanship.

C. BAS Contractor shall have work inspected by local and/or state authorities having jurisdiction over the work.

3.6 ELECTRICAL WIRING INSTALLATION

A. General Wiring Requirements

1. All control and interlock wiring shall comply with national and local electrical codes and Division 16 of this specification. Where the requirements of this section differ with those in Division 16, the requirements of this section shall take precedence.

2. Provide all electric wiring and wiring connections required for the installation of the BAS, as herein specified, unless specifically shown on the Electrical Drawings, directed as Division 16 work in this Specification Section, or called for in the Division 16 Specifications.

3. Control wiring provided by the BAS Contractor shall include all connections to control devices, interlock wiring, control relays, signal and communication wiring, minor power wiring and any other wiring required for a complete and operational system. Minor power wiring, 120 VAC and below, shall include requirements for such equipment as control damper actuators, solenoid valves, control valve actuators, control panel power, 1st tier and 2nd tier controller power, motor starter interconnect wiring and interconnecting wiring on apparatus that has not been factory installed. Low voltage (24 V AC/DC or below) I/O wiring shall not be run in same conduit as conductors carrying 120 VAC. All control wiring that is not shown on Electrical Drawings shall be provided by the BAS Contractor.

4. Power wiring, for the purpose of this Specification, shall be defined as follows:

a. Wiring from the power source, i.e. panelboard, or motor control center, etc., to the disconnect switch or disconnect switch and starter including wiring from these disconnect switches to the apparatus. This does not include 120 VAC motor control circuit interconnect wiring, which is the responsibility of the BAS Contractor.

b. Power for all control devices, whether or not interlocked with motor operation,

shall be obtained from a dedicated 120 VAC source at the controller enclosure location or where allocated by Division 16 at a power panel.

c. Division 16 shall provide separate 120 VAC, 20 amp circuits as shown on Electrical Drawings.

d. Provide power wiring from the source to all field mounted control devices.

5. Wiring run outdoors shall be installed in rigid EMT. Wire run across roof areas shall be properly supported and supports shall not penetrate roof. Any access holes through the roof are to be done with a pitch pocket by a qualified roofing Contractor that is acceptable to the Owner. Coordinate requirements with CM.

6. Wire run across roof areas shall be properly supported and supports shall not penetrate roof. Any access holes through the roof are to be done with a pitch pocket by a qualified roofing Contractor that is acceptable to the Owner. Coordinate requirements with CM.

7. All wiring outdoors or below floodplain in the building shall be in rigid EMT. BAS Contractor may use sealtight (no longer than 6' piece) on equipment to make final connection from rigid EMT to control device.

8. Wire one control relay or one solenoid air valve with maximum power draw of 50 VA, to derive pilot power directly from the motor starter control circuit. All devices shall be located remote and external from motor starter. All device wiring shall terminate on terminal blocks provided by Division 16 in motor starter compartment.

9. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway per NEC and Division 16 requirements.

10. All low voltage wiring shall meet NEC Class 2 requirements. Low voltage power circuits shall be sub-fused when required to meet Class 2 current limit.

11. Where NEC Class 2 (current limited) wires are in concealed and accessible locations including ceiling return air plenums, approved cables not in raceway may be used, provided that cables are UL Listed for the intended application. For example, plenums shall be UL Listed specifically for that purpose.

12. Install wiring in EMT raceways in the following areas: mechanical areas, electrical areas, service areas, attics, basements, tunnels, shafts, exposed areas, between floors, and in concrete pours.

13. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

14. Do not install wiring in raceway containing tubing.

15. Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it, and neatly tied at 10ft intervals.

16. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping or ceiling suspension systems.

17. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be made at a terminal block or wire nut at junction box.

18. All wiring within enclosures shall be neatly bundled and anchored to permit access and

prevent restriction to devices and terminals.

19. Maximum allowable voltage for control wiring shall be 120 VAC. If only higher voltages are available, the BAS Contractor shall provide step-down transformers.

20. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

21. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

22. Size of raceway and size and type of wire shall be the responsibility of the BAS Contractor, in keeping with the manufacturer's recommendation and NEC requirements, except as noted elsewhere.

23. Include one pull string in each raceway 1" or larger.

24. Use coded conductors throughout with different colored conductors.

25. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

26. Conceal all raceways, except within mechanical, electrical or service rooms. Install raceway to maintain a minimum clearance of 6" from high-temperature equipment (e.g. steam pipes or flues).

27. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

28. Adhere to Division 16 requirements where raceway crosses building expansion joints.

29. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.

30. The BAS Contractor shall terminate all control and interlock wiring, and shall maintain updated wiring diagrams with terminations identified at the job site.

31. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 3ft in length and shall be supported at each end. Flexible metal raceway less than 3/4" electrical trade size shall not be used. In areas exposed to moisture - including chiller and boiler rooms - liquid-tight, flexible metal raceways shall be used.

32. Raceway must be rigidly installed, adequately supported, properly reamed at both ends and left clean and free of obstructions. Raceway sections shall be joined with couplings (per code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

33. Control transformers in enclosures shall be sized for 30% greater VA capacity than is required by all devices powered by it.

34. Wire in plenum ceiling areas may be installed as plenum cable, installed in a neat manner along building lines and properly supported per requirements of NEC. Plenum cable may not be installed in any other areas unless approved by Owner.

35. Wire in non-plenum ceiling areas above drop ceilings, may be run as exposed non-plenum cable installed in a neat manner along building lines and properly supported per

requirements of NEC.

36. Coordinate work with all trades. The plans are diagrammatic only and are to be utilized as reference.

B. Signal (input and output) Wiring

1. Low voltage control wiring shall be minimum 16 gauge, twisted pair, 100%. shielded with PVC over Belden #9316 run separate from any wiring above 30 volts.

2. Output cables run within drywall shall be in EMT.

3. Ensure the integrity and proper shielding of all signal wiring run without conduit. Shield shall be grounded at the control enclosure only.

C. Communication wiring

1. Communication wiring shall be minimum three individually 100% shielded pairs (i.e. six conductors), minimum 24 gauge cable with overall PVC cover Belden #9773, run separate from all wiring over 30 volts. Shield shall be terminated as recommended by system component manufacturer.

2. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer installation recommendations for all communication cabling.

3. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.

4. Maximum pulling, tension and bend radius for cable installation as specified by the cable manufacturer shall not be exceed during the installation.

5. BAS Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

6. Upon entering and leaving a building, each conductor, including ground shield, shall terminate on a surge protector/lightning arrestor designed to interrupt the circuit and shunt all transient voltage to ground. Lighting arrestor shall be grounded to the closest building ground by minimum 12 AWG wire that is no longer than 50' in length and be of the clamp voltage as specified by the controls manufacturer.

7. All runs of communication wiring shall be unspliced length when that length is commercially available.

8. All communication wiring shall be labeled to indicate origination and destination data.

9. Grounding of coaxial cable shall be in accordance with NEC regulations Article on Communication Circuits, Cable and Protector Grounding.

10. Communication cable run within drywall shall be installed in conduit. Installation of communication cable must otherwise conform to the requirements spelled out above shall comply with paragraph A. above (Wiring).

11. All terminations shall be on panel-mounted terminal strips.

12. Provide all amplifiers, routers, bridges, network cards, etc. to facilitate proper operation of the communication network.

D. Fiber optic cable

1. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within the cable manufacturer specifications.

2. All cabling and associated components shall be installed in accordance with manufacturer instructions. Minimum cable and unjacketed fiber bend radii as specified by cable manufacturer shall be maintained.

3. All fiber optic cable shall be run in galvanized rigid conduit or intermediate metal conduit.

4. All communications wiring run outdoors shall be run in PVC coated rigid conduit. Upon entering and leaving a building or control enclosure, each fiber shall terminate on a patch panel, with minimum 3' patch cables.

5. Provide all amplifiers, routers, bridges, network cards, etc. to facilitate proper operation of the communication network.

3.7 PROJECT MANAGEMENT

A. General

1. Project Manager shall attend all meetings as required by CM, Owner or AE.

2. Project Manager shall be the sole point of contact for the CM, Owner and AE and shall make independent decisions for the work.

3. Project Manager shall be required to attend meetings as required prior to commencement of on-site mobilization.

4. Project Manager shall be available via pager or cell phone at all times during normal business hours and be available for emergencies via company answering service, with 1 hour response time prior to the commencement of warranty.

3.8 INSTALLATION OF SENSORS

A. Install sensors according to manufacturer's recommendations.

B. Mount sensors rigidly and adequately for operating environment.

C. Install room temperature sensors on concealed junction terminal units properly supported by wall framing.

D. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

E. Sensors used in mixing plenums, and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across duct. Each bend shall be supported with a capillary clip.

F. Low limit sensors used in coil discharge shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1ft of sensing element for each square ft of coil area.

G. All pipe mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

H. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

I. Differential Air Static Pressure.

1. Supply duct static pressure: Pipe the high pressure tap to the duct using a pitot tube. Pipe the low pressure port to a tee in the high pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high pressure tap and leave open to the plenum.

2. Return duct static pressure: Pipe the high pressure tap to the duct using a pitot tube. Pipe the low pressure port to a tee in the low pressure tap tubing of the corresponding building static pressure sensor.

3. Building static pressure: Pipe the low pressure port of the pressure sensor to the static pressure port located on the outside of the building at roof level to serve as a common outdoor reference. Pipe the high pressure port to a location behind a thermostat cover.

4. The piping to pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.

5. All pressure transducers other than those controlling VAV terminal units shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without the use of ladders or special equipment.

6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to all taps. Water gauges shall also have shutoff valves installed before the tee.

J. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

3.9 FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.

B. Adjust flow switch according to manufacturer's instructions.

3.10 ACTUATORS

A. General. Mount and link control damper actuators per manufacturer’s instructions.

1. Check operation of control damper/actuator combination to confirm that actuator modulates control damper smoothly throughout stroke to both open and closed positions.

2. Provide all mounting hardware and linkages for actuator installation.

B. Electric and Electronic Control Damper Actuators. Mount actuators directly on control damper shaft or jackshaft unless shown as a linkage installation. Link actuators according to manufacturer's recommendations.

1. Control dampers: Actuators shall be direct-mounted on control damper shaft or jackshaft unless shown as a linkage installation. Actuators shall be mounted following manufacturer’s recommendations.

2. Control valves, Actuators shall be connected to control valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.11 WARNING LABELS

A. Affix permanent warning labels to equipment that can be automatically started by the control system.

1. Labels shall use white lettering (12-point type or larger) on a red background.

2. Warning labels shall read as follows.

C A U T I O N
This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing.

B. Affix permanent warning labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.

1. Labels shall use white lettering (12-point type or larger) on a red background.

2. Warning labels shall read as follows.

C A U T I O N
This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

3.12 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring, cabling and tubing within factory-fabricated panels shall be labeled within 2" of termination.

B. Identify control panels with minimum 1/2” letters on laminated plastic nameplates.

C. Manufacturers' name plates and UL or CSA label is to be visible and legible after equipment is installed.

D. Label each control component with a permanent label. Label plug-in components such that label remains stationary during component replacement.

E. Label room sensors related to terminal terminal units or control valves with nameplates.

F. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

G. Label identifiers shall match record documents.

3.13 CLEANING

A. The BAS Contractor shall clean up all debris resulting from its activities daily. The BAS Contractor shall remove all cartons, containers, crates, etc., under its control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the BAS Contractor shall clean all of its work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.14 PROGRAMMING

A. Point Naming. Name points as shown on the equipment points list provided with each sequence of operation. See BAS Drawings for BAS sequences of operation. If character limitations or space restrictions make it advisable to shorten the name. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.

B. Software Programming. Programming shall provide actions for each possible situation. Graphic- or parameter-based programs shall be documented. Text-based programs shall be modular, structured, and commented to clearly describe each section of the program.

1. Application Programming. Provide application programming that adheres to sequences of operation shown on the BAS Drawings. Program documentation or comment statements shall reflect language used in sequences of operation.

2. System Programming. Provide system programming necessary for system operation.

C. Operator Interface.

1. Standard Graphics. Provide graphics as specified in this Specification Section Article 2.3 (System Graphics). Show on each equipment graphic input and output points and relevant calculated points such as indicated on the applicable Points List on the BAS Drawings. Point information on graphics shall dynamically update.

2. Show terminal equipment information on a "graphic" summary table. Provide dynamic information for each point shown.

3. The BAS Contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

4. Install, initialize, start up, and troubleshoot operator interface software and functions (including operating system software, operator interface database, and third-party software installation and integration required for successful operator interface operation).

5. Time schedules shall be provided for each piece of primary equipment (i.e. – air handling units, chillers, boilers) as directed by the Owner.

6. Time schedules shall be assigned as directed by the Owner for unitary equipment.

7. At the discretion of the Owner, provide overall building holiday schedule(s) and special event schedule(s) to override regular equipment time schedules.

8. Alarm response shall be a maximum of 5 seconds from the time the alarm condition occurs. Alarm dispensation shall include (at the direction of Owner) printing to alarm printer, email, paging, voicemail, audible alarm at workstation and alarm popup box on workstation screen. Alarms shall be as indicated on the BAS Drawings.

9. Create trend log views for each piece of primary and unitary equipment. These trend log views shall include all inputs, outputs, setpoints, targets and calculated values. Create multiple trend log pages for every 16 points per piece of equipment.

10. Create printable text report for each piece of primary equipment.

D. Create the following for the web-based HTML interface:

1. Logon/logout security levels – view only, change setpoints, administrative.

2. Report for each piece of primary equipment showing input and output values, targets and setpoints.

3. Report/table with multiple terminal level equipment such as VAV/CAV terminal units, unit ventilators, unit heaters and fan coil units.

4. Report showing communication status of all 1st tier and 2nd tier controllers.

5. Trend log reports for all primary and terminal level equipment.

6. Reports shall either fit on a single screen or include all controls for scrolling to multiple pages.

3.15 SYSTEM SETUP/PERFORMANCE

A. The following is required for each controller at a minimum after all programming, logs and any other data required for proper operation have been loaded and final testing and acceptance has occurred:

1. All inputs, outputs and calculated values shall have trend logs of no less than 24 hours at 1-hour intervals.

2. All 1st tier controllers shall have a minimum of 20% spare memory capacity after all programming has been loaded and system startup and commissioning is complete.

3. Scan rate for 1st tier controllers shall not exceed 2 seconds and shall not exceed 1 second for 2nd tier controllers.

4. The BAS shall be capable of the following maximum response times:

a. Alarms - 3 seconds from field device to operator workstation.
b. Hardwired point - 1 second continual point refresh.
c. Graphic update – refresh of all points on graphics every 20 seconds.
d. Integration points – 10 second continual point refresh, 2 second update for critical points.

5. System shall have built-in menus and reports that can be accessed via a direct-connect or modem-connected laptop or by dumb terminal to 1st tier controller. Laptop connection must utilize off-the-shelf terminal mode software. The menus and reports at a minimum must allow user to view inputs, outputs, setpoint and targets of primary and unitary systems to allow for system monitoring and troubleshooting.

3.16 CONTROL SYSTEM TESTING, CHECKOUT AND COMMISSIONING

A. Startup Testing. All testing listed in this article shall be performed by the BAS Contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Owners Representative is notified of the system demonstration.

1. The BAS Contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.

2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures per manufacturers' recommendations.

4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The BAS Contractor shall check all control valves and automatic control dampers to ensure proper action and closure. The BAS Contractor shall make any necessary adjustments to control valve stem and control damper blade travel.

6. Verify that the system operation adheres to the Sequences of Operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum Start/Stop routines.

7. Alarms and Interlocks:

   a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
   b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
   c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

B. Adjust, calibrate and test all connected hardware and software to ensure that the system performs in accordance with the Specifications and sequence of operation. Tests shall be performed per the approved test plans (described below) and shall test all system inputs, outputs and the workstation(s).

C. Hardware and Software Testing Requirements

1. 60 days prior to system testing and commissioning, submit 6 copies of the system test documents described herein for review and approval. Provide a brief narrative describing any systems that cannot be tested due to seasonal or other constraints.

   a. Hardpoint test procedure. This shall consist of all test procedures required to test all inputs and outputs, non-BAS controls, BAS controllers and communication buses in the system and all forms required to record the results of the test procedures. Input test data to be recorded shall include at a minimum the value as read by the BAS input and a simultaneously read value measuring at the same location as the input sensor by a measuring instrument calibrated in the past 6 months to a NIST traceable standard. Output test data shall include at a minimum the value as read by the BAS output and the actual observed field range/action of the end device being controlled.

      1) Calibrate and prepare for service each instrument, control, and accessory equipment furnished under this Specification Section.
      2) Verify that control wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.
      3) Enable control systems and verify each input device's calibration. Calibrate each device according to manufacturer's recommendations.
      4) Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
      5) Verify that analog output devices such as actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic control dampers to ensure proper action and closure. Make necessary adjustments to control valve stem and control damper blade travel.
      6) Prepare a log documenting startup testing of each input and output

device, with technician's initials certifying each device has been tested and calibrated.

b. Functional test procedure. This shall consist of all test procedures required to test all controller software and non-DDC controls in the system to verify proper operation per the sequence of operation and all forms required to record the results of the test procedures. Test document shall include at a minimum descriptions of all tests to be performed, columns for BAS Contractor sign-off initials and date, Owner sign-off initials and date and AE sign-off initials and date. Test shall include printing real-time trend logs (with data recorded at 2 second intervals) during each stage of the test for whatever total length of time is necessary to verify the outcome of the testing.

1) Prepare a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.
2) Verify that system operates according to sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.
3) Alarms and Interlocks: Check each alarm with an appropriate signal at a value that will trip the alarm. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction. Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

c. Workstation test procedure. Submit a table with the items below for review and approval of the workstation interface. Table shall include columns for item tested (listed below), comments, columns for BAS Contractor sign-off initials and date, Owner sign-off initials and date and AE sign-off initials and date. See this Specification Section Article 3.15 for workstation requirements. List in this table these items for review at a minimum:

1) Review all system reports.
2) Test system alarms – are all alarms in place as specified? Does the response time and alarm dispensation requirements meet this Specification Section Article 3.15?
3) Review all system graphics for content and that all graphics are included as specified.
4) Demonstrate system diagnostics and troubleshooting capabilities.
5) Demonstrate viewing trend logs, verify trend logs have been set up per requirements of this Specification Section Article 3.15.
6) Demonstrate that controller scan times are per specification.
7) Demonstrate that open protocol interface point updates and command response are per specification.
8) Demonstrate spare memory capacity requirements are met in each controller per specification Section 4.04.
9) Demonstrate trend log data curve plot.
10) Demonstrate on-line help.
11) Demonstrate multi-tasking by having a minimum of 8 windows open simultaneously.
12) Demonstrate proper operation of each typical type of schedule (regular, special event and holiday).
13) Demonstrate system capability to edit/create programs, points, graphics, schedules, reports, trend log views and any other features of the workstation.
14) Demonstrate security features of login.

2. Prior to system demonstration with the Owner and AE, perform system hardpoint test, system functional test and workstation user interface tests per the approved test

documents. Deliver 6 copies of the completed system test documents to the Owner and AE within 5 working days of the completion of the test.

3. Once Owner and AE have reviewed and approved the test documents perform a final demonstration with the Owner and AE. This shall include replication of software and workstation testing of typical systems as performed by the BAS Contractor during step 2 above. Upon completion of each portion of the test, the Owner will sign and date.

4. The system shall operate for a minimum of one week after final demonstration without any major malfunctions. Major malfunction is defined as the system not performing per the sequence of operation or a failure of a major system component. If a malfunction occurs, that portion of the system must be re-tested per steps 2. and 3. above. Upon successful re-test, the one week clock re-starts. If this occurs, reimburse the Owner for the cost of its time and AE at the AE representatives' billable rate for their time spent witnessing re-test(s).

5. Owner instruction shall be scheduled once all testing, commissioning and final demonstration is complete, the O&M manuals are delivered and all air and water balancing and calibration is complete.

3.17 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification after and in addition to tests specified in Article 3.16 (Control System Checkout and Testing). These tests shall occur after the BAS Contractor has completed the installation, started up the system, and performed its own tests. Provide Engineer with log documenting completion of startup tests.

1. Engineer will be present to observe and review system demonstration. Notify Engineer at least 10 days before system demonstration begins.

2. Demonstration shall follow process submitted and approved under this Specification Section Article 1.10 (Submittals). Complete approved checklists and forms for each system as part of system demonstration.

3. Demonstrate actual field operation of each sequence of operation as indicated on the BAS Drawings. Provide at least two persons equipped with two-way communication. Demonstrate calibration and response of any input and output points requested by Engineer. Provide and operate test equipment required to prove proper system operation.

4. Demonstrate compliance with this Specification Section Article 3.15 (System Setup/Performance).

5. Demonstrate compliance with sequences of operation through each operational mode.

6. Demonstrate complete operation of operator interface.

7. Additionally, the following items shall be demonstrated.

a. DDC loop response. The BAS Contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point that represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the BAS Contractor.

b. Demand limiting (if implemented) The BAS Contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall

document the action on a minute-by-minute basis over at least a 30 minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.

c. Optimum Start Stop (if implemented). The BAS Contractor shall supply a trend data output showing the capability of the algorithm. The hour-by-hour trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.

d. Building fire alarm system interface.

e. Operational logs for each system that indicate all set points, operating points, control valve positions, mode, and equipment status shall be submitted to the Architect/Engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs as specified in this Specification Section Article 2.4 (Trend).

8. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The BAS Contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance.

1. All tests described in this specification shall have been performed to the satisfaction of both the Engineer and Owner prior to the acceptance of the control system as meeting the requirements of Completion. Any tests that cannot be performed due to circumstances beyond the control of the BAS Contractor may be exempt from the Completion requirements if stated as such in writing by the Engineer. Such tests shall then be performed as part of the warranty.

2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in this Specification Section Article 1.10 (Submittals).

3.18 FINAL DOCUMENTATION

A. Provide 3 sets of operator, system administrator, programmer and as-built manuals to the Owner.

1. Operator manual shall include site-specific instructions for workstation software for all operator functions specified under Training Article 3.19. This manual shall be for off-line study and refresher use.

2. System administrator manual shall include site-specific instructions for workstation software for all system administrator functions specified under Supervisor/system administrator training.

3. Provide Programmer's Manuals with descriptions of how to modify or create points and programs as specified under Programmer Training. This programmer's manual shall include detailed instructions for the creating, editing and modifying of all types of points, files and programs available in the BAS and detailed explanations of all programming language commands and keywords.

4. Provide project as-built manuals including revised as-built documents of all materials required under the paragraph "SUBMITTALS" on this specification such as updating room numbering on floor plans, drawings and I/O lists.

3.19 TRAINING

A. The BAS Contractor shall be responsible for day-to-day adjustment and operation of the system until training occurs. Training shall utilize specified manuals, as-built documentation and the on-line

help utility. The instructor shall circulate a sign-in sheet for each training session. The sign-in sheet shall include the name of the instructor, date of training and spaces for each attendee to print their name. A copy of the sign-in sheet shall be left with the primary Owner's representative after each training session. The Owner will specify who will attend each type of training session outlined below.

B. Provide training for a designated staff of Owner's representatives. Training shall utilize specified manuals, as-built documentation and the on-line help utility.

C. Provide course outline and materials according to this Specification Section Article 1.10 (Submittals). Provide one copy of training material per student.

D. Instructors shall be factory-trained and experienced in presenting this material.

E. Perform classroom training using a network of working controllers' representative of installed hardware.

F. Training shall enable students to accomplish the following objectives:

1. Proficiently operate system.

2. Understand control system architecture and configuration.

3. Understand DDC system components.

4. Understand system operation, including DDC system control and optimizing routines (algorithms).

5. Operate workstation and peripherals.

6. Log on and off system.

7. Access graphics, point reports, and logs.

8. Adjust and change system setpoints, time schedules, and holiday schedules.

9. Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools.

10. Understand system drawings and Operation and Maintenance manual.

11. Understand job layout and location of control components.

12. Access data from DDC controllers.

13. Operate portable operator's terminals.

14. Create and change system graphics.

15. Create, delete, and modify alarms, including configuring alarm reactions.

16. Create, delete, and modify point trend logs (graphs) and multi-point trend graph.

17. Configure and run reports.

18. Add, remove, and modify system's physical points.

19. Create, modify, and delete application programming.

20. Add operator interface stations.

21. Add a new controller to system.

22. Download firmware and advanced applications programming to a controller.

23. Configure and calibrate I/O points.

24. Maintain software and prepare backups.

25. Interface with job-specific, third-party operator software.

26. Add new users and understand password security procedures.

G. The instructor shall circulate a sign-in sheet for each training session. The sign-in sheet shall include the name of the instructor, date of training and spaces for each attendee to print their name. A copy of the sign-in sheet shall be left with the primary Owner's representative after each training session. The Owner will specify who will attend each type of training session outlined below.

H. Pre-requisites for Owner training - Training shall not to be scheduled until all of the following have occurred:

1. All system hardware and software is installed, tested and 100% operational and there are no remaining controls punchlist items.

2. All system testing and commissioning is complete and accepted by the Owner and AE and the system has passed the one week of operational test.

3. All panels and devices have been labeled and all laminated control drawings installed as specified.

4. System O & M manuals are approved by AE and required copies delivered to Owner.

I. Operator training shall include 40 hours (can be broken down into sessions of no less than 4 hours each) at the Owner site encompassing the following:

1. Walkthrough of system to view all controllers, controller panels and controlled equipment locations.

2. Review methods of manually overriding the system at control panels.

3. Review basic system troubleshooting procedures at control panels and at end devices.

4. Sequence of Operation review.

5. Turning on/shutting down file server and/or workstation(s).

6. Starting up workstation(s) software program(s).

7. Sign on-Sign off of workstation(s) and server.

8. Log on/off workstation(s) software.

9. Viewing of graphics and reports.

10. Viewing of graphics and reports.

11. Commanding of points via keyboard and mouse.

12. Changing system setpoints.

13. Use of all dialog terminal units and menus.

14. Viewing, acknowledging and managing system alarms.

15. Viewing and editing schedules.

16. Download and upload of 1st and 2nd tier controllers.

17. Purge and/or dump of historical data.

18. Troubleshooting of inputs and outputs via the workstation.

19. Troubleshooting of inputs and outputs via the workstation.

20. System routine and preventative maintenance procedures.

J. Supervisor/system administrator training shall include an additional eight hours (can be broken up into sessions of no less than 2 hours each) encompassing the following:

1. Editing/creating/managing workstation and controller username, password and security level assignment/modification.

2. Editing/creating/managing file server, operator workstation and database usernames, passwords and security levels.

3. Workstation and file server maintenance procedures.

4. Point disable/enable/modify.

5. File server and/or workstation backup and restoration.

6. Use of spreadsheet and other OLE applications with system data.

7. Modifying warning limits, alarm limits and alarm distribution paths.

8. Purging system logs.

9. Editing workstation software settings and attributes.

10. Review method of connection of 1st tier controllers and workstation(s) to site network (if applicable).

11. Upload/download and off-line archiving of 1st and 2nd tier controllers.

K. Programmer training shall be for Owner-designated personnel and shall be scheduled by the Owner with two-week notice anytime during the warranty period. Programmer training shall include an additional sixteen hours (can be broken up into sessions of no less than 4 hours) encompassing the following:

1. Review of Sequence of Operation.
2. Add/Delete/Modify control programs and parameters.

3. Add/Delete/Modify points.
4. Use of workstation diagnostic tools.
5. Upload/download and off-line archiving of all system software.
6. Graphic, report, schedule and trend log editing and creation.
7. Modifying warning limits, alarm limits and alarm distribution paths.
8. Review of controller manufacturer programming methods and programming language manuals.
9. Web page creation, setup, modification using the web server technology built-in to the system.

L. Total hours for training are the same total as listed above (64 hours). Adjustments to the training hours listed above can be shifted at the Owner's discretion.

+ + END OF SECTION + +

APPENDICES

APPENDIX 1

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware

Prepared by:
Duffield Associates

Project No. 2484.GQ

Dated: April 30, 2012

DUFFIELD ASSOCIATES

Water/Civil

Geotechnical

Natural Resources

Environmental

Construction

Project No. 2484.GQ

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware

April 30, 2012

Mr. Duncan Anderson, III
Delaware State University
Planning & Construction Department
1200 N. DuPont Highway
Dover, DE 19901-2277

RE: Project No. 2484.GQ
Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware

Dear Mr. Anderson:

Duffield Associates has completed our geotechnical evaluation for the proposed Applied Optical Research Building to be located on the Delaware State University campus in Dover, Delaware. Enclosed is a copy of our geotechnical report that summarizes this evaluation, and provides more detailed information regarding the field and laboratory testing programs, the subsurface conditions encountered, and recommendations for the design and construction of the proposed foundations. These services were provided in general accordance with our agreement dated March 12, 2012.

We have appreciated this opportunity to be of service to you on this project. Should you have any questions concerning this evaluation, do not hesitate to contact us.

Very truly yours,

DUFFIELD ASSOCIATES, INC.

Stacy B. Ziegler

Alison R. Schoch, E.I.
Geotechnical Engineer

Stacy B. Ziegler, P.E., LEED AP/ BD+C
Senior Geotechnical Engineer

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cc: Kelly Bauer - Richard + Bauer

.

DUFFIELD ASSOCIATES

GEOTECHNICAL EVALUATION

PROPOSED
APPLIED OPTICAL RESEARCH BUILDING
DELAWARE STATE UNIVERSITY
DOVER, DELAWARE

April 2012

Prepared for:

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A. PROJECT SUMMARY

PROPOSED CONSTRUCTION

Based on the information provided as well as discussions with the project structural engineer (Richard + Bauer), we understand that it is proposed to construct a research facility with two separate building phases. The first phase will be located at the northern side of the site and will consist of a 4-story building. The second phase will be a 5-story building to the south of the Phase 1 building with a bridged connection to connect the two structures. It is understood that the buildings will not contain basements (i.e., the finished floor will be constructed at grade). The buildings will be constructed of steel framing with concrete decks and will each have a roof penthouse for mechanical equipment. At the time of this report, building column loading information was not yet available. For analysis purposes, we have assumed maximum column loads on the order of 400 kips.

REFERENCES UTILIZED FOR THIS EVALUATION

- A document titled "Scope of Geotechnical Services," prepared by Ballinger and dated March 1, 2012, providing requested geotechnical services and information; and
- A drawing titled, "Topographic Survey," prepared by Becker Morgan Group and dated February 9, 2012.

EXISTING SITE CONDITIONS

The site of the proposed Applied Optical Research Building is located in the eastern portion of the Delaware State University campus as indicated on the Site Location Map attached with this report. The location of the proposed building is currently a relatively flat, grass-covered area occupied by three existing modular buildings on the northwest and southwest sides of the proposed building footprint. The aforementioned buildings and foundations are scheduled to be removed prior to the new building construction. For the purposes of analysis, it is assumed that only minor regrading (i.e., net cuts or fills of 2 feet or less) will be required in these areas. The site slopes gently downward toward the southwest, with grades varying from approximately elevation 30 feet to 26 feet. Several utilities, including electric, telephone, water, sanitary sewer, and storm sewer were identified by Miss Utility and Delaware State University representatives in the general vicinity of the proposed Applied Optical Research Building.

B. FIELD WORK AND LABORATORY TESTING RESULTS

STANDARD PENETRATION TEST BORINGS

On March 29, 2012, a total of 5 Standard Penetration Test borings (SPT, ASTM: D 1586) were performed at the site within the footprint of the proposed building. Three of the test borings (TB-2, TB-3, and TB-4) were performed to depths of approximately 30 feet. The remaining two test borings (TB-1 and TB-5) were performed to depths of approximately 15 feet. Test boring

locations were established and staked in the field by Duffield Associates' representatives utilizing existing site features as a reference prior to the start of this evaluation. The approximate locations of the test borings are indicated on the sketch included in Appendix A of this report.

Test borings were performed by CGC Geoservices, an affiliate company of Duffield Associates. A truck-mounted, Diedrich D-50 drill rig equipped with hollow stem augers was utilized for the SPT drilling. The subsurface conditions encountered during the performance of the test borings are described in logs included in Appendix B of this report. At the completion of drilling, the boreholes were backfilled with the soil cuttings and leveled off with the surrounding grade.

Further restoration of the borehole locations was beyond the scope of work performed for this geotechnical evaluation. However, additional settlement of the backfilled soil may occur, resulting in a depression or hole in the ground surface. Consequently, future maintenance and restoration of the site may be required.

GEOTECHNICAL LABORATORY TESTING

Following completion of the field program, soil samples, which were obtained from the SPT borings, were returned to Duffield Associates' laboratory for testing of selected samples. The laboratory testing program for this evaluation included the determination of natural water content (ASTM: D 2216) and silt/clay content (percent finer than a No. 200 sieve, ASTM: D 1140) for a total of 5 soil samples obtained during the field sampling program. The results of the laboratory testing are summarized in Table 1. No environmental testing or characterization was performed.

Table 1: Geotechnical Laboratory Testing

Location	Sample No.	Depth (Ft)	Moisture Content (%) ASTM D 2216	Percent Passing No. 200 Sieve (%) ASTM D 1140
TB-1	S-1	1 – 2.5	18.5	63.8
TB-2	S-5	13.5 – 15	25.4	18.5
TB-3	S-1	1 – 2.5	11.9	55.9
TB-3	S-5	13.5 – 15	30.8	23.9
TB-4	S-2	3.5 – 5	16.3	59.4

C. SUBSURFACE CONDITIONS

SITE GEOLOGY

The site of the proposed addition is located within the Atlantic Coastal Plain Physiographic Province. The Coastal Plain is a wedge-shaped accumulation of unconsolidated sediments deposited on a sloping shelf of Piedmont-type bedrock. Based on Delaware Geologic Survey (DGS) mapping, the depth to weathered bedrock in the general area of the site is estimated to be on the order of 3,000 feet.

SITE STRATIGRAPHY

STRATUM	APPROXIMATE THICKNESS (FT.)	GENERALIZED DESCRIPTION[1]
A[2]	0.3 – 0.6	TOPSOIL
B[3]	2.6 – 3	Apparent FILL: Gray, gray-brown, dark brown fine sand and graded aggregate, little silt, trace to some medium to coarse sand (dry to moist, medium to dense density)
C[4]	2.5 – 5.2	Gray, brown, orange SILT, and to little fine sand, little medium sand, trace coarse sand, trace gravel, trace organics (medium to very stiff consistency); USCS: ML
D[5]	4	Orange, gray CLAY, trace fine sand (stiff consistency); USCS: CL
E	---[6]	Orange, light brown, gray fine SAND, some to trace silt, trace to little medium sand, trace coarse sand (medium to dense density); USCS: SM
E1	4 – ---[7]	Orange-brown, light brown fine SAND, little to some silt, trace medium sand (very loose to loose density); USCS: SM

NOTES:
1. The soil descriptions utilized herein and on the test boring logs are defined by the General Notes included in Appendix F.
2. Stratum A not encountered in test boring TB-2.
3. Stratum B only encountered in test borings TB-2 and TB-5.
4. Stratum C not encountered in test boring TB-5.
5. Stratum D only encountered in test boring TB-4.
6. Stratum E not fully penetrated in any test boring.
7. Stratum E1 not fully penetrated in test borings TB-1 and TB-5.

GROUNDWATER CONDITIONS

Groundwater was encountered in the all of the test borings performed at depths ranging from approximately 8.0 to 13.4 feet below the existing ground surface, corresponding to an elevation range of approximately 15.6 to 22.0 feet.

Regional groundwater mapping by the Delaware Geological Survey (DGS) indicates typical groundwater levels at the site at approximately elevation 25 feet, which is slightly higher than the elevations observed during drilling at the site. These observations are consistent with the relatively low rainfall levels during the past spring and summer, suggesting groundwater

levels deeper than average conditions. Groundwater levels at this site are likely to be regularly affected by seasonal and annual variations in precipitation. It is estimated that fluctuations in groundwater levels several feet higher than those noted by the DGS mapping could be experienced during extreme seasonal variations in precipitation.

D. ANALYSIS AND DESIGN RECOMMENDATIONS

DISCUSSION OF ANALYSIS

1. **BEARING CAPACITY**

The natural site soils encountered beneath the surface topsoil (Stratum A) and apparent fill strata (Stratum B) are considered capable of supporting the proposed structure on a conventional spread foundation system and slab-on-grade. Geotechnical analysis, based on the results of the SPT borings and laboratory testing, indicates that the spread foundations could be sized for a **maximum allowable bearing pressure of 2,500 pounds per square foot (psf)**. This analysis has assumed a shallow foundation system with a minimum width of 5 feet and a minimum burial depth of 3 feet.

2. **FOUNDATION SETTLEMENT**

Estimates of settlement were performed to assist in evaluating the effect of the proposed foundation loading and configuration on the subsurface conditions observed. Due to the stratum of very loose density sand observed at the site (described herein as Stratum E1), some settlement of the building should be expected. Due the generally granular texture of the soils at the site, settlement should occur relatively quickly following the application of the loads. Assuming that approximately one-half of the total foundation loading is due to dead load, post-construction settlement is estimated to be on the order of 1 inch. Post construction differential settlements are estimated to be on the order of ½ inch over a distance of 30 feet.

Due to the differing loading conditions and foundation types between the four-story and the five-story portions of the structure, up to ¾ inch of differential settlement is estimated between the two portions of the structure. The differential settlement should be considered in the design of the building and expansion jointing may be required to accommodate this differential settlement.

3. **EXISTING SITE UTILITIES**

Several utilities, including electric, telephone, water, sanitary sewer, and storm were identified by Miss Utility and Delaware State University representatives in the general vicinity of the proposed building. The depth and specific location of utilities is currently unknown. However, utilities will likely be encountered during foundation excavation and the presence of the existing utilities must be considered in the foundation design.

For foundations bearing over utility areas, the potential for undermining of the soils supporting the new foundations and slab due to failures in underlying utilities or the crushing of pipes from foundation loads must be considered. The least-risk solution to this situation is to relocate the existing utilities outside and away from the proposed building foundations. If this solution is not considered practical, the base of the foundation elevations should be lowered beneath the inverts for the existing utilities. Another alternative, which would not require utility relocation or deepening the foundations, would be to fully encase the existing utilities in concrete. However, with this latter alternative, there remains some risk that utility damage and/or foundation undermining could occur.

DESIGN RECOMMENDATIONS

1. ALLOWABLE FOUNDATION BEARING CAPACITY

It is Duffield Associates' opinion that the natural site soils (described herein as Strata C, D, E, and E1) are generally considered suitable for supporting the proposed additions on a shallow foundation system. These soils were encountered below the surface stratum of topsoil (Stratum A) and a thin layer of apparent fill materials (Stratum B) encountered in several of the borings. Structural fill, placed, compacted, and reviewed as recommended in this report, is also considered suitable for supporting shallow building foundations. It is recommended that the proposed foundations be designed for a maximum net allowable bearing pressure of **2,500 psf**.

2. FOUNDATION BURIAL DEPTH AND SIZE

The base of all exterior spread footings in areas exposed to frost should be placed at least 32 inches below final exterior grade. Interior foundations in insulated areas should be placed at least 18 inches below the proposed finished floor elevation. All isolated column footings should be at least 5 feet wide, and all continuous wall footings should be at least 3 feet wide, regardless of bearing pressure. If a winter construction schedule is proposed for the foundations, provisions for the protection of shallow foundations from frost heave during construction should be included in the contract specifications.

3. ESTIMATED FOUNDATION SETTLEMENT

Settlement of the site soils will result from the building loads. In each of the borings, a zone of very loose density sand soils was observed generally at a depth of 12 to 18 feet below grade. This soil stratum, described above as Stratum E1, will exhibit settlement under foundation loading that extends into this subsurface zone. The results of the settlement analysis indicate that maximum total foundation settlement for the proposed structures

designed with a bearing capacity of 2,500 psf should be on the order of 1 inch. Higher settlements would likely occur if a higher bearing pressure was utilized for design.

Due to the generally low plasticity, unsaturated condition, and granular nature of the site soils within the zone of foundation influence, most of the estimated settlement should occur relatively quickly following the application of loads.

4. SLAB-ON-GRADE

Ground-supported floor slabs should be designed as free floating and should not be connected to the structural elements (e.g., walls, framing, etc.) of the buildings. Isolation joints should be utilized at the interface of proposed, ground-supported floor slab and structural elements to accommodate potential differential settlement. A minimum 10-mil polyethylene vapor barrier and free-draining subbase, consisting of at least 4 inches of poorly graded, crushed stone aggregate, such as AASHTO SP-57 stone, should be provided beneath all floor slabs. Subgrade conditions should be modeled for design, utilizing a subgrade modulus, K_S, of 150 pci, assuming the subgrade is prepared as described herein.

5. SEISMIC DEISGN PARAMETERS

Based on subsurface conditions encountered during the field exploration at the site and review of regional geologic maps, a “D” soil profile type, as defined by Table 1613.5.2 of the 2009 International Building Code, is recommended for design.

6. INFLUENCE OF PHASE 2 STRUCTURE ON PHASE 1 STRUCTURE

It is understood that the proposed facility will be built in two phases of construction. The burial depth of the foundations for the second phase should be selected such that additional loads will not be imparted to the footings of the first phase building. The proposed foundations immediately adjacent to the first phase structure should be founded at an elevation equal to, or below, the existing foundations.

The connection between the proposed and the existing structures should be designed to tolerate up to 1 inch of differential settlement, as the existing structure will have likely already experienced its full load-induced settlement.

7. EXISTING UTILITIES

The presence of utilities beneath new foundations could result in crushing of the pipes and/or undermining of the proposed foundations and slab-on-grade. Therefore, it is recommended that any existing utilities be relocated outside the limits of the proposed construction. The resulting excavations should be backfilled with structural fill, placed, and compacted as recommended in this report. If the utilities cannot be relocated outside of the proposed building area, foundations should be designed to bear at or below the invert elevations of the pipe. If these options are not considered economical, or are otherwise impractical to

accomplish, a potentially less expensive method of construction, with resultant greater potential for future undermining is to expose, sleeve, and fully encapsulate the existing utilities in concrete beneath the proposed building area. The latter alternative should only be considered if the former alternatives cannot be accomplished.

8. **SITE GRADING**

Site grading should be designed to provide positive drainage away from the proposed building areas. Positive site drainage should be maintained throughout the construction activities.

9. **ASSUMPTIONS**

Due to the limited structural information available, this evaluation has been based on assumptions regarding design loads and finished floor elevations for the proposed structure. These assumptions should be verified by the project team prior to the completion of their design. If the proposed loading conditions vary from those assumed herein, Duffield Associates should be notified to possibly modify the recommendations provided herein as required.

E. CONSTRUCTION RECOMMENDATIONS

PROOFROLL AND SUBGRADE PREPARATION

At the start of construction, the proposed building addition area should be stripped of all topsoil and concrete sidewalks. Several wooden plant boxes and small trees were observed to be in the general vicinity of the proposed structure. These should be removed in their entirety. It is also recommended that the existing building foundations be removed in their entirety and backfilled in accordance with the recommendations of this report.

Following rough grading and prior to footing excavation, placement of fill, or construction of the floor slab, it is recommended that the exposed subgrade be proofrolled. The proofroll should be performed using a minimum 10-ton vibratory roller or a fully loaded tandem dump truck in the presence of a qualified soils technician working under the supervision of a geotechnical engineer. The purpose of the proofrolling is to densify the exposed subgrade and to identify yielding subgrade conditions. Yielding subgrade conditions encountered within the proposed building and pavement areas should be undercut to firm subgrade conditions and be backfilled in accordance with the recommendations of this report. Provisions for the undercutting and subsequent replacement of these materials should be anticipated by the construction contract documents and project budget estimates. The subgrade review should also confirm the consistency and texture of the exposed soils with the conditions encountered during this evaluation as described herein.

FOUNDATION SUBGRADE REVIEW

All foundations should be placed on natural, firm, dry, non-frozen subgrade or compacted structural fill. Foundation excavations should be reviewed by a qualified technician working

under the supervision of a geotechnical engineer who is familiar with the recommendations of this report. Subgrade review should be performed prior to the placement of reinforcing steel or concrete and should verify the presence of the medium dense or denser sand of Stratum C (or compacted structural fill placed as backfill in foundation undercuts). If these conditions are not encountered at the proposed foundation depth, additional undercutting may be required, as evaluated and recommended by a qualified geotechnical engineer. If acceptable to the project's geotechnical engineer, granular soils may be densified in place. Foundation undercut areas should be backfilled with structural fill, as recommended herein, or, if acceptable to the project structural engineer, lean concrete.

RE-USE OF ON-SITE SOILS AS STRUCTURAL FILL

On-site soils free of organic material, debris, and rock fragments, in excess of 3 inches in their largest dimension, may be suitable as structural fill. The shallow, predominately granular soils at the site were generally encountered with moisture contents at which the specified compaction could be achieved. The thin surficial layer of silty materials was encountered at a moisture content slightly above that at which compaction as structural fill could be obtained, therefore some drying of these materials may be required in order to reuse them a structural fill.

If sufficient quantities of suitable on-site soils are not available for structural fill, imported borrow consisting of predominately granular soils conforming to the requirements of Delaware Department of Transportation Standard Specifications Borrow Type C (Backfill) should be utilized. AASHTO SP-57 stone could also be utilized as structural fill at locations, as recommended by the project engineer, and should be considered for localized, relatively deep fills such as foundation undercuts or utility trenches and as a base beneath the slabs.

COMPACTION REQUIREMENTS

Structural fill utilized within the proposed building area should be placed in loose lifts with a maximum thickness of 8 inches.

The following compaction requirements should be utilized for each lift of fill placed at the site:

- Structural fill placed within the building area should be compacted to at least 95% of the maximum dry density, as determined by the Modified Proctor test (ASTM D 1557).

- Structural fill for utility trenches and wall backfill, located outside of the proposed building, should be compacted to at least 90% of the maximum dry density as determined by the Modified Proctor test (ASTM D 1557).

The placement and compaction of structural fill should be monitored on a full-time basis by a qualified technician under the supervision of a geotechnical engineer.

PROTECTION OF SUBGRADE SOILS

Subgrade soils disturbed by precipitation and construction traffic should be either scarified and re-compacted, or undercut and replaced with structural fill as previously discussed. Subgrade disturbance could be reduced by maintaining positive surface drainage, by establishing and maintaining a sump throughout the construction period, and by limiting construction traffic on the exposed subgrade soils.

GROUNDWATER CONTROL

Groundwater was encountered at depths of approximately 8 to 13 feet below grade during the performance of the test borings. Although this groundwater depth is well below the anticipated excavation depth for foundations, it is possible that shallow perched groundwater conditions could be encountered during foundation excavation. If "perched" groundwater is encountered, localized sumping may be required. It is recommended that wherever groundwater is encountered during shallow foundation or utility excavations, the resulting excavation should be over-excavated by at least 4 inches and replaced with AASHTO SP-57 stone to protect the exposed subgrade soils and to facilitate sumping.

EXCAVATION SAFETY

All foundation and utility excavation should be performed in accordance with OSHA guidelines. Typically, sand soils can be characterized by OSHA CFR Part 1926 Excavation Standards as Type C soils. Should it be required, all temporary sheeting and shoring should be designed by a qualified engineer registered in the State of Delaware.

CONSTRUCTION REVIEW

It is recommended that the project budget include provisions for the cost for independent construction monitoring of the earthwork and foundation construction by a qualified engineering firm retained by the owner to review conformance of construction with the recommendations of the project geotechnical evaluation, and the project plans and specifications.

F. LEED 2009 RECOMMENDATIONS

Duffield Associates is a participating member of the U.S. Green Building Council and has been a leader in innovative and sustainable site design, storm and wastewater management, and conservation since our inception more than 30 years ago. As part of our continued efforts to be environmentally responsible, Duffield Associates provides this list of New Construction and Major Renovations recommendations for the design team to consider. If requested, we can assist in developing these items.

Energy and Atmosphere

Credit 2 – On-site Renewable Energy

- Assist in the evaluation and design of geothermal heating/cooling systems.

Materials and Resources

Credit 5 – Regional Materials

- Identify local borrow pits within 500 miles of the project site to reduce environmental effects and reduce construction costs.

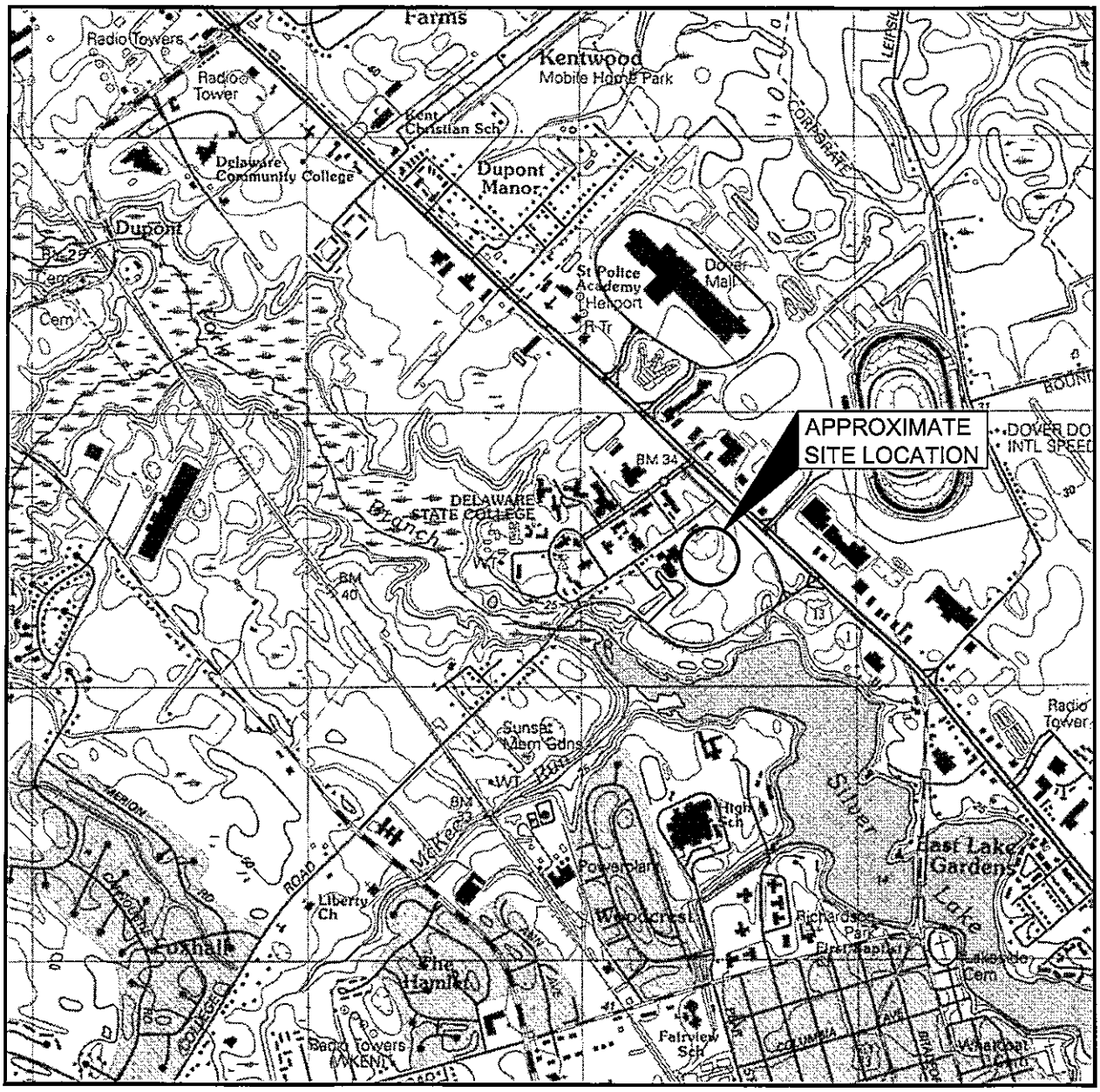
Innovation and Design Process

Credit 2 – LEED Accredited Professional

- Provide LEED Accredited Professionals with project experience and knowledge of the LEED rating system.

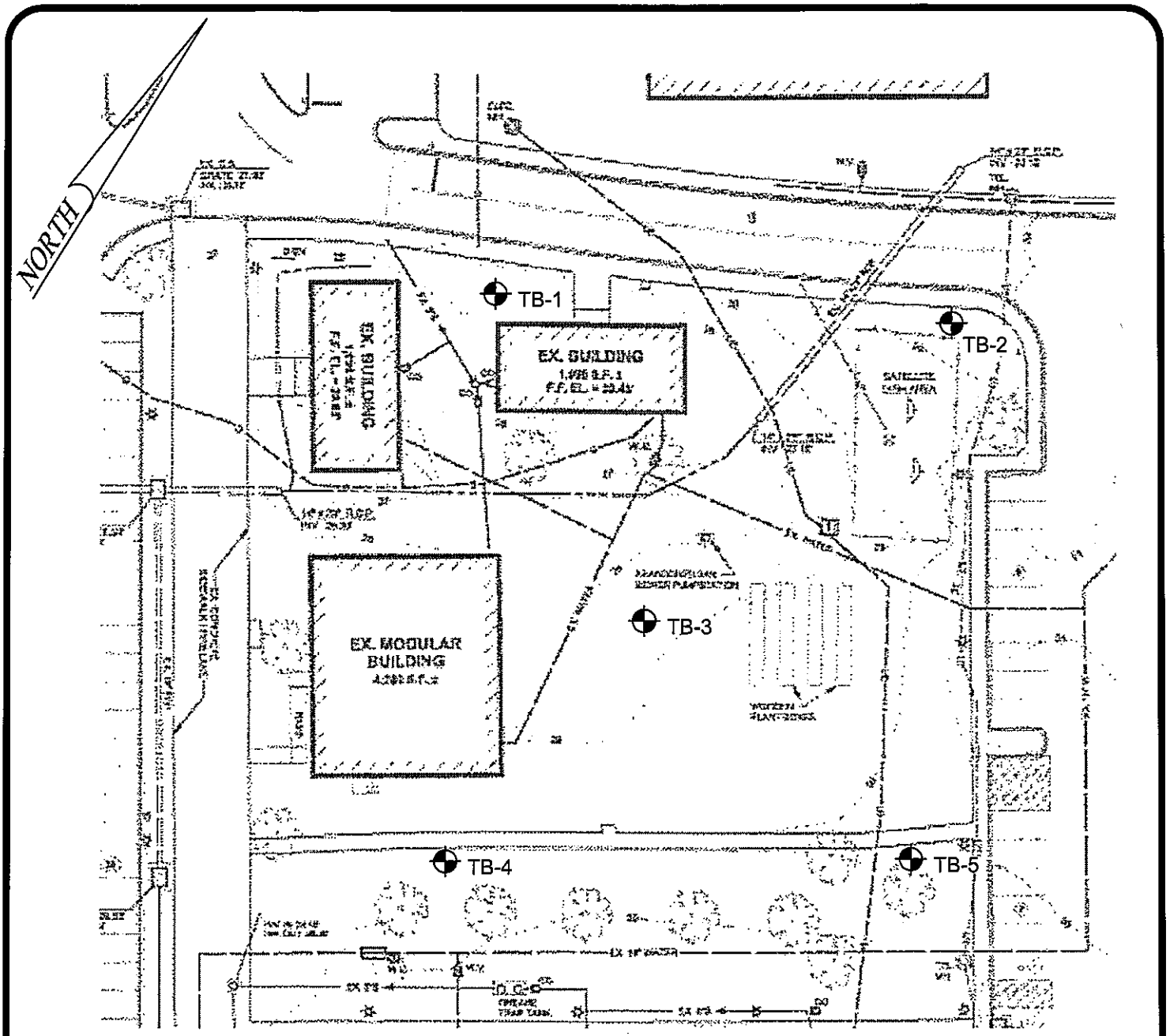
G. SKETCHES AND LOGS

- **SITE LOCATION SKETCH**
- **TEST BORING LOCATION SKETCH**
- **TEST BORING LOGS (4)**
- **GENERAL NOTES**



NOTE:
THIS LOCATION SKETCH IS ADAPTED FROM THE U.S.G.S. TOPOGRAPHIC MAP, 7.5 MINUTE SERIES, FOR DOVER, DELAWARE, 1993.

DATE: 18 APRIL 2012	SITE LOCATION SKETCH	DESIGNED BY: SBZ	DUFFIELD ASSOCIATES
SCALE: 1"=2000'	DELAWARE STATE UNIVERSITY APPLIED OPTICAL RESEARCH BUILDING	DRAWN BY: ARS	5400 LIMESTONE ROAD WILMINGTON, DE 19808-1232 TEL (302)239-6634 FAX (302)239-8485
PROJECT NO. 2484.GQ		CHECKED BY: SBZ	OFFICES IN DELAWARE, MARYLAND PENNSYLVANIA AND NEW JERSEY
SHEET: FIGURE 1	DOVER ~ KENT COUNTY ~ DELAWARE	FILE: A-2484GQ-01	E-MAIL: DUFFIELD@DUFFNET.COM



KEY:

TB-1 - APPROXIMATE LOCATION OF TEST BORING

NOTE:
THIS SKETCH IS ADAPTED FROM A DRAWING TITLED "TOPOGRAPHIC SURVEY," PREPARED BY BECKER MORGAN GROUP, DATED FEBRUARY 9, 2012.

DATE: 18 APRIL 2012	TEST BORING LOCATION SKETCH	DESIGNED BY: SBZ	DUFFIELD ASSOCIATES
SCALE: 1"=50'	DELAWARE STATE UNIVERSITY APPLIED OPTICAL RESEARCH BUILDING	DRAWN BY: ARS	5400 LIMESTONE ROAD WILMINGTON, DE 19808-1232 TEL: (302)239-6634 FAX: (302)239-8485
PROJECT NO. 2484.GQ		CHECKED BY: SBZ	OFFICES IN DELAWARE, MARYLAND PENNSYLVANIA AND NEW JERSEY
SHEET: FIGURE 2	DOVER ~ KENT COUNTY ~ DELAWARE	FILE: A-2484GQ-02	E-MAIL: DUFFIELD@DUFFNET.COM

DUFFIELD ASSOCIATES

TEST BORING TB-1

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

Date Started : March 29, 2012
Date Completed : March 29, 2012
Logged by : CGCG
Weather : Clear, 60s
Driller/Agency : Wayne Proud/CGCG

Drilling Equipment Truck-Mounted Diedrich D-50
Drilling Methods : HSA (SPT, ASTM D 1586)

Sample Condition: ⊠ Remolded
Water Levels: ▼ During Drilling

Depth in feet	Layer Depth feet	GRAPHIC	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
0	0.6			TOPSOIL (± 7 inches)							
	3.0		ML	Gray, brown SILT and fine SAND, little medium sand, trace coarse sand, trace organics (dry to moist)	⊠	S-1	3-4-3	1.4	18.5	63.8	
5	5.5		ML	Gray, orange, brown SILT, trace to little fine sand (slightly mottled) (moist)	⊠	S-2	5-9-14	0.9			
			SM	Orange, gray-brown fine SAND, little silt, trace medium sand (wet)	⊠	S-3	5-4-5	1.3			▼
10	12.0		SM	Orange, gray-brown fine SAND, little silt, trace medium to coarse sand (wet)	⊠	S-4	3-3-2	0.8			
15	15.0		SM	Orange, gray fine SAND, some silt (wet)	⊠	S-5	3-2-3	1.5			
20											
25											
30											

NOTES:
1. Test boring terminated ± 15.0 feet below existing ground surface (b.e.g.s.).
2. Wet-on-spoon observed at ± 7.5 feet b.e.g.s. with augers at ± 8.5 feet b.e.g.s.
3. Water level observed at ± 8.0 feet b.e.g.s. with augers at ± 8.5 feet b.e.g.s.
4. Borehole caved at ± 9.3 feet b.e.g.s. with water level observed at ± 6.8 feet b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled with soil cuttings.
6. Soil descriptions performed in accordance with ASTM D 2488, the Practice for Description and Identification of Soils (Visual-Manual Procedure).

DUFFIELD ASSOCIATES

TEST BORING TB-2

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

Date Started : March 29, 2012
Date Completed : March 29, 2012
Logged by : CGCG
Weather : Clear, 60s
Driller/Agency : Wayne Proud/CGCG

Drilling Equipment: Truck-Mounted Diedrich D-50
Drilling Methods : HSA (SPT, ASTM D 1586)

Sample Condition: Remolded
Water Levels: During Drilling

Depth in feet	Layer Depth feet	GRAPHIC	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
0				Apparent FILL: Dark brown, orange, gray-brown fine sand, little to some medium to coarse sand, little silt, trace gravel (dry to moist)	X	S-1	8-16-5	0.9			
	3.0		ML	Gray, dark gray, orange SILT, some to and fine sand, trace medium sand (moist)	X	S-2	2-3-3	1.5			
5	5.5		SM	Orange-brown, gray fine SAND, some silty, trace medium to coarse sand (moist)	X	S-3	6-8-9	1.3			
	8.0		SM	Orange-brown, light brown fine SAND, little to some silt (moist to wet)	X	S-4	4-4-5	1.5			▼
10											
15				Orange-brown, light brown fine SAND, little silt, trace coarse to medium sand (moist to wet)	X	S-5	1-1-2	1.5	25.4	18.5	
	16.5		SM	Orange, orange-brown fine SAND, little to some silt (wet)	X	S-6	3-3-6	1.0			
20											
25				Orange-brown, orange, gray-brown fine SAND, little silt, trace medium sand (wet)	X	S-7	4-5-5	0.9			
30	30.0			Orange, red-orange fine SAND, little silt, trace medium sand (wet)	X	S-8	5-8-10	1.0			

NOTES:
1. Test boring terminated ± 30.0 feet below existing ground surface (b.e.g.s.).
2. Wet-on-rods observed at ± 11.8 feet b.e.g.s. with augers at ± 13.5 feet b.e.g.s.
3. Water level observed at ± 11.7 feet b.e.g.s. with augers at ± 13.5 feet b.e.g.s.
4. Borehole caved at ± 12.1 feet b.e.g.s. with water level observed at ± 10.9 feet b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled with soil cuttings.
6. Soil descriptions performed in accordance with ASTM D 2488, the Practice for Description and Identification of Soils (Visual-Manual Procedure).

DUFFIELD ASSOCIATES

TEST BORING TB-3

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

Date Started : March 29, 2012
Date Completed : March 29, 2012
Logged by : CGCG
Weather : Clear, 60s
Driller/Agency : Wayne Proud/CGCG

Drilling Equipment : Truck-Mounted Diedrich D-50
Drilling Methods : HSA (SPT, ASTM D 1586)

Sample Condition: Remolded
Water Levels: During Drilling

Depth in feet	Layer Depth feet	GRAPHIC	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
0	0.3			TOPSOIL (± 4 inches)							
			ML	Dark brown, brown, gray SILT and fine SAND, little medium sand, trace coarse sand, trace gravel, trace organics (dry to moist)	X	S-1	7-10-11	1.3	11.9	55.9	
	3.0		ML	Gray, orange-brown SILT, some fine sand (slightly mottled) (moist)	X	S-2	4-5-9	1.5			
5	5.5		SM	Light brown fine SAND, trace silt, trace medium sand (moist)	X	S-3	7-8-7	1.3			
				Light brown fine SAND, trace silt, trace medium sand (moist)	X	S-4	2-4-2	1.0			
10	12.0		SM	Light brown fine SAND, some silt (moist to wet)	X	S-5	1-1-2	1.5	30.8	23.9	▼
15											
				Light brown fine SAND, little silt (wet)	X	S-6	2-2-4	1.3			
20	22.0		SM	Orange-brown, red-orange fine SAND, little silt, trace medium sand (wet)	X	S-7	5-8-7	1.1			
25											
				Orange-brown, red-orange fine SAND, little silt, trace medium sand (wet)	X	S-8	13-14-14	0.7			
30	30.0										

NOTES:
1. Test boring terminated ± 30.0 feet below existing ground surface (b.e.g.s.).
2. Wet-on-spoon observed at ± 13.3 feet b.e.g.s. with augers at ± 13.5 feet b.e.g.s.
3. Water level observed at ± 13.4 feet b.e.g.s. with augers at ± 13.5 feet b.e.g.s.
4. Borehole caved at ± 12.0 feet b.e.g.s. with water level observed at ± 9.4 feet b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled with soil cuttings.
6. Soil descriptions performed in accordance with ASTM D 2488, the Practice for Description and Identification of Soils (Visual-Manual Procedure).

DUFFIELD ASSOCIATES

TEST BORING TB-4

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

Date Started : March 29, 2012
Date Completed : March 29, 2012
Logged by : CGCG
Weather : Clear, 60s
Driller/Agency : Wayne Proud/CGCG

Drilling Equipment : Truck-Mounted Diedrich D-50
Drilling Methods : HSA (SPT, ASTM D 1586)

Sample Condition: ⊠ Remolded
Water Levels: ▼ During Drilling

Depth in feet	Layer Depth feet	GRAPHIC	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
0	0.4			TOPSOIL (± 5 inches)							
			ML	Brown SILT, little to some fine sand, trace organics (moist)	⊠	S-1	7-7-7	1.5			
	3.0		ML	Brown, gray SILT and fine SAND, little medium sand, trace coarse sand, trace gravel (moist)	⊠	S-2	2-2-3	1.5	16.3	59.4	
5	5.5		SM	Orange-brown fine SAND, trace silt, trace medium sand (moist)	⊠	S-3	5-10-11	1.3			
	8.0		CL	Orange, gray CLAY, trace fine sand (slightly mottled)	⊠	S-4	3-4-6	1.5			
10	12.0										▼
			SM	Orange, gray fine SAND, little to some silt (moist to wet)	⊠	S-5	2-4-3	1.4			
15				Orange, gray fine SAND, little silt, trace medium sand (wet)	⊠	S-6	2-1-3	1.1			
20				Orange, gray fine SAND, little silt, trace medium sand (wet)	⊠	S-7	3-6-6	1.2			
25				Orange fine SAND, little medium sand, trace silt (wet)	⊠	S-8	15-16-18	1.0			
30	30.0										

NOTES:
1. Test boring terminated ± 30.0 feet below existing ground surface (b.e.g.s.).
2. Wet-on-spoon observed at ± 18.0 feet b.e.g.s. with augers at ± 18.5 feet b.e.g.s.
3. Water level observed at ± 13.0 feet b.e.g.s. with augers at ± 18.5 feet b.e.g.s.
4. Borehole caved at ± 14.3 feet b.e.g.s. with water level observed at ± 11.6 feet b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled with soil cuttings.
6. Soil descriptions performed in accordance with ASTM D 2488, the Practice for Description and Identification of Soils (Visual-Manual Procedure).

DUFFIELD ASSOCIATES

TEST BORING TB-5

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

Date Started : March 29, 2012
Date Completed : March 29, 2012
Logged by : CGCG
Weather : Clear, 60s
Driller/Agency : Wayne Proud/CGCG

Drilling Equipment : Truck-Mounted Diedrich D-50
Drilling Methods : HSA (SPT, ASTM D 1586)

Sample Condition: ⊠ Remolded
Water Levels: ▼ During Drilling

Depth in feet	Layer Depth feet	GRAPHIC	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
0	0.4			TOPSOIL (± 5 inches)							
	3.0			Apparent FILL: Gray, gray-brown graded aggregate, little silt, trace fine to medium sand	⊠	S-1	19-22-16	0.9			
5	5.5		SM	Dark brown fine SAND, little silt (dry to moist)	⊠	S-2	9-10-10	0.6			
			SM	Light gray, orange fine SAND, some silt, trace medium to coarse sand, trace gravel (moist)	⊠	S-3	4-4-7	1.3			
10				Light brown, orange-brown, gray fine SAND, trace silt, trace medium sand (moist)	⊠	S-4	6-7-7	1.4			
	12.0		SM	Orange, gray fine SAND, little to some silt (wet)	⊠	S-5	2-2-4	1.5			▼
15	15.0										
20											
25											
30											

NOTES:
1. Test boring terminated ± 15.0 feet below existing ground surface (b.e.g.s.).
2. Wet-on-spoon observed at ± 13.4 feet b.e.g.s. with augers at ± 13.5 feet b.e.g.s.
3. Water level observed at ± 13.1 feet b.e.g.s. with augers at ± 13.5 feet b.e.g.s.
4. Borehole caved and dry at ± 7.9 feet b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled with soil cuttings.
6. Soil descriptions performed in accordance with ASTM D 2488, the Practice for Description and Identification of Soils (Visual-Manual Procedure).

APPENDIX 2

Supplemental Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware

Prepared by:
Duffield Associates
5400 Limestone Road
Wilmington, DE 19808

Phone: 302-239-6634
Fax: 302-239-8485

Project No. 2484.GQ

Dated: October 17, 2012

DUFFIELD ASSOCIATES

Water/Civil

Geotechnical

Natural Resources

Environmental

Construction

Project No. 2484.GQ

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware

October 2012

DUFFIELD ASSOCIATES

5400 Limestone Road
Wilmington, DE 19808
Phone: 302.239.6634
Fax: 302.239.8485
duffnet.com

October 17, 2012

Mr. Duncan Anderson, III
Planning and Construction Department
Delaware State University
1200 North DuPont Highway
Dover, DE 19901-2277

RE: Project No. 2484.GQ
Supplemental Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware

Dear Mr. Anderson:

Duffield Associates, Inc. (Duffield Associates) has completed our supplemental geotechnical evaluation for the proposed Applied Optical Research Building to be located on the Delaware State University campus in Dover, Delaware. Enclosed is a copy of our geotechnical report that summarizes this evaluation, and provides more detailed information regarding the field and laboratory testing programs, the subsurface conditions encountered, and recommendations for the design and construction of the proposed foundations. These services were provided in general accordance with our agreement dated September 18, 2012.

We have appreciated this opportunity to be of service to you on this project. Should you have any questions concerning this evaluation, please do not hesitate to contact us.

Very truly yours,

DUFFIELD ASSOCIATES, INC.

Stacy B. Ziegler, P.E., LEED AP BD+C
Senior Geotechnical Engineer

ARS/SBZ/JFC:jst
WORD\2484GQ.1012-DSUAPPLIEDOPTICS_SUPP.RPT

cc: Kelly Bauer, FIIDA – Richard + Bauer
Angela Fante, P.E., LEED AP – Ballinger

.

DUFFIELD ASSOCIATES

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A. PROJECT SUMMARY

PROPOSED CONSTRUCTION

Based on the information provided, as well as discussions with the project team (Richard + Bauer and Ballinger), we understand that it is proposed to construct a research facility with two separate building phases. The first phase will be located at the northern side of the site and will consist of a four-story building. The second phase will be a five-story building to the south of the Phase 1 building, with a bridged connection between the two structures. It is understood that the buildings will not contain basements (i.e., the finished floor will be constructed at grade). The buildings will be constructed of steel framing with concrete decks and will each have a roof penthouse for mechanical equipment. At the time of this report, building column loading information was not yet available. For analysis purposes, we have assumed maximum column loads on the order of 400 kips.

Duffield Associates, Inc. (Duffield Associates) originally performed a geotechnical evaluation for the site, as summarized in our report dated April 2012. Based on the subsurface conditions encountered at the site, in conjunction with the proposed building design and settlement tolerances, it appears that the use of a spread foundation system will not be feasible for the proposed structure, due to anticipated total and differential foundation settlement that exceed the allowable tolerances for the proposed construction. Duffield Associates has assisted the project team in evaluating several other foundation or ground improvement alternatives, including surcharging, compaction grouting, dynamic compaction, stone columns, and deep foundations. Based on the project site constraints and schedule, as well as a review of estimated construction costs, a drilled shaft foundation system, such as auger cast piles, appears to be the approach preferred by the project team. Additional field evaluation and analysis have been performed, as summarized further in this report, to address a drilled shaft foundation system approach. This report should be considered a supplement to the April 2012 Geotechnical Report.

REFERENCES UTILIZED FOR THIS EVALUATION

- A document titled “Scope of Geotechnical Services,” prepared by Ballinger, dated March 1, 2012, providing requested geotechnical services and information;

- A drawing titled “Topographic Survey,” prepared by Becker Morgan Group, dated February 9, 2012; and

- An electronic mail correspondence prepared by Ballinger, dated September 13, 2012, which listed items to be addressed in the supplemental geotechnical report.

EXISTING SITE CONDITIONS

The site of the proposed Applied Optical Research Building is located in the eastern portion of the Delaware State University campus, as indicated on the site location sketch attached with this report. The location of the proposed building is currently a relatively flat, grass-covered area occupied by three existing modular buildings on the northwest and southwest sides of the proposed building footprint. The aforementioned buildings and foundations are scheduled to be removed prior to the new building construction. For the purposes of analysis, it is assumed that only minor regrading (i.e., net cuts or fills of 2 feet or less) will be required in these areas. The site slopes gently downward toward the southwest, with grades varying from approximately elevation 30 feet to 26 feet. Several utilities, including electric, telephone, water, sanitary sewer, and storm sewer were identified by Miss Utility and Delaware State University representatives in the general vicinity of the proposed Applied Optical Research Building.

B. FIELD WORK AND LABORATORY TESTING RESULTS

STANDARD PENETRATION TEST BORINGS

On March 29, 2012, a total of five Standard Penetration Test borings (SPT, ASTM D 1586) were performed at the site within the footprint of the proposed building. Three of the test borings (TB-2, TB-3, and TB-4) were performed to depths of approximately 30 feet. The remaining two test borings (TB-1 and TB-5) were performed to depths of approximately 15 feet. Test boring locations were established and staked in the field by Duffield Associates' representatives utilizing existing site features as a reference prior to the start of this evaluation. The approximate locations of the test borings are indicated on the sketch included in Section G of this report.

On September 26 and 27, 2012, three additional test borings were performed at the site. The borings, designated as borings TB-2A, TB-3A, and TB-4A, were performed immediately adjacent to borings TB-2, TB-3, and TB-4, which were performed as part of the original evaluation in March 2012. The recent borings were extended to depths of 60 to 75 feet below grade. The initial 25 feet of each recent boring was augered (i.e., no sampling performed), since they were performed immediately adjacent to the original 30-foot deep borings. Boring logs that combine the shallow and deep subsurface information from each boring are included in Section G of this report.

Test borings were performed by CGC Geoservices, LLC, an affiliate company of Duffield Associates. A truck-mounted, Diedrich D-50 drill rig equipped with hollow stem augers was utilized for the SPT drilling. The subsurface conditions encountered during the performance of the test borings are described in logs included in this report. At the completion of drilling, the boreholes were backfilled with the soil cuttings and leveled off with the surrounding grade.

Further restoration of the borehole locations was beyond the scope of work performed for this geotechnical evaluation. However, additional settlement of the backfilled soil may occur, resulting in a depression or hole in the ground surface. Consequently, future maintenance and restoration of the site may be required.

GEOTECHNICAL LABORATORY TESTING

Following completion of the field program, soil samples, which were obtained from the SPT borings, were returned to Duffield Associates' laboratory for testing of selected samples. The laboratory testing program for this evaluation included the determination of natural water content (ASTM D 2216) and silt/clay content (percent finer than a No. 200 sieve, ASTM D 1140) for a total of five soil samples obtained during the field sampling program. The results of the laboratory testing are summarized in Table 1. No environmental testing or characterization was performed.

Table 1: Geotechnical Laboratory Testing

Location	Sample No.	Depth (Ft)	Moisture Content (%) ASTM D 2216	Percent Passing No. 200 Sieve (%) ASTM D 1140
TB-1	S-1	1.0 – 2.5	18.5	63.8
TB-2	S-5	13.5 – 15.0	25.4	18.5
TB-3	S-1	1.0 – 2.5	11.9	55.9
TB-3	S-5	13.5 – 15	30.8	23.9
TB-4	S-2	3.5 – 5.0	16.3	59.4

C. SUBSURFACE CONDITIONS

SITE GEOLOGY

The site of the proposed addition is located within the Atlantic Coastal Plain Physiographic Province. The Coastal Plain is a wedge-shaped accumulation of unconsolidated sediments deposited on a sloping shelf of Piedmont-type bedrock. Based on Delaware Geologic Survey (DGS) mapping, the depth to weathered bedrock in the general area of the site is estimated to be on the order of 3,000 feet.

SITE STRATIGRAPHY

A stratigraphic profile is included in Section G of this report. The site stratigraphy is further described in the table below:

STRATUM	APPROXIMATE THICKNESS (FT.)	GENERALIZED DESCRIPTION[1]
A[2]	0.3 – 0.6	TOPSOIL
B[3]	2.6 – 3	Apparent FILL: Gray, gray-brown, dark brown fine sand and graded aggregate, little silt, trace to some medium to coarse sand (dry to moist, medium to dense density)
C[4]	2.5 – 5.2	Gray, brown, orange SILT, and to little fine sand, little medium sand, trace coarse sand, trace gravel, trace organics (medium to very stiff consistency); USCS: ML
D[5]	4	Orange, gray CLAY, trace fine sand (stiff consistency); USCS: CL
E	22 – 30	Orange, light brown, gray fine SAND, some to trace silt, trace to little medium sand, trace coarse sand (medium to dense density); USCS: SM
E1	7 – 10 [6]	Orange-brown, light brown fine SAND, little to some silt, trace medium sand (very loose to loose density); USCS: SM
F [7]	10 - --	Dark brown/ gray SILT, little sand (soft to very stiff consistency); USCS: ML
G [8]	---	Brown/gray fine to medium SAND, some to and silt (medium dense); USCS: SM

NOTES:
1. The soil descriptions utilized herein and on the test boring logs are defined by the General Notes included in Section G.
2. Stratum A not encountered in test boring TB-2.
3. Stratum B only encountered in test borings TB-2 and TB-5.
4. Stratum C not encountered in test boring TB-5.
5. Stratum D only encountered in test boring TB-4.
6. Stratum E1 not fully penetrated in test borings TB-1 and TB-5
7. Stratum F not fully penetrated in test borings TB-2A and TB-4A.
8. Stratum G only encountered in test boring TB-3A, and not fully penetrated.

GROUNDWATER CONDITIONS

Groundwater was encountered in all of the test borings performed at depths ranging from approximately 8.0 to 13.4 feet below the existing ground surface, corresponding to an elevation range of approximately 15.6 to 22.0 feet.

Regional groundwater mapping by the Delaware Geological Survey (DGS) indicates typical groundwater levels at the site at approximately elevation 25 feet, which is slightly higher than the elevations observed during drilling at the site. These observations are consistent with the relatively low rainfall levels during the past spring and summer, suggesting groundwater levels deeper than average conditions. Groundwater levels at this site are likely to be regularly affected by seasonal and annual variations in precipitation. It is estimated that fluctuations in groundwater levels several feet higher than those noted by the DGS mapping could be experienced during extreme seasonal variations in precipitation.

D. DESIGN RECOMMENDATIONS

1. FOUNDATION APPROACH

Duffield Associates originally performed a geotechnical evaluation for the site, as summarized in our report dated April 2012. Based on the subsurface conditions encountered at the site in conjunction with the proposed building design and settlement tolerances, it appears that the use of a spread foundation system will not be feasible for the proposed structure due to anticipated total and differential foundation settlement that exceeds the allowable tolerances for the proposed construction.

Once it was determined that the spread footing approach resulted in settlement that exceeded the allowable tolerances, Duffield Associates assisted the project team in evaluating several other foundation or ground improvement alternatives, including surcharging, compaction grouting, dynamic compaction, stone columns, and deep foundations. Based on the project site constraints and schedule, as well as a review of estimated construction costs, a drilled shaft foundation system, such as auger cast piles, appears to be the approach preferred by the project team. Therefore, the remainder of this report focuses on the use of an auger cast pile foundation system for support of the proposed columns and ground supported slab-on-grade.

2. PILE CAPACITY

Static pile analysis was utilized to assess the compressive, uplift and lateral capacity of an auger cast pile system installed at the site. Based on the site stratigraphy, it is recommended that the pile terminate in the medium dense to dense granular soils observed at a depth of approximately 45 feet below grade in the borings, or in medium dense granular soils observed at a depth of 70 feet below grade. It is not recommended to bear the end of the pile in the medium to stiff consistency silt stratum (Stratum F), observed at a depth range of approximately 50 to 62 feet below grade.

The following is a summary of the estimated allowable pile capacity for various diameter piles. These allowable capacities are based on a factor of safety of 3, assuming that no load test will be performed to assess the installed pile capacity.

Pile Length (ft)	**Allowable Pile Compressive Capacity 14-inch Diameter Drilled Pier (tons)**			**Allowable Pile Compressive Capacity 16-inch Diameter Drilled Pier (tons)**		
	End Bearing	Skin Friction	Total	End Bearing	Skin Friction	Total
45	12	16	28	16	17	33
70	12	26	38	16	26	42

Pile uplift capacity was also reviewed. The following is the recommended uplift capacity per pile. These uplift capacities consider the weight of the pile in allowable uplift capacity. A factor of safety of 3 was utilized in this analysis.

Pile Length (ft)	**Allowable Uplift Capacity 14-inch diameter Drilled Pier (tons)**	**Allowable Uplift Capacity 16-inch diameter Drilled Pier (tons)**
45	13	15
70	20	23

It is understood that the piles will generally be installed in groupings of 2 to 6 piles. When piles are installed close to each other, it is typically assumed that there is some overlap of stresses transmitted to the soil, and this may reduce the load carrying capacity of the piles. Ideally, piles in a group should be spaced to minimize this overlap of loads. Analysis was performed to assess the potential group pile effect based on the site soils. Based on this analysis, a group efficiency factor of 0.8 is recommended if a center-to-center pile spacing of 3 times the pile diameter is utilized. This applies to both uplift and compressive capacity.

The lateral capacity of an individual pile was also reviewed. Anticipated lateral loads on a pile cap were not available at the time of this evaluation. For the lateral pile analysis, we utilized the computer program LPILE to assess the lateral deflection of a single pile under various lateral loads at the top of the pile. For this analysis, we assumed a pile cross section of either a 14 or 16-inch diameter auger cast pile, consisting of 4,000 psi concrete and a single No. 8 rebar in the center of the pile section. We also assumed a "free head" condition at the top of the pile. The following are the estimated loading conditions that resulted in a ¼ or ½-inch deflection, utilizing a factor of safety of 2.

Pile Diameter (in)	Lateral Load resulting in ¼-inch lateral deflection (tons)	Lateral Load resulting in ½-inch lateral deflection (tons)
14	1.25	1.5
16	1.5	2

3. PILE FOUNDATION SETTLEMENT

Estimates of foundation settlement were performed to assist in evaluating the effect of the proposed foundation loading and configuration on the subsurface conditions observed. Settlement of pile foundation will be caused by elastic shortening of the pile, as well as settlement of the pile caused by load transferred to the soil at the pile tip and along the length of the pile. For this analysis, 4,000 psi grout strength was assumed for the auger cast piles.

The following is the total estimated pile settlement for an individual pile loaded to the allowable compressive load capacity stated above:

Pile Length (ft)	Estimated Pile Settlement 14-inch diameter Drilled shaft (in)	Estimated Pile Settlement 16-inch diameter Drilled shaft (in)
45	0.7	0.8
70	0.8	0.9

If the piles are installed to a uniform depth and are loaded uniformly, differential settlement between adjacent piles and pile caps is estimated to be less than ¼-inch.

Since the proposed structure is to be constructed in phases, differential settlement between the phases of construction should be considered. The initial phase will have likely experienced total settlement under full structural loading conditions prior to the construction of the second building phase. As with any building addition, it will settle relative to the existing construction. The differential settlement should be considered in the design of the building and expansion jointing may be required to accommodate this differential settlement.

4. SLAB–ON-GRADE

It is understood that the structure will be designed with an auger-cast, pile-supported foundation system and ground-supported slab-on-grade. Ground-supported floor slabs should be designed as free floating and should not be connected to the structural elements (e.g., walls, framing, pile caps, etc.) of the buildings. Isolation joints should be utilized at the interface of proposed, ground-supported floor slab and pile caps to accommodate potential differential settlement. A minimum 10-mil polyethylene vapor barrier and free-draining subbase, consisting of at least 4 inches of poorly graded, crushed stone aggregate, such as AASHTO SP-57 stone, should be provided beneath all floor slabs. Subgrade conditions should be modeled for design, utilizing a subgrade modulus, K_S, of 150 pci, assuming the subgrade is prepared as described herein.

5. SEISMIC DESIGN PARAMETERS

Based on subsurface conditions encountered during the field exploration at the site and review of regional geologic maps, a “D” soil profile type, as defined by Table 1613.5.2 of the 2009 International Building Code, is recommended for design.

6. SITE GRADING

Site grading should be designed to provide positive drainage away from the proposed building areas. Positive site drainage should be maintained throughout the construction activities.

7. EXISTING SITE UTILITIES

Several utilities, including electric, telephone, water, sanitary sewer, and storm were identified by Miss Utility and Delaware State University representatives in the general vicinity of the proposed building. The depth and specific location of utilities is currently unknown. However, utilities will likely be encountered during pile installation or pile cap excavation, and the presence of the existing utilities must be considered in the foundation design.

For building areas bearing over utilities, the potential for undermining of the soils supporting the slab-on-grade due to failures in underlying utilities or the crushing of pipes from foundation loads must be considered. The least-risk solution to this situation is to relocate the existing utilities outside and away from the proposed building foundations. If this solution is not considered practical, the base of the foundation elevations should be lowered beneath the inverts for the existing utilities. Another alternative, which would not require utility relocation or deepening the foundations, would be to fully encase the existing utilities in concrete. However, with this latter alternative, there remains some risk that utility damage and/or foundation undermining could occur.

8. ASSUMPTIONS

Due to the limited structural information available, this evaluation has been based on assumptions regarding design loads and finished floor elevations for the proposed structure. These assumptions should be verified by the project team prior to the completion of their design. If the proposed loading conditions vary from those assumed herein, Duffield Associates should be notified to possibly modify the recommendations provided herein as required.

E. CONSTRUCTION RECOMMENDATIONS

1. PROOFROLL AND SUBGRADE PREPARATION

At the start of construction, the proposed building slab area should be stripped of all topsoil and concrete sidewalks. Several wooden plant boxes and small trees were observed to be in the general vicinity of the proposed structure. These should be removed in their entirety. It is also recommended that the existing building foundations be removed in their entirety and backfilled in accordance with the recommendations of this report.

Following rough grading and prior to pile cap excavation, placement of fill, or construction of the floor slab, it is recommended that the exposed subgrade be proofrolled. The proofroll should be performed using a minimum 10-ton vibratory roller or a fully-loaded tandem dump truck in the presence of a qualified soils technician working under the supervision of a geotechnical engineer. The purpose of the proofrolling is to densify the exposed subgrade and to identify yielding subgrade conditions. Yielding subgrade conditions encountered within the proposed building and pavement areas should be undercut to firm subgrade conditions and be backfilled in accordance with the recommendations of this report. Provisions for the undercutting and subsequent replacement of these materials should be anticipated by the construction contract documents and project budget estimates. The subgrade review should also confirm the consistency and texture of the exposed soils with the conditions encountered during this evaluation, as described herein.

2. AUGER CAST PILE REVIEW

The quality of auger cast piles is highly dependent on the construction method and appropriate construction quality control, including review of the placement of grout for the pile. Only contractors that can demonstrate at least five years of experience in the installation of auger cast pile for similar projects and subsurface conditions should be allowed to bid on this project. Further, prior to the start of construction, the pile contractor should submit proposed installation and construction quality control methods.

A qualified engineering technician should be on site during pile construction to review installation. The technician should maintain records of pile installation including depth of pile installation, penetration rate of auger, and quantity of grout utilized to fill the pile.

3. RE-USE OF ON-SITE SOILS AS STRUCTURAL FILL

On-site soils free of organic material, debris, and rock fragments, in excess of 3 inches in their largest dimension, may be suitable as structural fill. The shallow, predominately granular soils at the site were generally encountered with moisture contents at which the specified compaction could be achieved. The thin surficial layer of silty materials was encountered at a moisture content slightly above that at which compaction as structural fill could be obtained; therefore, some drying of these materials may be required in order to reuse them a structural fill.

If sufficient quantities of suitable on-site soils are not available for structural fill, imported borrow consisting of predominately granular soils conforming to the requirements of Delaware Department of Transportation Standard Specifications Borrow Type C (Backfill) should be utilized. AASHTO SP-57 stone could also be utilized as structural fill at locations, as recommended by the project engineer, and should be considered for localized, relatively deep fills such as foundation undercuts or utility trenches and as a base beneath the slabs.

4. COMPACTION REQUIREMENTS

Structural fill utilized within the proposed building slab area should be placed in loose lifts with a maximum thickness of 8 inches.

The following compaction requirements should be utilized for each lift of fill placed at the site:

- Structural fill placed within the building slab area should be compacted to at least 95% of the maximum dry density, as determined by the Modified Proctor test (ASTM D 1557).

- Structural fill for utility trenches and wall backfill, located outside of the proposed building, should be compacted to at least 90% of the maximum dry density as determined by the Modified Proctor test (ASTM D 1557).

The placement and compaction of structural fill should be monitored on a full-time basis by a qualified technician under the supervision of a geotechnical engineer.

5. PROTECTION OF SUBGRADE SOILS

Subgrade soils disturbed by precipitation and construction traffic should be either scarified and re-compacted, or undercut and replaced with structural fill as previously discussed. Subgrade disturbance could be reduced by maintaining positive surface drainage, by establishing and maintaining a sump throughout the construction period, and by limiting construction traffic on the exposed subgrade soils.

6. GROUNDWATER CONTROL

Groundwater was encountered at depths of approximately 8 to 13 feet below grade during the performance of the test borings. Although this groundwater depth is well below the anticipated excavation depth for pile caps, it is possible that shallow perched groundwater conditions could be encountered during foundation excavation. If "perched" groundwater is encountered, localized sumping may be required. It is recommended that wherever groundwater is encountered during shallow foundation or utility excavations, the resulting excavation should be over-excavated by at least 4 inches and replaced with AASHTO SP-57 stone to protect the exposed subgrade soils and to facilitate sumping.

7. EXCAVATION SAFETY

All foundation and utility excavation should be performed in accordance with OSHA guidelines. Typically, sand soils can be characterized by OSHA CFR Part 1926 Excavation Standards as Type C soils. Should it be required, all temporary sheeting and shoring should be designed by a qualified engineer registered in the State of Delaware.

8. CONSTRUCTION REVIEW

It is recommended that the project budget include provisions for the cost for independent construction monitoring of the earthwork and foundation construction by a qualified engineering firm retained by the owner to review conformance of construction with the recommendations of the project geotechnical evaluation, and the project plans and specifications.

F. LEED 2009 RECOMMENDATIONS

Duffield Associates is a participating member of the U.S. Green Building Council and has been a leader in innovative and sustainable site design, storm and wastewater management, and conservation since our inception more than 30 years ago. As part of our continued efforts to be environmentally responsible, Duffield Associates provides this list of New Construction and Major Renovations recommendations for the design team to consider. If requested, we can assist in developing these items.

Energy and Atmosphere

Credit 2 – On-site Renewable Energy

- Assist in the evaluation and design of geothermal heating/cooling systems.

Materials and Resources

Credit 5 – Regional Materials

- Identify local borrow pits to reduce environmental effects and reduce construction costs.

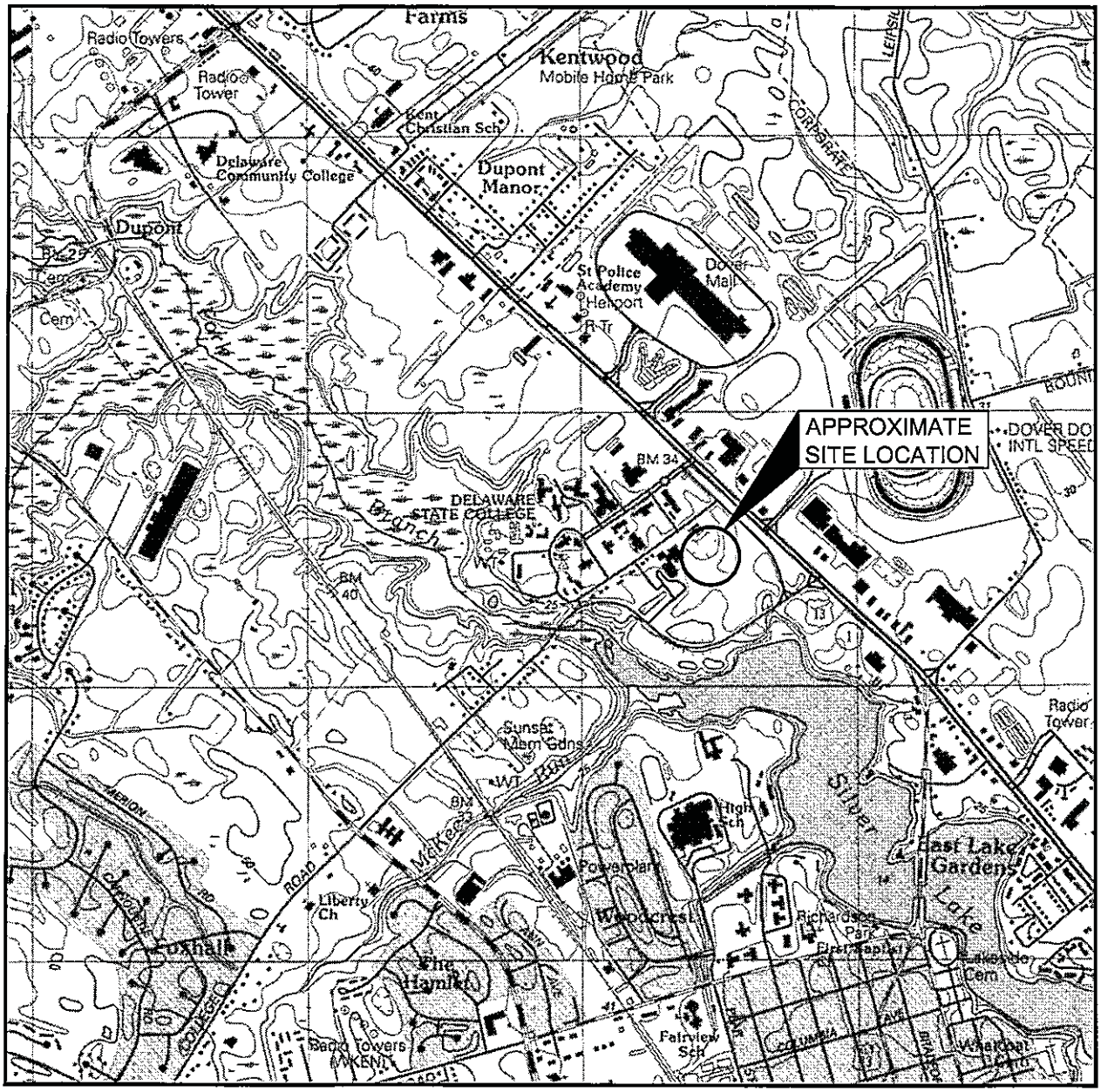
Innovation and Design Process

Credit 2 – LEED Accredited Professional

- Provide LEED Accredited Professionals with project experience and knowledge of the LEED rating system.

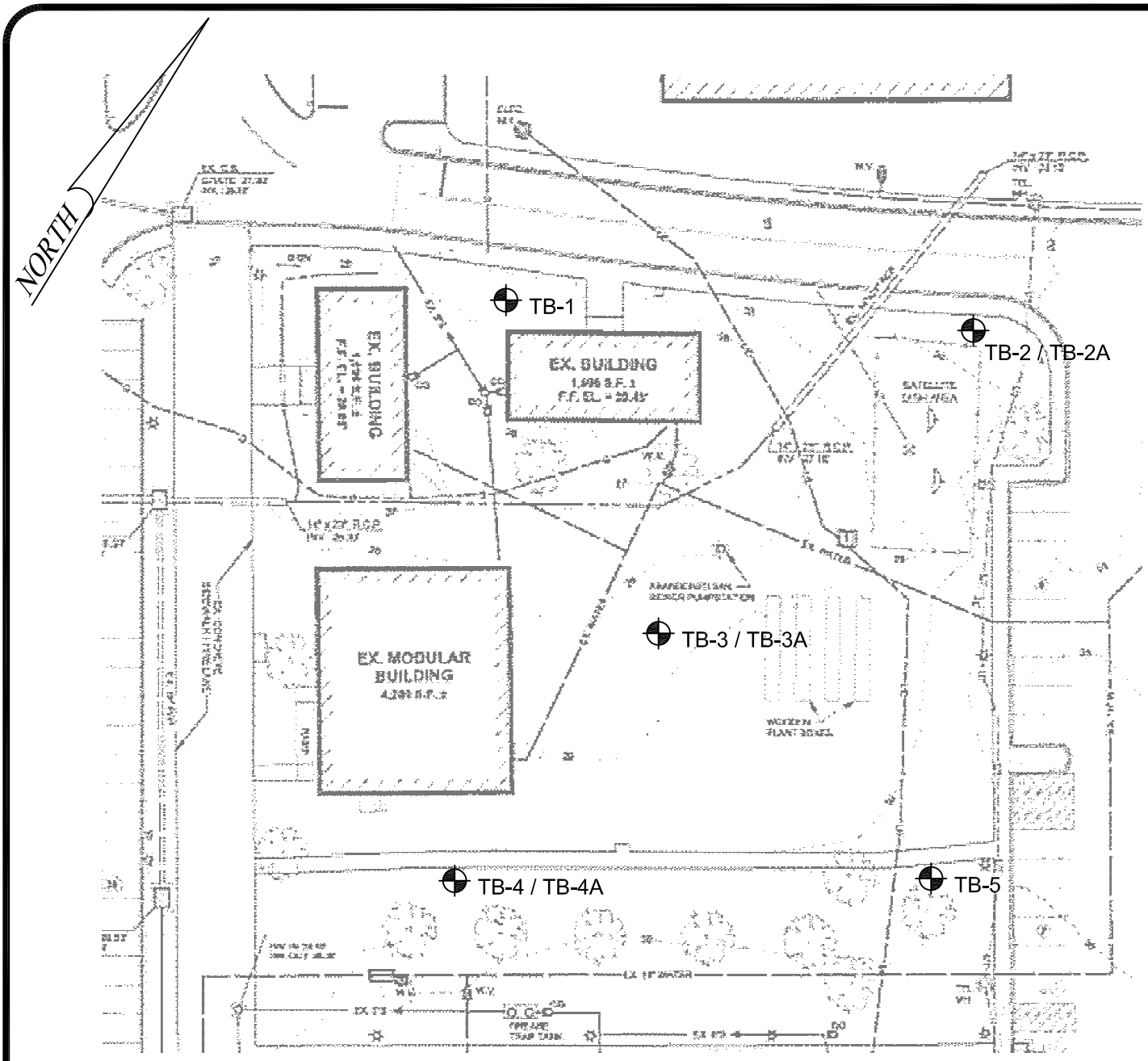
G. SKETCHES AND LOGS

- **SITE LOCATION SKETCH**
- **TEST BORING LOCATION SKETCH**
- **TEST BORING LOGS (4)**
- **STRATIGRAPHIC PROFILE**
- **GENERAL NOTES**



NOTE:
THIS LOCATION SKETCH IS ADAPTED FROM THE U.S.G.S. TOPOGRAPHIC MAP, 7.5 MINUTE SERIES, FOR DOVER, DELAWARE, 1993.

DATE: 18 APRIL 2012	SITE LOCATION SKETCH	DESIGNED BY: SBZ	DUFFIELD ASSOCIATES
SCALE: 1"=2000'	DELAWARE STATE UNIVERSITY APPLIED OPTICAL RESEARCH BUILDING	DRAWN BY: ARS	5400 LIMESTONE ROAD WILMINGTON, DE 19808-1232 TEL: (302)239-6634 FAX (302)239-8485
PROJECT NO. 2484.GQ		CHECKED BY: SBZ	OFFICES IN DELAWARE, MARYLAND PENNSYLVANIA AND NEW JERSEY
SHEET: FIGURE 1	DOVER ~ KENT COUNTY ~ DELAWARE	FILE: A-2484GQ-01	E-MAIL: DUFFIELD@DUFFNET.COM



KEY:

TB-1 - APPROXIMATE LOCATION OF TEST BORING

NOTE:
THIS SKETCH IS ADAPTED FROM A DRAWING TITLED "TOPOGRAPHIC SURVEY," PREPARED BY BECKER MORGAN GROUP, DATED FEBRUARY 9, 2012.

DATE: 01 OCTOBER 2012	TEST BORING LOCATION SKETCH	DESIGNED BY: SBZ	DUFFIELD ASSOCIATES
SCALE: 1"=50'	**DELAWARE STATE UNIVERSITY APPLIED OPTICAL RESEARCH BUILDING**	DRAWN BY: ARS	5400 LIMESTONE ROAD WILMINGTON, DE 19808-1232 TEL. (302)239-6634 FAX (302)239-8485
PROJECT. NO. 2484.GQ		CHECKED BY: SBZ	OFFICES IN DELAWARE, MARYLAND PENNSYLVANIA AND NEW JERSEY
SHEET: FIGURE 2	DOVER ~ KENT COUNTY ~ DELAWARE	FILE: A-2484GQ-02	E-MAIL: DUFFIELD@DUFFNET.COM

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Consultants in the Geosciences

TEST BORING TB-1

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

Date Started	: March 29, 2012	Drilling Equipment	: Truck-Mounted Diedrich D-50
Date Completed	: March 29, 2012	Drilling Methods	: HSA (SPT, ASTM D 1586)
Logged by	: CGCG		
Weather	: Clear, 60s		
Driller/Agency	: Wayne Proud/CGCG		

Sample Condition: Remolded
Water Levels: During Drilling

Depth in feet	Layer Depth feet	GRAPHIC	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
0	0.6			TOPSOIL (± 7 inches)							
			ML	Gray, brown SILT and fine SAND, little medium sand, trace coarse sand, trace organics (dry to moist)	☒	S-1	3-4-3	1.4	18.5	63.8	
	3.0		ML	Gray, orange, brown SILT, trace to little fine sand (slightly mottled) (moist)	☒	S-2	5-9-14	0.9			
5	5.5		SM	Orange, gray-brown fine SAND, little silt, trace medium sand (wet)	☒	S-3	5-4-5	1.3			▼
10			SM	Orange, gray-brown fine SAND, little silt, trace medium to coarse sand (wet)	☒	S-4	3-3-2	0.8			
	12.0		SM	Orange, gray fine SAND, some silt (wet)	☒	S-5	3-2-3	1.5			
15	15.0										
20											
25											
30											
35											
40											

NOTES:
1. Test boring terminated ± 15.0 feet below existing ground surface (b.e.g.s.).
2. Wet-on-spoon observed at ± 7.5 feet b.e.g.s. with augers at ± 8.5 feet b.e.g.s.
3. Water level observed at ± 8.0 feet b.e.g.s. with augers at ± 8.5 feet b.e.g.s.
4. Borehole caved at ± 9.3 feet b.e.g.s. with water level observed at ± 6.8 feet b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled with soil cuttings.
6. Soil descriptions performed in accordance with ASTM D 2488, the Practice for Description and Identification of Soils (Visual-Manual Procedure).

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TEST BORING TB-2/2A

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

Date Started	: March 29, 2012	Drilling Equipment	: Truck-Mounted Diedrich D-50
Date Completed	: September 27, 2012	Drilling Methods	: HSA (SPT, ASTM D 1586)
Logged by	: CGCG/GSB	Surface Elevation	: 28 feet
Weather	: Clear, 60s & Cloudy, 60s	Northing	: 0
Driller/Agency	: Wayne Proud/CGCG	Easting	: 0

Sample Condition: Remolded
Water Levels: ▼ During Drilling

Depth in feet	Surf. Elev. 28 ft	GRAPHIC	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
0				Apparent FILL: Dark brown, orange, gray-brown fine sand, little to some medium to coarse sand, little silt, trace gravel (dry to moist)	☒	S-1	8-16-5	0.9			
	25		ML	Gray, dark gray, orange SILT, some to and fine sand, trace medium sand (moist)	☒	S-2	2-3-3	1.5			
5			SM	Orange-brown, gray fine SAND, some silty, trace medium to coarse sand (moist)	☒	S-3	6-8-9	1.3			
	20			Orange-brown, light brown fine SAND, little to some silt (moist to wet)	☒	S-4	4-4-5	1.5			
10			SM								▼
	15			Orange-brown, light brown fine SAND, little silt, trace coarse to medium sand (moist to wet)	☒	S-5	1-1-2	1.5	25.4	18.5	
15											
	10			Orange, orange-brown fine SAND, little to some silt (wet)	☒	S-6	3-3-6	1.0			
20											
	5			Orange-brown, orange, gray-brown fine SAND, little silt, trace medium sand (wet)	☒	S-7	4-5-5	0.9			
25											
	0		SM	Orange, red-orange fine SAND, little silt, trace medium sand (wet)	☒	S-8	5-8-10	1.0			
30											
	-5			Orange-red fine to medium SAND, little silt, trace coarse sand (wet)	☒	S-9	6-5-5	1.0			
35											
	-10			Light brown, orange-brown, gray-brown fine to medium SAND, little silt (wet)	☒	S-10	4-3-4	0.7			
40											

NOTES:
1. TB-2 terminated ± 30.0 ft on 03/29/12. TB-2A performed within 2 ft of TB-2 and terminated at a depth of ± 60.5 ft on 09/27/12 (b.e.g.s.).
2. Wet-on-rods observed at ± 11.8 ft b.e.g.s. during TB-2 w/augers at ± 13.5 ft b.e.g.s.
3. Water level observed at ± 11.7 ft b.e.g.s. during TB-2 w/augers at ± 13.5 ft b.e.g.s.
4. Borehole caved at ± 12.1 ft b.e.g.s. during TB-2 w/water level observed at ± 10.9 ft b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled w/soil cuttings during TB-2 and TB-2A.
6. Rods dropped from 58.5 ft to 59.5 ft and borehole caved (dry) at ± 10.33 ft during TB-2A.

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Consultants in the Geosciences

TEST BORING TB-2/2A

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

Date Started	: March 29, 2012	Drilling Equipment	: Truck-Mounted Diedrich D-50
Date Completed	: September 27, 2012	Drilling Methods	: HSA (SPT, ASTM D 1586)
Logged by	: CGCG/GSB	Surface Elevation	: 28 feet
Weather	: Clear, 60s & Cloudy, 60s	Northing	: 0
Driller/Agency	: Wayne Proud/CGCG	Easting	: 0

Sample Condition: Remolded
Water Levels: During Drilling

Depth in feet	Surf. Elev. 28 ft	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
40		SM								
	-15	SM	Light brown fine to medium SAND, trace coarse sand (wet)	☒	S-11	7-15-27	1.2			
45										
	-20		Light gray fine to medium SAND (wet)	☒	S-12	38-50/6"	1.0			
50										
	-25	ML	Dark brown SILT, few gray fine sand laminations throughout	☒	S-13	4-4-5	1.5			
55										
	-30		Dark gray SILT, few gray fine sand laminations throughout	☒	S-14	WOR	0.8			
60			Dark gray SILT, few gray fine sand laminations throughout	☒	S-15	2-3-5	1.2			
	-35									
65										
	-40									
70										
	-45									
75										
	-50									
80										

NOTES:
1. TB-2 terminated ± 30.0 ft on 03/29/12. TB-2A performed within 2 ft of TB-2 and terminated at a depth of ± 60.5 ft on 09/27/12 (b.e.g.s.).
2. Wet-on-rods observed at ± 11.8 ft b.e.g.s. during TB-2 w/augers at ± 13.5 ft b.e.g.s.
3. Water level observed at ± 11.7 ft b.e.g.s. during TB-2 w/augers at ± 13.5 ft b.e.g.s.
4. Borehole caved at ± 12.1 ft b.e.g.s. during TB-2 w/water level observed at ± 10.9 ft b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled w/soil cuttings during TB-2 and TB-2A.
6. Rods dropped from 58.5 ft to 59.5 ft and borehole caved (dry) at ± 10.33 ft during TB-2A.

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TEST BORING TB-3/3A

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

Date Started	: March 29, 2012	Drilling Equipment	: Truck-Mounted Diedrich D-50
Date Completed	: September 27, 2012	Drilling Methods	: HSA (SPT, ASTM D 1586)
Logged by	: CGCG/GSB	Surface Elevation	: 28 feet
Weather	: Clear, 70s, & Cloudy 60s	Northing	: 0
Driller/Agency	: Wayne Proud/CGCG	Easting	: 105

Sample Condition: Remolded
Water Levels: During Drilling

Depth in feet	Surf. Elev. 28 ft	GRAPHIC	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
0				TOPSOIL (± 4 inches)							
	25		ML	Dark brown, brown, gray SILT and fine SAND, little medium sand, trace coarse sand, trace gravel, trace organics (dry to moist)	☒	S-1	7-10-11	1.3	11.9	55.9	
5			ML	Gray, orange-brown SILT, some fine sand (slightly mottled) (moist)	☒	S-2	4-5-9	1.5			
	20		SM	Light brown fine SAND, trace silt, trace medium sand (moist)	☒	S-3	7-8-7	1.3			
10				Light brown fine SAND, trace silt, trace medium sand (moist)	☒	S-4	2-4-2	1.0			
	15		SM	Light brown fine SAND, some silt (moist to wet)	☒	S-5	1-1-2	1.5	30.8	23.9	▼
15											
	10			Light brown fine SAND, little silt (wet)	☒	S-6	2-2-4	1.3			
20											
	5		SM	Orange-brown, red-orange fine SAND, little silt, trace medium sand (wet)	☒	S-7	5-8-7	1.1			
25											
	0			Orange-brown, red-orange fine SAND, little silt, trace medium sand (wet)	☒	S-8	13-14-14	0.7			
30											
	-5		SM	Light orange-brown fine to medium SAND, trace coarse sand, trace silt (wet)	☒	S-9	12-18-21	1.4			
35											
	-10		SM	Dark brown, orange-brown fine to medium SAND, trace silt (wet)	☒	S-10A S-10B	5-4-4	1.5			
40											

NOTES:
1. TB-3 terminated ± 30.0 ft b.e.g.s. on 03/29/12. TB-3A performed within 2 ft of TB-3 and terminated at a depth of ± 75.0 ft b.e.g.s. on 09/27/12.
2. Wet-on-spoon observed at ± 13.3 ft b.e.g.s. during TB-3 w/augers at ± 13.5 ft b.e.g.s.
3. Water level observed at ± 13.4 ft b.e.g.s. during TB-3 w/augers at ± 13.5 ft b.e.g.s.
4. Borehole caved at ± 12.0 ft b.e.g.s. during TB-3 w/water level observed at ± 9.4 ft b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled w/soil cuttings during TB-3 and TB-3A.
6. During TB-3A drilled auger to 28.5 ft then switched to mud rotary.
7. Upon completion, TB-3A caved (dry) at 3.9 ft .

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TEST BORING TB-3/3A

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

Date Started	: March 29, 2012	Drilling Equipment	: Truck-Mounted Diedrich D-50
Date Completed	: September 27, 2012	Drilling Methods	: HSA (SPT, ASTM D 1586)
Logged by	: CGCG/GSB	Surface Elevation	: 28 feet
Weather	: Clear, 70s, & Cloudy 60s	Northing	: 0
Driller/Agency	: Wayne Proud/CGCG	Easting	: 105

Sample Condition: Remolded
Water Levels: During Drilling

Depth in feet	Surf. Elev. 28 ft	GRAPHIC	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
40			SM	Dark brown, orange-brown fine to medium SAND, little silt, trace coarse sand (wet)							
	-15		SM	Light brown-orange fine to medium SAND, trace silt, trae coarse sand (wet)	☒	S-11	15-21-20	1.0			
45											
	-20			Light brown fine to medium SAND, trace silt, trace coarse sand (wet) Gray, brown fine to medium SAND, trace silt (brown silt lens @ 49.1 feet, 1/2" thick)	☒	S-12A S-12B	13-50/4"	0.9			
50											
	-25		ML	Dark brown, gray SILT, trace fine to medium sand (53.7 feet to 53.8 feet gray sand lens) (wet) Dark gray fine to medium SAND, little coarse sand, trace silt (wet) Brown-gray SILT, little to trace fine sand (wet)	☒	S-13A S-13B S-13C	4-7-5	1.4			
55											
	-30			Brown, gray SILT, trace to little fine sand (wet)	☒	S-14	4-6-8	1.5			
60											
	-35		SM	Gray-brown, brown SILT & fine SAND, trace medium sand (wet)	☒	S-15	6-9-10	1.5			
65											
	-40			Brown-gray fine SAND, some silt, little to trace medium sand (wet)	☒	S-16	4-4-6	1.5			
70											
	-45			Gray-green fine SAND, little silt, trace amount shell hash (wet)	☒	S-17	8-11-13	1.2			
75											
	-50										
80											

NOTES:
1. TB-3 terminated ± 30.0 ft b.e.g.s. on 03/29/12. TB-3A performed within 2 ft of TB-3 and terminated at a depth of ± 75.0 ft b.e.g.s. on 09/27/12.
2. Wet-on-spoon observed at ± 13.3 ft b.e.g.s. during TB-3 w/augers at ± 13.5 ft b.e.g.s.
3. Water level observed at ± 13.4 ft b.e.g.s. during TB-3 w/augers at ± 13.5 ft b.e.g.s.
4. Borehole caved at ± 12.0 ft b.e.g.s. during TB-3 w/water level observed at ± 9.4 ft b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled w/soil cuttings during TB-3 and TB-3A.
6. During TB-3A drilled auger to 28.5 ft then switched to mud rotary.
7. Upon completion, TB-3A caved (dry) at 3.9 ft .

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TEST BORING TB-4/4A

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

Date Started	: March 29, 2012	Drilling Equipment	: Truck-Mounted Diedrich D-50
Date Completed	: September 26, 2012	Drilling Methods	: HSA (SPT, ASTM D 1586)
Logged by	: CGCG/GSB	Surface Elevation	: 28 feet
Weather	: Clear, 60s	Northing	: 0
Driller/Agency	: Wayne Proud/CGCG	Easting	: 245

Sample Condition: Remolded
Water Levels: During Drilling

Depth in feet	Surf. Elev. 28 ft	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
0			TOPSOIL (± 5 inches)							
	25	ML	Brown SILT, little to some fine sand, trace organics (moist)	X	S-1	7-7-7	1.5			
5		ML	Brown, gray SILT and fine SAND, little medium sand, trace coarse sand, trace gravel (moist)	X	S-2	2-2-3	1.5	16.3	59.4	
	20	SM	Orange-brown fine SAND, trace silt, trace medium sand (moist)	X	S-3	5-10-11	1.3			
10		CL	Orange, gray CLAY, trace fine sand (slightly mottled)	X	S-4	3-4-6	1.5			
	15									▼
15		SM	Orange, gray fine SAND, little to some silt (moist to wet)	X	S-5	2-4-3	1.4			
	10									
20		SM	Orange, gray fine SAND, little silt, trace medium sand (wet)	X	S-6	2-1-3	1.1			
	5									
25		SM	Orange, gray fine SAND, little silt, trace medium sand (wet)	X	S-7	3-6-6	1.2			
	0									
30		SM	Orange fine SAND, little medium sand, trace silt (wet)	X	S-8	15-16-18	1.0			
	-5									
35		SM	Orange-brown fine to medium SAND, trace coarse sand (wet)	X	S-9	17-18-20	1.1			
	-10									
40		SM	Dark orange-brown fine to medium SAND, trace gravel, trace coarse sand, trace silt (wet)	X	S-10	13-16-20	0.9			

NOTES:
1. TB-4 terminated ± 30.0 ft b.e.g.s. on 03/29/12. TB-4A performed within 2 ft of TB-4 and terminated at a depth of ± 60.0 ft b.e.g.s. on 09/27/12.
2. Wet-on-spoon observed at ± 18.0 ft b.e.g.s. during TB-4 w/augers at ± 18.5 ft b.e.g.s.
3. Water level observed at ± 13.0 ft b.e.g.s. during TB-4 w/augers at ± 18.5 ft b.e.g.s.
4. Borehole caved at ± 14.3 ft b.e.g.s. during TB-4 w/water level observed at ± 11.6 ft b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled w/soil cuttings during TB-4.
6. TB-4A augured to 28.5 ft and switched to mud rotary at 18.5 ft.
7. Upon completion, TB-4A caved (dry) at 7.3 ft and backfilled w/cuttings.

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Consultants in the Geosciences

TEST BORING TB-4/4A

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

Date Started	: March 29, 2012	Drilling Equipment	: Truck-Mounted Diedrich D-50
Date Completed	: September 26, 2012	Drilling Methods	: HSA (SPT, ASTM D 1586)
Logged by	: CGCG/GSB	Surface Elevation	: 28 feet
Weather	: Clear, 60s	Northing	: 0
Driller/Agency	: Wayne Proud/CGCG	Easting	: 245

Sample Condition: Remolded
Water Levels: During Drilling

Depth in feet	Surf. Elev. 28 ft	GRAPHIC	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
40											
	-15		SM	Orange-brown fine to medium SAND, trace gravel, trace coarse sand, trace silt (wet)	☒	S-11	11-12-12	0.8			
45											
	-20			Light brown fine to coarse SAND, trace silt (wet) Dark gray fine to medium SAND, trace coarse sand, trace silt (wet)	☒	S-12A S-12B	11-16-18	1.0			
50											
	-25		ML	Dark gray-brown, dark gray SILT, trace fine sand (53.9 feet to 54.0 feet dark gray fine to medium sand lens and sand lens 54.6 feet to 54.7 feet)	☒	S-13	7-5-8	1.4			
55											
	-30			Dark gray-brown, gray SILT, with moderate fine laminations of gray silt & fine sand throughout (2 jars)	☒	S-14	7-9-12	1.5			
60											
	-35										
65											
	-40										
70											
	-45										
75											
	-50										
80											

NOTES:
1. TB-4 terminated ± 30.0 ft b.e.g.s. on 03/29/12. TB-4A performed within 2 ft of TB-4 and terminated at a depth of ± 60.0 ft b.e.g.s. on 09/27/12.
2. Wet-on-spoon observed at ± 18.0 ft b.e.g.s. during TB-4 w/augers at ± 18.5 ft b.e.g.s.
3. Water level observed at ± 13.0 ft b.e.g.s. during TB-4 w/augers at ± 18.5 ft b.e.g.s.
4. Borehole caved at ± 14.3 ft b.e.g.s. during TB-4 w/water level observed at ± 11.6 ft b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled w/soil cuttings during TB-4.
6. TB-4A augured to 28.5 ft and switched to mud rotary at 18.5 ft.
7. Upon completion, TB-4A caved (dry) at 7.3 ft and backfilled w/cuttings.

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DUFFIELD ASSOCIATES
Consultants in the Geosciences

TEST BORING TB-5

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

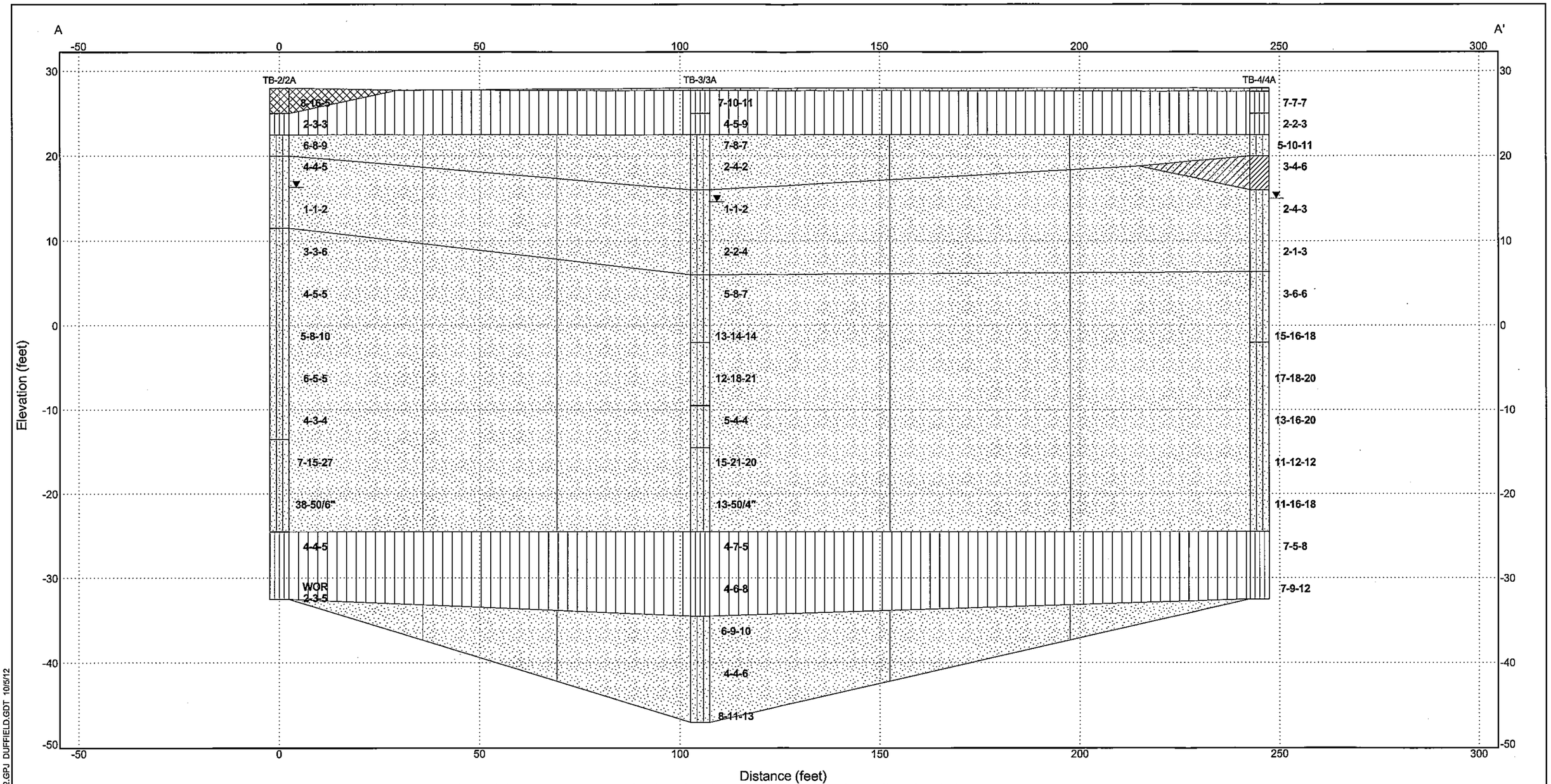
Date Started	: March 29, 2012	Drilling Equipment	: Truck-Mounted Diedrich D-50
Date Completed	: March 29, 2012	Drilling Methods	: HSA (SPT, ASTM D 1586)
Logged by	: CGCG		
Weather	: Clear, 60s		
Driller/Agency	: Wayne Proud/CGCG		

Sample Condition: Remolded
Water Levels: During Drilling

Depth in feet	Layer Depth feet	GRAPHIC	USCS	DESCRIPTION	SAMPLES	Sample Number	Blows per 6 inches	Recovery (ft)	Moisture Content (%)	Percent Passing 200 Sieve	WATER LEVEL
0	0.4			TOPSOIL (± 5 inches)							
				Apparent FILL: Gray, gray-brown graded aggregate, little silt, trace fine to medium sand	☒	S-1	19-22-16	0.9			
	3.0		SM	Dark brown fine SAND, little silt (dry to moist)	☒	S-2	9-10-10	0.6			
5	5.5			Light gray, orange fine SAND, some silt, trace medium to coarse sand, trace gravel (moist)	☒	S-3	4-4-7	1.3			
			SM	Light brown, orange-brown, gray fine SAND, trace silt, trace medium sand (moist)	☒	S-4	6-7-7	1.4			
10	12.0										▼
			SM	Orange, gray fine SAND, little to some silt (wet)	☒	S-5	2-2-4	1.5			
15	15.0										
20											
25											
30											
35											
40											

NOTES:
1. Test boring terminated ± 15.0 feet below existing ground surface (b.e.g.s.).
2. Wet-on-spoon observed at ± 13.4 feet b.e.g.s. with augers at ± 13.5 feet b.e.g.s.
3. Water level observed at ± 13.1 feet b.e.g.s. with augers at ± 13.5 feet b.e.g.s.
4. Borehole caved and dry at ± 7.9 feet b.e.g.s. upon removal of augers.
5. Upon completion, borehole backfilled with soil cuttings.
6. Soil descriptions performed in accordance with ASTM D 2488, the Practice for Description and Identification of Soils (Visual-Manual Procedure).

TBLOGPASSIM% 2484GQ WITH SEPT 2012.GPJ DUFFIELD.GDT 10/17/12



Note: This stratigraphic profile is based on a "straight line interpolation" between the test borings. Actual conditions between the test borings, may (and probably do) vary.

DUFFIELD ASSOCIATES
Consultants in the Geosciences

LEGEND

LITHOLOGY

- FILL
- TOPSOIL
- SILT (ML)
- CLAY (CL)
- SILTY SAND (SM)

Water Levels

- Minimum Water Level

STRATIGRAPHIC PROFILE

Geotechnical Evaluation
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware
Project No. 2484.GQ

SECTION11X17 2484GQ WITH SEPT 2012.GPJ DUFFIELD.GDT 10/5/12

GENERAL NOTES

DUFFIELD ASSOCIATES uses the following definitions and terminology to classify and correlate the field and laboratory samples.

VISUAL UNIFIED CLASSIFICATIONS: The soil samples are described by color, major constituent, modifiers (by percentage), and density (or consistency). Coarse Grained or Granular Soils have more than 50% of their dry weight retained on a No. 200 sieve; they are described as: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a No. 200 sieve; they are described as: clays or clayey silts if they are cohesive and silts if they are noncohesive. In addition to gradation, granular soils are defined on the basis of their relative in-place density and fine grained soils on the basis of their strength or consistency and their plasticity.

The Unified Soil Classification symbols are:

COARSE GRAINED SOILS

GW - Well graded gravels
GP - Poorly graded gravels
GM - Silty gravels
GC - Clayey gravels
SW - Well graded sands
SP - Poorly graded sands
SM - Silty sands
SC - Clayey sands

FINE GRAINED SOILS

ML - Silts of low plasticity
CL - Clays of low to medium plasticity
OL - Organic silt clays of low plasticity
MH - Silts of high plasticity
CH - Clays of high plasticity
OH - Organic silt clays of high plasticity
PT - Peat and highly organic soils

SIZE DESCRIPTION

F - Fine
M - Medium
C - Coarse
G - Gravel

MODIFIERS (PERCENTAGE)

Tr -	Trace	1 - 10%
Ltl -	Little	11 - 20%
Some		21 - 35%
& -	And	36 - 50%

COLOR

Or - Orange
Yel - Yellow
Br - Brown
Blk - Black
Gr - Gray
R - Red
Vc - Varicolored
Dk - Dark
Lt - Light

DENSITY: COARSE GRAINED SOILS

Very loose	4 blows/ft or less
Loose	5 to 10 blows/ft
Medium	11 to 30 blows/ft
Dense	31 to 50 blows/ft
Very Dense	51 blows/ft or more

CONSISTENCY: FINE GRAINED SOILS

Very soft	2 blows/ft or less
Soft	3 to 4 blows/ft
Medium	5 to 8 blows/ft
Stiff	9 to 15 blows/ft
Very stiff	16 to 30 blows/ft
Hard	31 blows/ft or more

NOTE: The Standard Penetration Test "N" value is the number of blows per foot of a 140 pound hammer falling 30 inches on a 2 inch O.D. split spoon sampler, except where otherwise noted.

APPENDIX 3

Preliminary Vibration Analysis of Floor Framing
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Dated: November 7, 2012

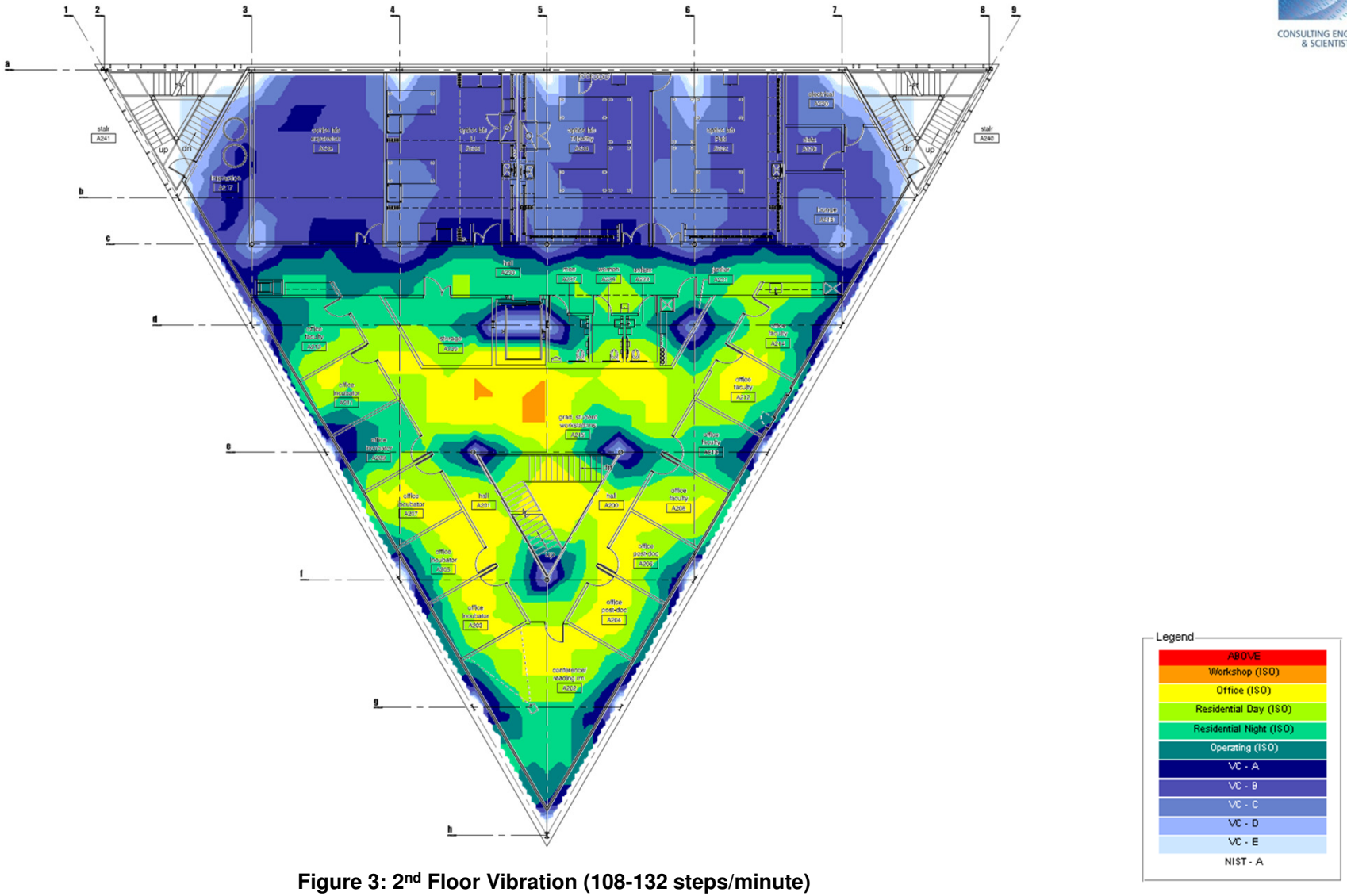

Figure 3: 2nd Floor Vibration (108-132 steps/minute) (October 29, 2012 Properties) – Mitigation 2

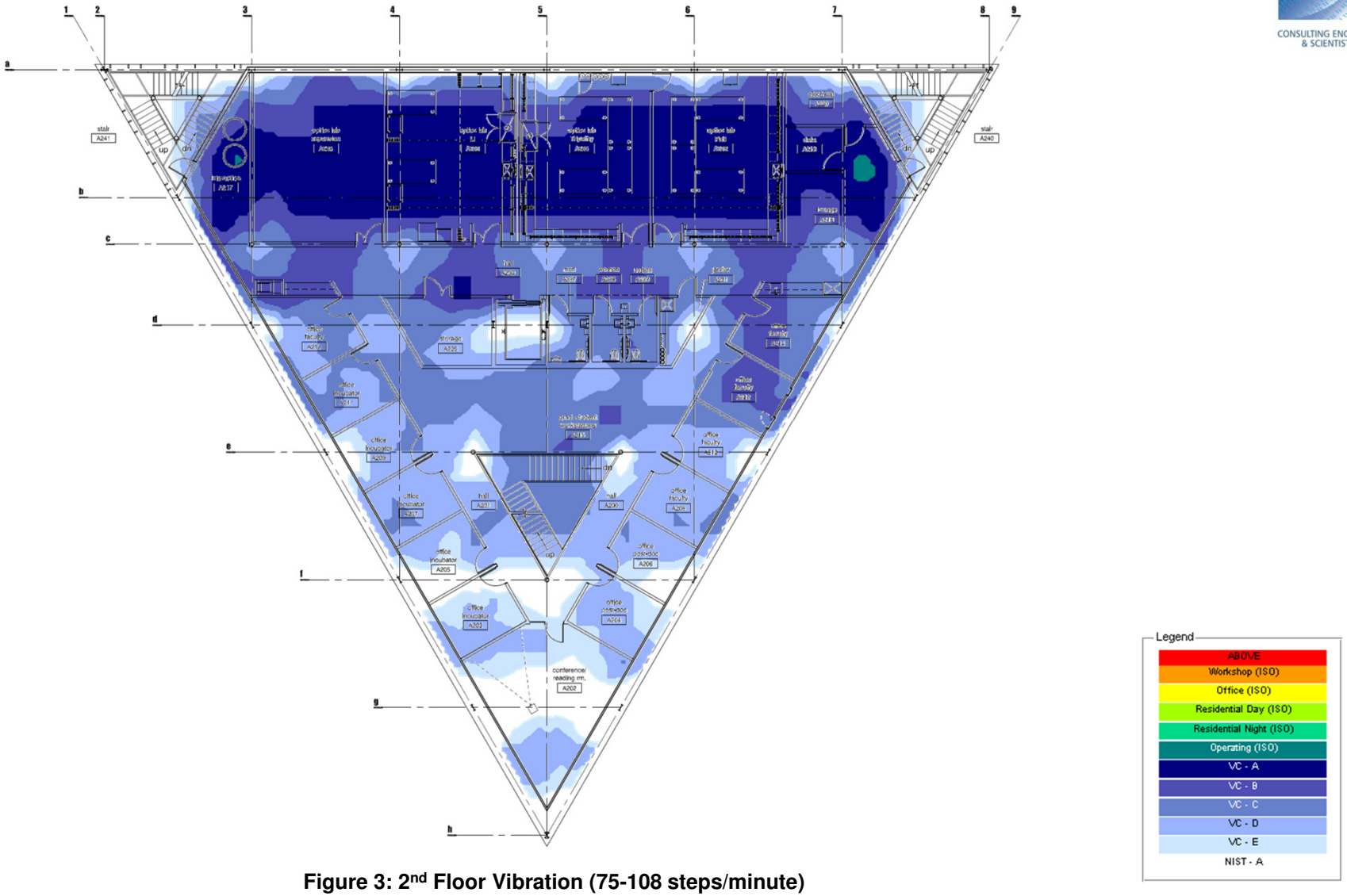

Figure 3: 2nd Floor Vibration (75-108 steps/minute) (October 29, 2012 Properties) – Mitigation 2

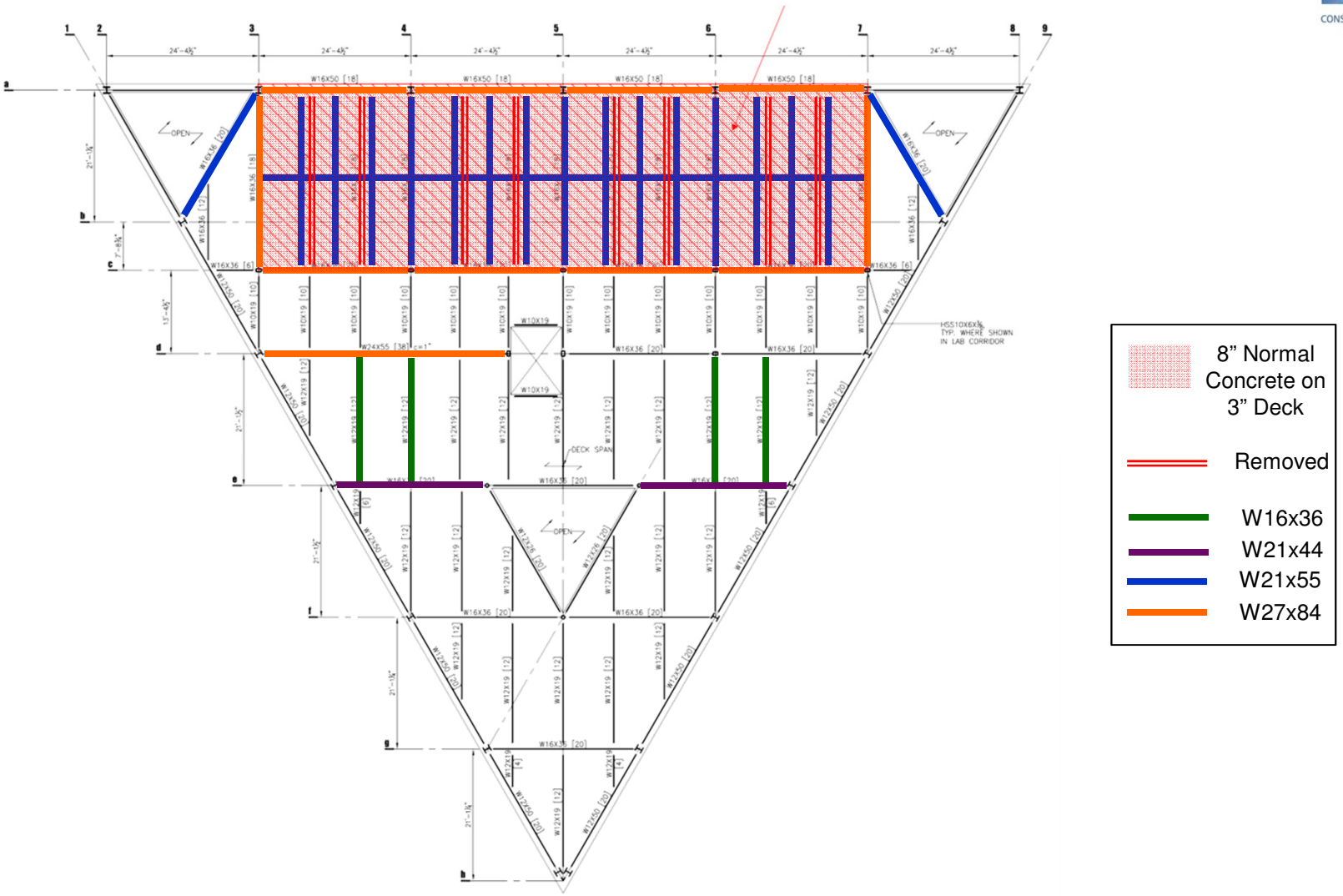

Figure 4 – 2nd Floor Mitigation 2 Scheme

Appendix A: Overview of Vibration Criteria

Over the past 25 years, generic vibration limits have been developed, which provide frequency dependent sensitivities for wide classes building occupancies. The vibration criterion (VC) curves that have been developed are internationally accepted as a basis for designing and evaluating the performance of vibration sensitive areas and the structures that support them. Figure A1 shows the vibration criterion curves, which range between ISO Workshop (least stringent) through VC-G (most stringent).

These curves are based on the ISO 2631-2 (1989) base curve for human response to whole body vibration, which is the threshold of human perception, but have since evolved somewhat. The ISO base curve is often referred to as the ISO-Operating Room criteria, and is less stringent than the VC-A curve. See Table A1 and Figure A1 for descriptions and plots of the commonly referred to ISO curves.

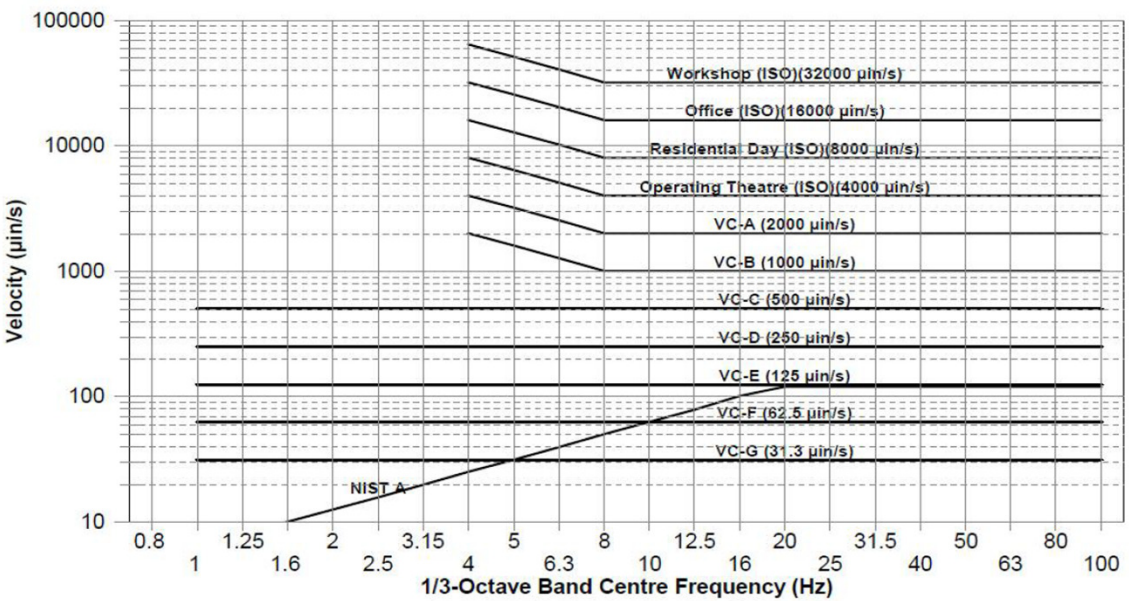

Figure A1 – Vibration Criteria Curves

Table A1 – Description of Vibration Criteria

Vibration Criteria Curve	Velocity Max Level[1] µm/s (µin/s)	Description of Use
Workshop (ISO)	800 (32,000)	Distinctly perceptible vibration. Appropriate to workshops and non-sensitive areas.
Office (ISO)	400 (16,000)	Perceptible vibration. Appropriate to offices and non-sensitive areas.
Residential Day (ISO)	200 (8000)	Barely perceptible vibration. Maximum recommended for general sleep areas. Usually adequate for computer equipment and microscopes with less than 40X magnification.
Residential Night (ISO)	140 (5600)	Appropriate for most sleep areas such as hospital recovery rooms.
Op. Theatre (ISO)	100 (4000)	Threshold of perceptible vibration. Suitable in most instances for surgical suites, catheterization procedures and microscopes to 100 X magnifications and for other equipment of low sensitivity. Suitable for very sensitive sleep areas.
VC- A	50 (2000)	Adequate in most instances for optical microscopes to 400X, micro-balances, and optical balances.
VC- B	25 (1000)	Micro-surgery, eye surgery and neurosurgery, CT, CAT, PET, fMRI, SPECT, DOT, EROS.
VC- C	12.5 (500)	Appropriate for MRIs, NMRs, standard optical microscopes to 1000X magnification, and moderately sensitive electron microscopes to 1µm detail size.
VC- D	6.25 (250)	Suitable in most instances for demanding equipment, including may electron microscopes (SEMs and TEMs) at more than 30,000X magnification and up to 0.3 micron geometries, and E-beam systems.
VC- E	3.12 (125)	A challenging criterion to achieve. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems, systems working at nanometer scales and other systems requiring extraordinary dynamic stability.
VC- F	1.56 (62.5)	Appropriate for extremely quiet research spaces. Generally difficult to achieve in most instances. Not recommended for use as a design criterion, only for evaluation.
VC- G	0.78 (31.3)	Appropriate for extremely quiet research spaces. Generally difficult to achieve in most instances. Not recommended for use as a design criterion, only for evaluation.

Appendix A: Overview of Vibration Criteria (cont'd)

The American Institute of Steel Construction (AISC, 1997) has recommended acceleration criteria for various occupancies of residential and commercial buildings (Figure A2). These criteria are based on peak acceleration values, and are dependent on the fundamental frequency of response of the floor. The recommended acceleration levels for rhythmic activities are ten times greater than those for residential and office occupancies, as people engaged in those activities are more likely to accept greater vibrations due to the nature of their activities. A greater allowance is also made for shopping malls and spaces intended for dining and dancing. As with the VC criteria described above, these curves are based on the ISO 2631-2 (1989) base curve for human response (also shown in this figure). The Chinese Building Code (JGJ 3-2010) (Table A2) and the National Building Code of Canada (NBCC 2005) provide similar guidelines.

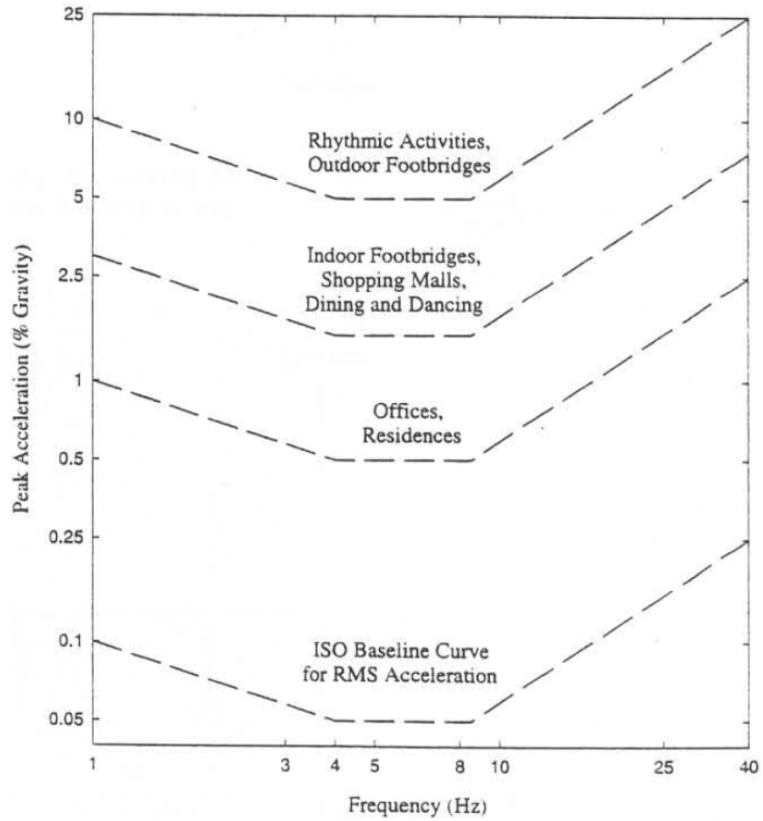

Figure A2 – AISC Acceleration Criteria Curves

Table A2 – Limit Value of Vertical Vibration Accelerations

Circumstance around people	Limit value of the peak vertical vibration acceleration (m/s^2)	
	Vertical frequency not larger than 2Hz	Vertical frequency not less than 4Hz
Residence and office	0.07	0.05
Market area and lobby	0.22	0.15

Note: While the vertical vibration frequency of a floor system is between 2Hzand 4Hz, the limit value of the peak acceleration can be linear interpolated.

APPENDIX 4

SUPPLEMENTAL PILE ANALYSIS
Prepared by:

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Project No. 2484.GQ

Dated: February 22, 2013

DUFFIELD ASSOCIATES

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duffnet.com

February 22, 2013

Mr. Duncan Anderson, III
Delaware State University
Planning & Construction Department
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Dover, DE 19901

RE: Project No. 2484.GQ
Supplemental Pile Analysis
Proposed Applied Optical Research Building
Delaware State University
Dover, Delaware

Dear Mr. Anderson:

In accordance with your recent request, Duffield Associates, Inc. (Duffield Associates) has performed additional pile capacity analysis for the proposed Applied Optical Research Building on the Delaware State University campus in Dover, Delaware.

As you are aware, Duffield Associates performed a geotechnical evaluation for the site as summarized in our reports dated April 2012 and October 2012. In our initial report, a spread foundation system was recommended. However, based on the loose soil conditions at the site, the design loads, and the resulting estimated settlement, the project team indicated that the estimated settlement exceeded the tolerances for the building and recommended review of other foundation types. Duffield Associates assisted the project team in evaluating several other foundation or ground improvement alternatives, including surcharging, compaction grouting, dynamic compaction, stone columns, and deep foundations. Based on the project site constraints and schedule, as well as a review of estimated construction costs, a drilled shaft foundation system, such as auger-cast piles, was selected as the approach preferred by the project team. In our October 2012 report, recommendations regarding the design and construction of an auger-cast pile system were provided.

Based on recent discussions with the design team, we understand that the use of an auger-cast pile with an increased pile capacity would be a cost-effective approach to the foundation design. Duffield Associates discussed several options with the project team, and the project's pile contractor indicated that a 55-ton allowable compressive capacity pile would be cost-effective for the proposed structure. It is understood that a pile load test will be performed at the start of construction.

Based on this information, Duffield Associates performed additional analysis in order to provide recommendations for the design and construction of a 55-ton allowable compressive capacity pile. A summary of this analysis is provided below.

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PILE CAPACITY

Static pile analysis was utilized to assess the compressive, uplift and lateral capacity of an auger cast pile system installed at the site. Based on the site stratigraphy, it is recommended that the pile terminate in the medium dense to dense granular soils observed in the borings to a depth of approximately 45 to 50 feet below grade (up to approx. elevation -22) , or in medium dense granular soils observed below a depth of 70 feet below grade (approx. elevation -42). It is not recommended for the end of the pile to bear in the soft to stiff consistency silt stratum observed at a depth range of approximately 50 to 62 feet below grade (approx. elevation -22 to -37).

The following is a summary of the estimated allowable pile capacity for various length piles. This allowable capacity is based on a factor of safety of 2, assuming that a load test will be performed to assess the installed pile capacity.

Pile Length (ft)	**Allowable Pile Compressive Capacity 16-inch Diameter Drilled Pier (tons)**		
	End Bearing	Skin Friction	Total
45	26	29	55
70	26	44	70

Based on the project drawings (dated November 12, 2012 "Design Development"), we understand the following:

- Building finished floor elevation = 30.0
- Pile cutoff elevation
  - approx. elevation 27 for 36-inch thick pile caps
  - approx. elevation 26 for 48-inch thick pile caps.

A 45-foot long pile installed within a 48-inch thick pile cap would be embedded the deepest and would extend to a tip elevation of -19 feet. Based on the test borings performed at the site, the elevation at which the sand soils were penetrated and silt soils were encountered varied from approximately elevation -22 to elevation -25. Therefore, it appears that a 45-foot long pile should be end-bearing in the sand soils. If the pile were to extend through the sand and into the silt soils, a decrease in the capacity and increased settlement are likely to occur. Therefore, it is important that the pile installation be closely reviewed to confirm that the piles do not exceed the recommended length or extend into the silt soils. **A pile tip elevation of -19 should not be exceeded (i.e., the base of the pile should not be installed any deeper than elevation -19).** This requirement should be clearly communicated to the pile installation contractor. Ground surface elevations should be clearly identified in the field.

Pile uplift capacity was also reviewed. The following is the recommended uplift capacity per pile. These uplift capacities consider the weight of the pile in allowable uplift capacity. A factor of safety of 3 was utilized in this analysis.

Pile Length (ft)	Allowable Uplift Capacity 16-inch diameter Drilled Pier (tons)
45	13
70	20

It is understood that the piles will generally be installed in groupings of 2 to 6 piles. When piles are installed close to each other, there is some overlap of stresses transmitted to the soil which may reduce the load carrying capacity of the piles in certain soil types. Ideally, piles in a group should be spaced to minimize the overlap of loads. Analysis was performed to assess the potential group pile efficiency based on the site soils. Based on this analysis, a group efficiency factor of 0.8 is recommended if a center-to-center pile spacing of 3 times the pile diameter is utilized. This applies to both uplift and compressive capacity.

The lateral capacity of an individual pile was also reviewed. For the lateral pile analysis, we utilized the computer program LPILE to assess the lateral deflection of a single pile under various lateral loads at the top of the pile. For this analysis, we assumed a pile cross section of 16-inch diameter auger cast pile, consisting of 4,000 psi concrete and a single No. 8 rebar in the center of the pile section. We also assumed a “free head” condition at the top of the pile. The following are the estimated loading conditions that resulted in a ¼ or ½-inch deflection, utilizing a factor of safety of 2.

Pile Diameter (in)	Lateral Load resulting in ¼-inch lateral deflection (tons)	Lateral Load resulting in ½-inch lateral deflection (tons)
16	1.5	2

PILE FOUNDATION SETTLEMENT

Estimates of foundation settlement were performed to assist in evaluating the effect of the proposed foundation loading and configuration on the subsurface conditions observed. Settlement of pile foundation will be caused by elastic shortening of the pile, as well as settlement of the pile caused by load transferred to the soil at the pile tip and along the length of the pile. For this analysis, 4,000 psi grout strength was assumed for the auger cast piles.

The following is the total estimated pile settlement for an individual pile loaded to the allowable compressive load capacity of 55 tons as stated above:

Pile Length (ft)	Estimated Pile Settlement 16-inch diameter Drilled shaft (in)
45	1.0

If the piles are installed to a uniform depth and are loaded uniformly, differential settlement between adjacent piles and pile caps is estimated to be less than ¼-inch.

Since the proposed structure is to be constructed in phases, differential settlement between the phases of construction should be considered. The initial phase will have likely experienced total settlement under full structural loading conditions prior to the construction of the second building phase. As with any building addition, the newly construction portion of the building will settle relative to the existing construction. The differential settlement should be considered in the design of the building and expansion jointing may be required to accommodate this differential settlement.

PILE LOAD TEST RECOMMENDATIONS

It is recommended that a compressive pile load test be performed. The test pile should be loaded to a minimum of two (2) times the design load. A static load test should be performed in accordance with ASTM D 1143 (for deep foundations under static axial compressive load). We recommend the load test be performed on a “sacrificial” pile located within the proposed building footprint.

In order to obtain additional information from the load test, it is recommended that after the loading of the pile to 2 times the design load, holding for a minimum period of 2 hours, and unloading the pile in accordance with ASTM D1143, that the test pile then be reloaded in increments to “failure”. Failure could be defined as the safe load limit of the test frame and load cell, or until a point at which excessive deflection is observed.

The contractor should also submit the proposed pile equipment, design mixes, and historical laboratory testing results for each type of grout and material utilized. The pile load test set up should also be submitted for review and approval.

The recommendations provided herein are considered a supplement to the geotechnical report prepared by Duffield Associates, dated October 2012. The complete geotechnical report, as well as this supplement, should be provided to any contractors proposing on the foundation work for this project.

We appreciate this opportunity to be of continued service to you on this project. Should you have any questions concerning the enclosed or require any further information, please contact us.

Very truly yours,

DUFFIELD ASSOCIATES, INC.

Stacy B. Ziegler, PE, LEED AP/ BD+C
Senior Geotechnical Engineer

JJ\SBZ:
WORD\2484GQ.0213.DSU Optics Additional Pile Analysis Letter