

10. Once an alarm is acknowledged at one OWS, it shall display as acknowledged at all operator workstations.
11. An BAS operator shall be able to select multiple alarms for single action acknowledgement.
12. There shall be the ability to disable alarms and display all disabled alarms in a separate alarm view.
13. The OWS alarm viewer shall be able to display the last 100 active alarms. If there are more than 100 active alarms, as alarms are acknowledged and removed from the viewer, older alarms shall be viewable to keep the viewer showing the last 100 active alarms until there are less than 100 active alarms.

G. Trends

1. Real Time Trends:

- a. At each OWS the operator shall be able to initiate a real time trending instance of up to 20 variables simultaneously.
- b. The polling interval setting shall be adjustable down to a rate of every second.
- c. The data for each instance shall be presented on a single graphical display that automatically updates with each new data collection cycle.
- d. The graphical presentation shall plot the variables on the Y axis and time on the X axis.
- e. A minimum of two Y axis scales shall be available.
- f. The operator shall have the ability to set the range on each Y axis scale or let the scales auto range to cover the range of the values being trended.
- g. Each element of data on the graphical display must be labeled by name or by a unique color. If color is used, a color legend must be included on the graph page.
- h. The BAS operator shall be able to open up to five instances simultaneously for a total of 100 points being trended at one time.
- i. A BAS operator shall be able to print an instance of real time data.
- j. The system shall be capable of trending any variable in the system.
- k. The BAS operator shall be able to save pre-configured instances of real time trending that can be initiated with simple point and click actions.
- l. The system shall provide the ability to expand the graphical presentation to full screen.

2. Historical Data Collection:

- a. Historical trend data shall be collected by field level devices and periodically uploaded to the data storage PC.
- b. The trend log objects in the field level devices shall have the capacity to store 300 samples per variable. When the 301st sample is collected, the 1st sample shall be discarded.

- c. The field level devices shall be configured to request an upload of data when the number of samples is not greater than 180. Uploads may be configured to occur at a greater frequency.
- d. Initiation of historical data collection shall be configurable.
 - 1) By manual operator intervention in a point and click manner.
 - 2) By a user adjustable time schedule or date.
 - 3) Triggered by a binary status variable (when the fan status is on, start the trend of the mixed air temperature).
 - 4) The system shall be capable of trending any variable in the system.
- e. The status and capacity of the trend logs in the field devices shall be viewable from the operator workstation.

3. Historical Data Presentation:

- a. An OWS shall have the capability to present the historical data for a variable in a tabular presentation of the values along with the date and time of the sample. The time period for the values to be presented shall be user adjustable.
- b. An OWS shall have the capability to present the historical data for a variable in a graphical presentation of the values plotted against time and date.
- c. The graphical presentation capabilities for historical trends shall equal those described above for real time trends.
- d. The BAS operator shall be able to save pre-configured instances of historical trending that can be initiated with simple point and click actions.
- e. The BAS operator shall be able to print the tabular presentations and graphical presentations of historical trend data.
- f. The system shall provide the ability to expand the graphical presentation to full screen.

- 4. The data collection, storage, retrieval and presentation system shall provide the features necessary for the control system (TAC) to achieve certification under Regulation 21 CFR Part 11 of the US Food and Drug Administration. (FDA) The key issue is the integrity of the data, the ability to verify that the data has not been modified after collection by the system.

H. Application Programming

- 1. The application programming tool may be based on Line Programming or Graphical Programming concepts.
- 2. If the application programming is object based and graphical:
 - a. There shall be an off-line simulation capability.
 - b. There shall be the ability to view dynamic data displayed on the object diagram in real time.

3. There shall be self checking for errors in programming to be used by the programmer.
4. Key functions that must be supported are:
 - a. Timer functions to include Delay Off, Delay On and Sample Rate Support
 - b. Interval timer
 - c. Math functions to include Addition, Subtraction, Multiplication, Division, Exponentiation, Trigonometric Functions and Logarithmic Functions (base 2 and base 10)
 - d. If-Then-Else Instructions (also referred to as switching logic)
 - e. Look up tables with a minimum of 100 entries, with and without extrapolation
 - f. Bit Wise Logic
 - g. Sample and hold binary
 - h. Sample and hold analog
 - i. Latch on and latch off functions with resets
 - j. Input network variable definition
 - k. Output network variable definition
 - l. Sensor measurement definition
 - m. End device control definition
 - n. Logic functions to include And, Or, Not and Exclusive Or
 - o. Detection of a power cycle
 - p. Common function support (standard objects in graphical programs and subroutines in line programs). As a minimum the common functions shall include:
 - 1) PID with analog output
 - 2) PID with tri-state outputs
 - 3) Enthalpy from temperature and relative humidity
 - 4) Optimum start stop based on occupancy schedule, temperature, set point and outside air temperature.
 - 5) Polynomial equation
 - q. Search function.

I. Report Creation

1. The BAS operators shall be able to extract historical data from the data collection files and present the data in a Microsoft Excel format. All of the data in the log shall be exportable to include the date, time and values
2. The number of trend logs that can be inserted into a single Excel Workbook shall not be limited by the OWS software.
3. The operators shall be able to pre-configure reports for manual execution or automated execution.
4. The OWS shall be able to auto execute any report based on:
 - a. A time schedule
 - b. An alarm trigger
 - c. The status of a binary point (state=1, execute the report)

5. The BAS operators shall be able to pre-configure the destination of the report:
 - a. OWS screen
 - b. Write to file on the hard drive
 - c. Send to a printer
6. The generation of a report shall not interrupt the use of the OWS by the operator, that is, it shall execute in the background.

J. Network Configuration Software

1. Network Configuration Software shall be accessible from any operator workstation.
2. This software may be a separate software tool, multiple software tools or the functions may be integral to the engineering software.
 - a. Functions that must be supported are:
 - 1) Addressing of field level devices
 - 2) Establishing data flow from device to device
 - 3) The ability to query a field bus and identify all installed devices by domain number, subnet number and node number.
3. If configuration of event driven communication is a function of the network configuration tool (in lieu of the application programs), the tool shall provide the capability to select the binding services used. See the definition of terms section for a discussion of binding services.

2.6 HVAC CONTROL HARDWARE IDENTIFICATION

A. Automatic Control Valve Tags

1. Use metal tags with a 2-inch minimum diameter, fabricated of brass, stainless steel or aluminum. Attach the tags with a chain of the same material.
2. Stamp or engrave metal tags with color contrasting identification information
3. For lubrication instructions, use plastic laminated information/ instruction sheets with nylon or ploy wrap ties
4. Tag the valves with identifying number and system information
5. Prepare a list of all tagged valves showing location, floor level, tag number and use. Organize the list by system. Include all tag information in all maintenance manuals.
6. Prepare a valve tag identification chart integrated with an single line diagram generated from the BAS as built drawings

B. Panels and Control Devices

1. Control Panels (Enclosures) shall be labeled with stamped or engraved tags with contrasting color identification information permanently mounted on the panels.

C. HVAC Test and Balance Requirements

1. The BAS provider shall provide the Test and Balance Contractor a single set of BAS test tools to interface with the control system for testing and balancing.
2. The BAS provider shall provide a minimum of 8 hours of training on the use of the BAS test tools.
3. The BAS provider shall provide a qualified BAS Test technician to assist with the testing and balancing of one system controlled by a programmable controller and the first ten terminal units.
4. The Test and Balance contractor is required to return the interface test tools unaltered and in working condition after completion of the testing and balancing.

2.7 GENERAL WORKMANSHIP REQUIREMENTS

- A. The BAS provider shall install equipment, conduit, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
- B. The BAS provider shall provide sufficient slack and flexible connections to allow for vibration of piping, equipment and service loops.
- C. The BAS provider shall install all equipment in readily accessible locations as defined by Chapter 1, Article 100 and Part A of the National Electrical Code (NEC).
- D. The BAS provider shall verify the 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.

2.8 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 Part 1 of this specification.
- B. The BAS provider shall continually monitor the field installation for code compliance and quality of workmanship.
- C. The BAS provider shall have work inspected by local and/or state authorities having jurisdiction over the work.

2.9 WIRING

- A. All control and interlock wiring shall comply with national and local electrical codes and Division 25 of this specification. Where the requirements of this section differ from those in Division 27, the requirements of this section shall take precedence.
- B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway according to NEC and Division 26 requirements.
- C. Low voltage wiring shall meet NEC Class 2 requirements. Sub-fuse low voltage power circuits as required to meet Class 2 current limits.
- D. 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.
- E. All wiring in mechanical, electrical, or service rooms, or where subject to mechanical damage, shall be installed in raceway at levels below 11 feet.
- F. The BAS provider shall 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).
- G. The BAS provider shall not install wiring in raceway containing tubing.
- H. Where Class 2 wiring is exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 8 foot intervals.
- I. 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.
- J. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire to wire connections shall be at a terminal block.
- K. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- L. Maximum allowable voltage for control wiring shall be 125 Volts. If only higher voltages are available, the contractor shall provide step-down transformers.
- M. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
- N. Install plenum wiring in sleeves where it passes through walls and floors. Maintain the fire rating at all penetrations.

- O. The size of raceway and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.
- P. Include one pull string in each raceway that is 1 inch in diameter or larger.
- Q. Use coded conductors throughout with conductors of different colors.
- R. 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.
- S. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway, to maintain a minimum clearance of 9 inches from high-temperature equipment such as steam pipes, electrical transformers or flues.
- T. 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, plumber tape or tie rods. Raceways may not be run on or attached to air distribution ductwork.
- U. Adhere to specification requirements where raceway crosses building expansion joints.
- V. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
- W. The BAS provider shall terminate all control and/or interlock wiring and shall maintain updated as-built wiring diagrams with terminations identified at the job site.
- X. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 2.5 feet in length and shall be supported at each end. Flexible metal raceway less than ½ inch electrical trade size shall not be used. In areas exposed to moisture, including chiller, pumps, chemical mixing and boiler rooms, liquid-tight, flexible metal raceways shall be used.
- Y. 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 coupling according to code. Terminations must be made with fittings at boxes and ends not terminating in boxes shall have protective bushings installed.

2.10 COMMUNICATION WIRING

- A. The BAS provider shall adhere to the items listed in the previous section on WIRING.
- B. The BAS provider shall install all cabling in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

- C. The BAS provider shall not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
- D. When a cable enters or exits a building, the BAS provider shall install a lighting arrestor between the lines and ground. The lighting arrestor shall be installed according to the manufacturer's instructions.
- E. The BAS provider shall install all runs of communication wiring with un-spliced lengths when that length is commercially available.
- F. The BAS provider shall provide a permanent tagged label on all communication wiring to indicate origination and destination data.
- G. The BAS provider shall ground coaxial cable in accordance with NEC regulations on "Communications Circuits, Cable, and Protector Grounding."
- H. When shielded wiring is use, the BAS provider shall ground the shield only once for each continuous segment of cable. The grounding location shall be at the end of the segment that is most readily accessible.

2.11 SENSORS

- A. The BAS provider shall install sensors in accordance with the manufacturer's recommendations.
- B. The BAS provider shall mount sensors rigidly and adequately for the environment within which the sensor operates.
- C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the 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 the duct. Each bend shall be supported with a capillary clip.
- F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the duct. Each bend shall be supported with a stainless steel capillary clip. Provide 1 foot of sensing element for each square foot of coil area.
- G. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in the thermal wells.
- H. Install outdoor air temperature sensors on the north wall, complete with a sun shield at the designated location.
- I. Differential air static pressure sensors:

1. For supply duct static pressure, pipe the high pressure tap to a duct probe that measures at a 90 degree angle +/- 5 degrees to flow (to measure only the static pressure and not the effects of velocity). Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor if one is installed or to the plenum if a building static pressure sensor is not installed.
 2. For return duct static pressure, pipe the high pressure tap to a duct probe that measures at a 90 degree angle +/- 5 degrees to flow (to measure only the static pressure and not the effects of velocity). Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor if one is installed or to the plenum if a building static pressure sensor is not installed.
 3. For building static pressure, pipe the low-pressure port of the sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
 4. The piping to the 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 boxes, shall be located in field device panels and not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without the use of ladders or special equipment to the maximum extent possible.
 6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.
- J. Annular pilot tubes shall be installed so that the total head pressure ports are set-in-line with the pipe axis upstream and the static port facing downstream. The total head pressure ports shall extend diametrically across the entire pipe. Annular pilot tubes shall not be used where the flow is pulsating or where pipe vibration exists.

2.12 FLOW SWITCHES

A. Airflow Switches

1. Install in horizontal duct runs whenever possible.
2. If a vertical duct run is the only option, then install in a location with an upward airflow.

2.13 ACTUATORS

- A. Damper actuators manufactured by Belimo featuring Multi-Function Technology for HVAC and Belimo FS type for Smoke Control applications or approved comparable product of equal functional reliability and warranty duration.
- B. Damper actuators shall be provided with all appropriate mounting hardware and linkages.
- C. Mount and link control damper actuators according to manufacturer's instructions.

- D. When spring return actuators are used on normally closed dampers, the seals shall be compressed when the dampers have been closed by the actuator.
- E. Damper/actuator combinations shall modulate smoothly from fully closed to fully open and return.
- F. Electric/Electronic Damper Actuators
 - 1. Shall be direct-mounted on the damper shaft or jackshaft unless shown as a linkage installation.
 - 2. Shall be mounted following the actuator manufacturer's recommendations.
- G. Electric Electronic HVAC Dampers and Smoke Control Device Actuators shall be manufactured by Belimo with a five year warranty and 1 million duty cycle stroke reliability guarantee or approved comparable product of equal functional reliability and warrantee duration.
 - 1. Shall be connected to the valve with adapters approved by the actuator manufacturer
 - 2. Shall be mounted following the actuator manufacturer's recommendations.

Shall be mounted following the actuator manufacturer's

- H. Electric / Electronic Control valves shall be manufactured by Belimo, Model Type, and PICCV design with a five year warranty or approved comparable product of equal functional reliability and warrantee duration.
 - 1. Shall be connected to the valve with adapters approved by the actuator manufacturer.
 - 2. Shall be mounted following the actuator manufacturer's recommendations.

2.14 IP INTERFACE DEVICES

- A. Install IP to LON routers or Building Controllers for each required connection to the owner's TCP/IP network. Locations are identified on the drawings.
- B. The IP to LON routers or Building Controller shall be configured and commissioned to ensure that the only data traffic on the TCP/IP is data that is essential for operation of the system. Messages between field devices on the same field bus shall not be allowed to pass onto the TCP/IP network.

2.15 CONTROLLERS

- A. Install programmable process controllers, supervisory logic controllers and application specific devices on each field bus to meet the requirements of the sequence of control for all systems.

- B. All process control loops for an integral system shall reside in a single controller. Each controllable end device creates one process control loop
- C. To the maximum extent possible, all process control loops for built up systems shall reside in a single controller. The objective of this requirement is that the contractor shall use large point count, primary controllers in lieu of multiple secondary controllers.
- D. Supervisory logic for integral and built up systems may reside in separate supervisory logic controllers with the output commands to the process control loops traversing the field bus to the controllers executing the process control.

2.16 CONTROL DAMPERS

- A. Install dampers in accordance with the manufacturer's instructions to operate and to obtain leakage rates specified herein. Adjust the damper linkage such that the damper closes before the Belimo or approved equal actuator is fully closed to assure tight shutoff of the damper.
- B. Blank-off and seal around dampers and between dampers and sleeves or frames with EPA and CARB approved, low VOC solvent based, sealants to eliminate air bypass leakage. (*Note; no water base sealants are acceptable*)
- C. For outdoor air damper assemblies, stage the opening of each section to prevent stratification and poor mixing of outside and return air.

2.17 CONTROL VALVES

- A. Install in an accessible location, with room for actuator removal and service. Adjust the actuator to provide tight shutoff. Provide visible, color coded, valve stem indicator and adjust to indicate proper travel.
- B. Where butterfly valves are used, permanently mark the end of the valve shaft to indicate the valve position.

2.18 PROGRAMMING FOR PROGRAMMABLE DEVICES

- A. These requirements apply to Building Controllers, programmable process controllers, supervisory logic controllers, automatic time scheduling devices, trend logging devices, alarm handling devices and automatic time schedule switch-over devices.
- B. The BAS provider shall create and download application programs that meet the requirements of the sequence of control, time scheduling requirements, trend logging requirements and alarm handling requirements.
 - 1. The BAS provider shall use a consistent point naming concept throughout the project that allows for easy transition from building to building and system to system.
 - 2. The BAS provider shall employ extensive code annotation for each functional block, signal and device. The owner shall be able to easily

- recognize the function of each functional block, signal in or out of any device or the device itself.
3. All time schedules shall be fully configured with weekly schedules and all of the holidays identified by the OWNER.
 4. All trend logs identified in the sequence of control shall be fully configured and operational.
 5. All alarm handling shall be fully configured with consistent alarm messages and priorities or category numbers to identify the system from which the alarm originates.
 6. All application parameters identified as (adj) in the sequence of control shall be exposed as viewable parameters using LonTalk network variables with an appropriate SNVT and appropriate initial values shall be set.
 7. All external point values and internal point values identified as (rpt) in the sequence of control shall be exposed as viewable values using LonTalk network variables with an appropriate SNVT.
 8. Manual control of all external points (and those internal points requiring manual control) shall be programmed using either the priority override concept or the software switchover concept (See the definition of terms section for a discussion of these two concepts). The network variables that communicate manual control commands from the OWS to the controllers shall be LonTalk variables with an appropriate SNVT. Proprietary implementation of manual control is not acceptable.
 9. For all variables broadcast onto the field bus, event driven communication shall be used to avoid data storms. As a minimum the program shall provide for the *send on delta parameter and minimum send time parameter* for each output variable.
 10. The BAS provider shall embed into the programs sufficient comment statements to clearly describe each section of the program. This applies to both line programming and graphical programming systems.
 11. If graphical programming systems with multiple layers for the functional block diagrams are used, no more than two layers shall be used.

2.19 CONFIGURATION OF APPLICATION SPECIFIC DEVICES

- A. Application specific devices shall be configured to meet the sequence of control.

2.20 DEVICE-TO-DEVICE DATA FLOW

- A. All device-to-device data flow shall be in place and configured to meet the sequence of control for the new systems and to integrate the existing systems.
- B. All device-to-device data flow shall be implemented through the use of LonTalk variables with an appropriate SNVT (Standard Network Variable Type). Proprietary data flow from device to device is not acceptable.
- C. Appropriate binding services shall be used to ensure that the average bandwidth utilization is less than 30%. The owner reserves the right to conduct network bandwidth testing to ensure this requirement is met.

- D. If reducing the number of devices per field bus is required to meet the network bandwidth requirements, all costs of making changes shall be borne by the contractor.

2.21 DISTRIBUTED CONTROL REQUIREMENTS

- A. The programmed applications for a single integrated system shall not be distributed over more than one field bus. Examples:
 - 1. A chiller is controlled by a controller on field bus number 1. The controllers that control the pumps and tower shall also be on field bus number 1 as these systems are integrated in their control requirements.
 - 2. Multiple air handling units are controlled by controllers on field bus number 1. The chiller system is controlled by controllers on field bus number 2. The chiller control logic requires the chilled water valve positions from each of the air handling unit controllers. It is acceptable that these related but non-integral systems are controlled by controllers on different field busses.

2.22 SYSTEM UNITS AND RESOLUTION

- A. The BAS provider shall use SNVTs with the appropriate units for each input network variable, input application parameter and output network variable.
- B. The BAS provider shall use SCPTs with the appropriate structure for each input application parameter that is based on the SCPT (Standard Configuration Property Types) concept.
- C. The UMCS must communicate with the operators visually and in reports using the inch-pound system.
- D. The conversion of data from a field level device must be automatically converted from SI units to inch-pound units prior to display.
- E. For BAS operator initiated values, the BAS operator shall be able to enter values in units from the inch-pound system of units and the system must then automatically convert the value to units from the SI system of units for dispatch to the field level devices.
- F. The system must be able to display values visually or in reports with a resolution equal to the resolution of the data as defined in the SNVT Master List or the SCPT Master list. Where conversion from the SI system to the Inch-Pound system of units results in a two numeric digit resolution, the resolution of display must be equal to the rounded up value. Example: SNVT temp data has a resolution of 0.01 degrees C. This is a single digit resolution. Upon conversion to degrees F, the resolution would be 0.018 degrees F. This is a two digit resolution. The round up process would produce a required resolution for display of 0.02 degrees F.

2.23 SERVERS AND BAS WORKSTATIONS

- A. The BAS provider shall install:
 - 1. System servers and operator work stations as shown on the contract drawings.
 - 2. A data server and a web server as shown on the contract drawings (and they can also occasionally be one appliance device)
- B. All required software for fully functional systems shall be installed and configured. The owner shall provide the IP connections and identify the specific rooms where the computers shall be installed.

2.24 SYSTEM SERVER

- A. All field level devices shall be addressed and imported into the system server database.
- B. For the existing control system that is being integrated into the new system, the addresses of the existing field devices shall not be changed.

2.25 BAS OPERATOR WORKSTATIONS

- A. Dynamic Data Displays:
 - 1. Points lists shall be organized on a per field device basis.
 - 2. If the software provides for the sub-division of point data within a field device, the data shall be organized by physical sub-system as a minimum (fan section, mixed air section, etc.).
 - 3. The workstation shall be configured to automatically update values without any action by the operator.
 - 4. Value updates in points lists shall be configured to update at least once every 5 seconds.
 - 5. Binary data shall be configured to display state descriptors (OFF, ON; OPEN, CLOSED; etc.) and not the states of 0 and 1.
 - 6. Analog data shall display with a resolution equal to the resolution defined as part of the SNVT used to transmit the data.
 - 7. Analog data displays shall include engineering units.
 - 8. All text fields associated with a specific element of data shall be filled out to provide the maximum amount of information to the operator.
- B. Color Graphic Pages
 - 1. Hierarchy:
 - a. The organization of graphic pages shall be from a global level down to a very detailed level through a series of links.
 - b. Linking shall allow the operator to move down the hierarchy, up the hierarchy and laterally within the hierarchy.
 - 2. Hierarchy Outline

- a. **Site Plan Page:** A visual representation of the site (map). One page or multiple linked pages depending on the size of the site plan.
 - 1) Link to individual building graphic pages.
 - 2) Display outdoor weather conditions.

- b. **Utility Management Page:** A summary of data on the utility consumption for the site.
 - 1) Link up to the site plan.
 - 2) Display
 - a) Utility consumption data.
 - b) Demand data.
 - c) Voltages, currents and power factors.
 - d) Demand control actions currently in effect.
 - 3) Presenting the utility management data may require more than one graphic page to effectively report the data from multiple meters.

- c. **Building Graphic Page:** Typically a picture of the building. One page per building.
 - 1) Link to floor plans within the building.
 - 2) Link to central plant graphics where the plant serves the entire building.
 - 3) Link to delivery systems if the deliver system serves the entire building
 - 4) Link up to the site plan.

- d. **Floor Plan Page:** This will be a two dimensional plan of a floor area. A minimum of one page per floor per building is required. Where floor plans are large, multiple linked pages are required. For each control zone the value of the controlled parameters shall be displayed. This will typically be lighting status, temperature and relative humidity if relative humidity is a controlled variable.
 - 1) Link up to the Building page.
 - 2) Link up to the Site Plan page.
 - 3) Link to any delivery system that serves the floor plan area (air handling unit is typical).
 - 4) Link to time schedules that affect the systems that serve the area
 - 5) Link to a Terminal Unit Summary page where multiple zones on the floor are served by unitary control devices such a VAVs or fan coil units.
 - 6) Individual control zones shall be identified.
 - 7) The location of terminal equipment serving each zone shall be shown.
 - 8) The location of sensors installed in the occupied space shall be shown.

- 9) Where room numbers are available, they shall be shown.
- e. Delivery System Page: A graphical representation of an air or water delivery system such as an air handling unit, roof top air handling unit, computer room air conditioning unit. One page for each delivery system.
- 1) If the Delivery System serves a specific floor area, link up to the Floor Area page.
 - 2) Link up to the Building page.
 - 3) Link up to the Site Plan page.
 - 4) Link to the Central Plant page if the Delivery System is served by a Central Plant.
 - 5) If the Delivery System supplies multiple terminal devices, link to a Terminal Unit Summary page.
 - 6) Link to a Delivery System Configuration page.
 - 7) The graphical representation of the equipment shall be 3-dimensional and represent the true physical characteristics of the installed system.
 - 8) Display:
 - a) Process variables.
 - b) Commands to end devices.
 - c) Status of end devices.
 - d) Status of different modes (economizer on/off, mechanical cooling enabled/disabled, occupied/unoccupied).
 - e) Alarm points.
 - 9) Link to any time schedules that affect the system operation.
 - 10) Link to any pre-configured trend charts for the system.
- f. Delivery System Configuration Page: On this page the service provider operator is given access to the configuration parameters for the delivery system. Typically, this page presents data in a tabular format. The type of data on this page is not changed frequently, but the operator may wish to view it frequently. One page per delivery system is required.
- 1) Display:
 - a) Set Points.
 - b) Tuning Parameters.
 - c) Calibration Parameters.
 - d) Timing Parameters.
 - e) Application parameters.
 - f) Reset Schedules.
 - g) Lead Lag Information
 - h) Time Schedules.
 - 2) Link up to the Delivery System page.

- 3) Link up to the Building page.
- 4) Link up to the Site Plan page.

C. User Groups

1. The BAS provider shall configure four users groups, one for each level of security. The group names shall be representative of the "names" below:
 - a. BAS Administrators
 - b. BAS Engineers
 - c. BAS Operators
 - d. BAS Viewers

D. Users

1. The BAS provider shall configure two users in each user group. The names and passwords shall be representative of the "names" below:
 - a. BAS Administrators Group
 - 1) Admin1 / Admin1
 - 2) Admin2 / Admin2
 - b. BAS Engineers Group
 - 1) Engr1 / Engr1
 - 2) Engr2 / Engr2
 - c. BAS Operators Group
 - 1) Oper1 / Oper1
 - 2) Oper2 / Oper2
 - d. BAS Viewers Group
 - 1) View1 / View1
 - 2) View2 / View2
2. With the exception of the BAS Viewers Group, these users shall not be added to the system until all testing has been completed and the system has been accepted. The BAS provider shall accept all responsibility for actions that result from the unauthorized issuance of user names and passwords above the level of viewers prior to system acceptance unless specifically instructed to do so in writing by the OWNER.

E. BAS Alarm Processing

1. All alarms required by the sequence of control shall be fully configured for delivery to the operator workstations and the alarm files.
2. A common alarm file shall be established to receive alarms from all of the field devices.
3. A separate alarm file shall be established on a per building basis to receive just the alarms from that building.

4. The alarm messages shall be descriptive and include as a minimum:
 - a. System identification
 - b. Date
 - c. Time to the second
 - d. Nature of the alarm such as high value, low value, or fail to start.
5. The system shall be configured to send an alarm message on return to normal.
6. All users shall receive all alarms.

2.26 WEB SERVER

- A. The web server shall be configured to present data from all of the field devices.
- B. The web server shall be configured to allow 3 concurrent users.
- C. The web server shall be configured to require a user name and password for log-in from a web client.
- D. The web server shall be configured to allow the web clients to do the following:
 1. View all graphic pages that can be viewed from a operator workstation.
 2. View historical trend logs
 3. Receive and acknowledge alarms
 4. Manually control points
 5. Initiate generation and view static reports
 6. Adjust time schedule parameters

2.27 CONTROL SEQUENCES

- A. BAS Control sequences are to be determined by the BAS provider in the design and deployment of BAS

2.28 CONTROL SYSTEM CHECKOUT, TESTING AND TRAINING

- A. The BAS provider shall furnish all labor and test apparatus required to execute the start up testing and owners commissioning plan. Key tasks to be executed and documented in the start up testing and commissioning verification report include:
 1. Verification of all primary and secondary voltages.
 2. Verification that power wiring for all devices conforms to manufacturer's instructions.
 3. Verification that all labeling is in place.
 4. Verification and Inspection of wiring for loose strands and tight connections.
 5. Verification and Inspection of all BAS control panel electrical grounding
 6. Verification of field bus topology, grounding of shields (if used) and installation of termination devices.

7. Verification that each I/O device is landed per the submittals and functions per the sequence of control.
 - a. Analog sensors shall be properly scaled and a value reported to the OWS.
 - b. Binary sensors shall have the specified normal position and the state is reported to the OWS.
 - c. Analog outputs have the specified normal position and move full stroke when so commanded.
 - d. Binary outputs have the specified normal state and respond to energize/de-energize commands.

8. Analog sensors have been calibrated with high quality instrumentation suitable for the sensor being calibrated.
 - a. The instruments shall display a current (12 month) NIST traceable calibration sticker. Associated instrument calibration certificates shall be made available within 24 hours of a request.
 - b. The measured value, reported value, and the calculated offset that was entered into the database shall be recorded.
 - c. The calibration criteria shall be:
 - 1) Space Temperature: +/- 0.4 degrees F
 - 2) Air Temperature: +/- 0.5 degrees F
 - 3) Air Flow Rate: +/- 5 %
 - 4) Differential Pressure: +/- 3 %
 - 5) Gauge Pressure: +/- 5%
 - 6) Relative Humidity: +/- 3 % relative humidity
 - 7) CO2: +/- 2 %

9. Loop Tuning
 - a. The contractor shall tune all P, PI and PID control loops.
 - b. The loop tuning criteria shall be a stable control loop where the average error over 15 minutes and 30 samples shall be less than:
 - 1) Space Temperature: +/- 0.75 degrees F
 - 2) Air Temperature: +/- 1.50 degrees F
 - 3) Air Humidity: +/- 5 % relative humidity
 - 4) Hot Water Temp: +/- 1.00 degrees F
 - 5) Duct Pressure: +/- 0.2 inches wg.

- B. Training: To be defined by the "Lon" System BAS provider, the OWNER representatives, and OWNER BAS designated service providers.

END OF SECTION

SECTION 23 23 00
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

1.2 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R410:
 - 1. Suction Lines for Air-Conditioning Applications: 400 psig.
 - 2. Suction Lines for Heat-Pump Applications: 400 psig.
 - 3. Hot-Gas and Liquid Lines: 400 psig.

1.3 SUBMITTALS

- A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.
- B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
 - 1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.5 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Brazing Filler Metals: AWS A5.8.
- F. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

- A. Diaphragm Packless Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
 - 2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
 - 3. Operator: Rising stem and hand wheel.
 - 4. Seat: Nylon.
 - 5. End Connections: Socket, union, or flanged.
 - 6. Working Pressure Rating: 500 psig.
 - 7. Maximum Operating Temperature: 275 deg F.
- B. Packed-Angle Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze.
 - 2. Packing: Molded stem, back seating, and replaceable under pressure.
 - 3. Operator: Rising stem.
 - 4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.

5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.
6. Manufacturer: Diamondback BV-Series ball valve or equivalent.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.

2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig.

H. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

I. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

J. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

K. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

L. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 240 deg F.

M. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.3 REFRIGERANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R410A, Azeotropic mixture of difluoromethane (R-32) and pentafluoroethane (R-125).

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Liquid Lines, and Suction Lines for Heat-Pump Applications:

1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Safety-Relief-Valve Discharge Piping:

1. NPS 1-1/2 and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install packed-angle valves in suction and discharge lines of compressor.
- B. Install service valves for gage taps at strainers if they are not an integral part of strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install packed-angle valves on inlet and outlet side of filter dryers.
- E. Install a full-sized, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.
- L. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- L. Install refrigerant piping in protective conduit where installed belowground.
- M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- N. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- O. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- Q. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

- R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."

3.4 PIPE JOINT CONSTRUCTION

- A. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- B. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 - 2. Use Type BA_g, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
 - 2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
 - 3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
 - 4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
 - 5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
 - 6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.

7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.

D. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
 2. Verify that compressor oil level is correct.
 3. Open compressor suction and discharge valves.
 4. Open refrigerant valves except bypass valves that are used for other purposes.
 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 23 31 13

METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.
6. Seismic-restraint devices.

B. Related Sections:

1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.

7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction

Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Lindab Inc.
 - b. McGill AirFlow LLC.
 - c. SEMCO Incorporated.
 - d. Sheet Metal Connectors, Inc.
 - e. Spiral Manufacturing Co., Inc.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Fabricate round ducts larger Than 90 inches in diameter with butt-welded longitudinal seams.
- D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be

free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- E. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
 - 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 - 2. Tape Width: 3 inches.
 - 3. Sealant: Modified styrene acrylic.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 - 7. Service: Indoor and outdoor.
 - 8. Service Temperature: Minus 40 to plus 200 deg F.
 - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

10. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
11. Sealant 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. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant 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."

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.6 SEISMIC-RESTRAINT DEVICES

- 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. Ductmate Industries, Inc.
 - 3. Hilti Corp.
 - 4. Kinetics Noise Control.
 - 5. Loos & Co.; Cableware Division.
 - 6. Mason Industries.
 - 7. TOLCO; a brand of NIBCO INC.
 - 8. Unistrut Corporation; Tyco International, Ltd.
- B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service 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: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories

for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

- D. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
- E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
- F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction."

3.2 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.
 - 4. Outdoor, Return-Air Ducts: Seal Class C.
 - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
 - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
 - 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
 - 8. Unconditioned Space, Return-Air Ducts: Seal Class B.
 - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
 - 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
 - 11. Conditioned Space, Exhaust Ducts: Seal Class B.
 - 12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.3 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.

4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.4 SEISMIC-RESTRAINT-DEVICE INSTALLATION

- A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet Insert dimension o.c.
 2. Brace a change of direction longer than 12 feet.
- B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install cable restraints on ducts that are suspended with vibration isolators.
- E. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service an agency acceptable to authorities having jurisdiction.
- F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.
- G. Drilling for and Setting Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items

- during drilling. Notify the Architect 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. Set anchors to manufacturer's recommended torque, using a torque wrench.
 5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.5 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 DUCT CLEANING

- A. Clean new and existing duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
 1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C. Particulate Collection and Odor Control:
 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- D. Clean the following components by removing surface contaminants and deposits:
 1. Air outlets and inlets (registers, grilles, and diffusers).
 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.

3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.7 START UP

- A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.8 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
 1. Underground Ducts: Concrete-encased, galvanized sheet steel.
- B. Supply Ducts:
 1. Ducts Connected to Fan Coil Units, :
 - a. Pressure Class: Positive 1-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 12.

- d. SMACNA Leakage Class for Round and Flat Oval: 12.
- C. Return Ducts:
- 1. Ducts Connected to Fan Coil Units:
 - a. Pressure Class: Positive or negative 1-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- D. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
- 1. Ducts Connected to Fan Coil Units:
 - a. Pressure Class: Positive or negative 1-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
- E. Intermediate Reinforcement:
- 1. Galvanized-Steel Ducts: Galvanized steel.
 - 2. PVC-Coated Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Match duct material.
- F. Elbow Configuration:
- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

- 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
- a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
- a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

G. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Turning vanes.
4. Duct-mounted access doors.
5. Flexible connectors.
6. Flexible ducts.
7. Duct accessory hardware.

1.2 SUBMITTALS

- A. Product Data:** For each type of product indicated.

1.3 QUALITY ASSURANCE

- A.** Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B.** Comply with AMCA 500-D testing for damper rating.

PART 2 - PRODUCTS

2.1 MATERIALS

- A.** Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel:** Comply with ASTM A 653/A 653M.
1. Galvanized Coating Designation: G90.
 2. Exposed-Surface Finish: Mill phosphatized.
- C. Stainless-Steel Sheets:** Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

- D. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- E. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Duro Dyne Inc.
 - 2. Greenheck Fan Corporation.
 - 3. Pottorff; a division of PCI Industries, Inc.
 - 4. Ruskin Company.
- B. Description: Gravity balanced.
- C. Maximum Air Velocity: 2000 fpm.
- D. Maximum System Pressure: 1-inch wg.
- E. Frame: 0.052-inch- thick, galvanized sheet steel, with welded corners.
- F. Blades: Multiple single-piece blades, maximum 6-inch width, 0.050-inch- thick aluminum sheet with sealed edges.
- G. Blade Action: Parallel.
- H. Blade Seals: Neoprene, mechanically locked.
- I. Blade Axles:
 - 1. Material: Galvanized steel.
 - 2. Diameter: 0.20 inch.
- J. Tie Bars and Brackets: Galvanized steel.
- K. Return Spring: Adjustable tension.
- L. Bearings: Steel ball.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flexmaster U.S.A., Inc.
 - b. METALAIRE, Inc.
 - c. Pottorff; a division of PCI Industries, Inc.
 - d. Ruskin Company.
2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:
 - a. Hat-shaped, galvanized-steel channels, 0.064-inch minimum thickness.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized-steel, 0.064 inch thick.
6. Blade Axles: Galvanized steel.
7. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
8. Tie Bars and Brackets: Galvanized steel.

B. Jackshaft:

1. Size: 1-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ductmate Industries, Inc.
 2. Duro Dyne Inc.
 3. METALAIRE, Inc.
 4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- E. Vane Construction: Single wall.
- F. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.5 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ductmate Industries, Inc.
 2. Flexmaster U.S.A., Inc.
 3. Greenheck Fan Corporation.
 4. Pottorff; a division of PCI Industries, Inc.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.

- d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
- 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

- 1. Door and Frame Material: Galvanized sheet steel.
- 2. Door: Single wall with metal thickness applicable for duct pressure class.
- 3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
- 4. Factory set at 10-inch wg.
- 5. Doors close when pressures are within set-point range.
- 6. Hinge: Continuous piano.
- 7. Latches: Cam.
- 8. Seal: Neoprene or foam rubber.
- 9. Insulation Fill: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.6 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Inc.
 - 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd..
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F.

- F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd..
 - 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F.

- G. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
 - 1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 - 2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 - 7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.7 FLEXIBLE DUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Flexmaster U.S.A., Inc.
 - 2. McGill AirFlow LLC.
 - 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

- B. Noninsulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire.
 - 1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
 - 2. Maximum Air Velocity: 4000 fpm.
 - 3. Temperature Range: Minus 20 to plus 210 deg F.

- C. Flexible Duct Connectors:
 - 1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

2.8 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Downstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans and seals.
 - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors; and shall be outward operation for

access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.

7. At each change in direction and at maximum 50-foot spacing.
8. Upstream from turning vanes.
9. Control devices requiring inspection.
10. Elsewhere as indicated.

H. Install access doors with swing against duct static pressure.

I. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

J. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

K. Install flexible connectors to connect ducts to equipment.

L. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

M. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

N. Connect flexible ducts to metal ducts with draw bands.

O. Install duct test holes where required for testing and balancing purposes.

P. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION

SECTION 23 34 23

HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Ceiling-mounted ventilators.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- 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. Wiring Diagrams: For power, signal, and control wiring.
 - 3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
- C. Operation and maintenance data.

1.3 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

2.1 CEILING-MOUNTED VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Broan-NuTone LLC.

2. Greenheck Fan Corporation.

- B. Housing: Steel, lined with acoustical insulation.
- C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
- D. Grille: Plastic, louvered grille with flange on intake and thumbscrew attachment to fan housing.
- E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.
- F. Accessories:
 - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
 - 3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
 - 4. Motion Sensor: Motion detector with adjustable shutoff timer.
 - 5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
 - 6. Filter: Washable aluminum to fit between fan and grille.
 - 7. Isolation: Rubber-in-shear vibration isolators.
 - 8. Manufacturer's standard roof jack or wall cap, and transition fittings.
- G. Capacities and Characteristics: See Schedule.

2.2 MOTORS

- A. 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."
 - 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: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
- B. Enclosure Type: Totally enclosed, fan cooled.

2.3 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.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Division 07 Section "Roof Accessories" for installation of roof curbs.
- B. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- C. Support suspended units from structure using threaded steel rods and elastomeric hangers having a static deflection of 1 inch. Vibration-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- D. Install units with clearances for service and maintenance.
- E. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

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. Verify that shipping, blocking, and bracing are removed.
 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 3. Verify that cleaning and adjusting are complete.
 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 5. Adjust belt tension.
 6. Adjust damper linkages for proper damper operation.
 7. Verify lubrication for bearings and other moving parts.
 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 10. Shut unit down and reconnect automatic temperature-control operators.
 11. Remove and replace malfunctioning units and retest as specified above.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

END OF SECTION

SECTION 23 37 13

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular and square ceiling diffusers.
2. Louver face diffusers.
3. Linear bar diffusers.
4. Linear slot diffusers.
5. Fixed face grilles.

B. Related Sections:

1. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers CD-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Krueger.
 - b. METALAIRE, Inc.
 - c. Nailor Industries Inc.

d. Titus.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel.
4. Finish: Baked enamel, white.
5. Face Size: 24 by 24 inches.
6. Face Style: Plaque.
7. Mounting: T-bar as required for ceiling type, concealed hardware.
8. Pattern: Adjustable.
9. Accessories:

a. Plaster ring.

B. Louver Face Diffuser SWS:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. METALAIRE, Inc.
 - b. Nailor Industries Inc.
 - c. Titus.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel.
4. Finish: Baked enamel, white.
5. Face Size: See plans.
6. Mounting: T-bar as required for Soffit type, concealed hardware.
7. Pattern: Adjustable core style.

2.2 CEILING LINEAR SLOT OUTLETS

A. Linear Bar Diffuser LD-1:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Anemostat Products; a Mestek company.
 - b. Krueger.
 - c. METALAIRE, Inc.
 - d. Nailor Industries Inc.
 - e. Titus.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel.
4. Finish: Baked enamel, white.
5. Mounting: As required, concealed hardware.
6. Accessories: Plaster frame.

B. Linear Slot Diffuser LD-2:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Anemostat Products; a Mestek company.
 - b. Krueger.
 - c. METALAIRE, Inc.
 - d. Nailor Industries Inc.
 - e. Titus.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material - Shell: Steel, insulated.
4. Material - Pattern Controller and Tees: Aluminum.
5. Finish - Face and Shell: Baked enamel, black.
6. Finish - Pattern Controller: Baked enamel, black.
7. Finish - Tees: Baked enamel, white.
8. Slot Width: See plans.
9. Number of Slots: See plans.
10. Length: See plans.
11. Accessories:
 - a. Plaster frames.

2.3 REGISTERS AND GRILLES

A. Fixed Face Grille RG-1/EG-1/TG-1/SWR:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Anemostat Products; a Mestek company.
 - b. Krueger.
 - c. Nailor Industries Inc.
 - d. Titus.
2. Material: Steel.
3. Finish: Baked enamel, white.
4. Face Arrangement: $\frac{3}{4}$ " blade spacing at 30 to 40 degree angle.
5. Frame: 1 inch wide.
6. Mounting: As required for ceiling or Soffit type, concealed hardware.
7. Accessory:
 - a. Plaster frame.

2.4 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 23 81 26

SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 – GENERAL

1.1 SUMMARY

- A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.
- B. The variable capacity, heat pump heat recovery air conditioning system shall be a Mitsubishi Electric CITY MULTI VRFZ (Variable Refrigerant Flow Zoning). The CITY MULTI VRFZ systems shall be the R2-Series (simultaneous cooling and heating)

The Mitsubishi City Multi system is the basis of design for this project and as such the piping systems, electrical systems, drains, equipment space (including service space), and equipment capacities are unique to the Mitsubishi City Multi system. Daikin and LG equipment is considered equal but systems for this project must be designed to include piping, electrical, drains, etc. that are unique to Daikin or LG. A bid based on using Daikin or LG equipment must also include the cost for the system design and installation which includes the additional or revised equipment, piping, electrical, supports, and drains required for proper operation. The alternate system design must be approved by the Architect before executing the sub-contract. The Contractor of the Daikin or LG system shall assume all additional cost for design review, design revisions, electrical, piping, and drains beyond those quantities required for City Multi.

1.2 SUBMITTAL

- A. Product Data: For each type of product indicated.
- 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.
- C. Operation and maintenance data.
- D. Warranty: Sample of special warranty.

1.3 QUALITY ASSURANCE

- A. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label.
- B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

- C. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
- D. A full charge of R-410A for the condensing unit only shall be provided in the condensing unit.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Unit shall be stored and handled according to the manufacturer's recommendation.

PART 2 – WARRANTY

- 2.1 The units shall be covered by the manufacturer's limited warranty for a period of one (1) year from date of installation.

- A. The system must be:

1. Designed by a certified CITY MULTI Diamond Designer,
2. Installed by a certified CITY MULTI Diamond Dealer, AND
3. Verified with a completed commissioning report submitted to and approved by the Mitsubishi Electric Service Department.

Then the units shall be covered by an extended manufacturer's limited warranty for a period of five (5) years from date of installation.

In addition the compressor shall have a manufacturer's limited warranty for a period of seven (7) years from date of installation.

If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer.

This warranty shall not include labor.

- 2.2 Manufacturer shall have a minimum of twenty-nine years of HVAC experience in the U.S. market.
- 2.3 All manufacturer technical and service manuals must be readily available for download by any local contractor should emergency service be required. Registering and sign-in requirements which may delay emergency service reference are not allowed.
- 2.4 Prior to bid, the Contractor shall be an authorized CITY MULTI Diamond Dealer. Contractor shall have a certificate of service training completion from the CITY MULTI Diamond Dealer service training. The mandatory contractor service and install training should be performed by the manufacturer. The CITY MULTI VRFZ system shall be installed by a Mitsubishi authorized CITY MULTI Diamond Dealer with at least 2 years of CITY MULTI install and service training.

PART 3 – PRODUCTS

3.1 MANUFACTURERS

A. **Basic-of-Design Product:** Subject to compliance with requirements, provide product indicated on Drawings:

1. Mitsubishi Electric & Electronics USA, Inc.; HVAC Advanced Products Division.
2. No Equal.

3.2 R2-SERIES OUTDOOR UNIT

A. **General:**

The R2-Series PURY outdoor unit shall be used specifically with CITY MULTI VRFZ components. The PURY outdoor units shall be equipped with multiple circuit boards that interface to the M-NET controls system and shall perform all functions necessary for operation. Each outdoor unit module shall be completely factory assembled, piped and wired and run tested at the factory.

1. The model nomenclature and unit requirements are shown below. All units requiring a factory supplied twinning kits shall be piped together in the field, without the need for equalizing line(s). If an alternate manufacturer is selected, any additional material, cost, and labor to install additional lines shall be incurred by the contractor.

Outdoor Unit Model Nomenclature					
208/230 Volt		Twinning Kit	460 Volt		Twinning Kit
Model Number	Units		Model Number	Units	
PURY-P240TSJMU	(2) PURY-P120TJMU	CMY-R100VBKXL	PURY-P240YSJMU	(2) PURY-P120YJMU	CMY-R100VBKXL

2. Outdoor unit shall have a sound rating no higher than 60 dB(A) individually or 64 dB(A) twinned. Units shall have a sound rating no higher than 50 dB(A) individually or 53 dB(A) twinned while in night mode operation. If an alternate manufacturer is selected, any additional material, cost, and labor to meet published sound levels shall be incurred by the contractor.
3. Both refrigerant lines from the outdoor unit to the BC (Branch Circuit) Controller (Single or Main) shall be insulated.
4. There shall be no more than 3 branch circuit controllers connected to any one outdoor unit.
5. Outdoor unit shall be able to connect to up to 50 indoor units depending upon model.

6. The outdoor unit shall have an accumulator with refrigerant level sensors and controls.
7. The outdoor unit shall have a high pressure safety switch, over-current protection, crankcase heater and DC bus protection.
8. The outdoor unit shall have the ability to operate with a maximum height difference of 164 feet and have total refrigerant tubing length of 1804-2625 feet. The greatest length is not to exceed 541 feet between outdoor unit and the indoor units without the need for line size changes or traps.
9. The outdoor unit shall be capable of operating in heating mode down to -4°F ambient temperature or cooling mode down to 23°F ambient temperature, without additional low ambient controls. If an alternate manufacturer is selected, any additional material, cost, and labor to meet low ambient operating condition and performance shall be incurred by the contractor.
10. The outdoor unit shall be capable of operating in cooling mode down to -10°F with optional manufacturer supplied low ambient kit.
11. Manufacturer supplied low ambient kit shall be provided with predesigned control box rated for outdoor installation and capable of controlling kit operation automatically in all outdoor unit operation modes.
12. Manufacturer supplied low ambient kit shall be listed by Electrical Laboratories (ETL) and bear the ETL label.
13. Manufacturer supplied low ambient kit shall be factory tested in low ambient temperature chamber to ensure operation. Factory performance testing data shall be available when requested.
14. The outdoor unit shall not cease operation in any mode based solely on outdoor ambient temperature.
15. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained.
16. Unit must defrost all circuits simultaneously in order to resume full heating more quickly. Partial defrost which may extend "no or reduced heating" periods shall not be allowed.

B. Unit Cabinet:

1. The casing(s) shall be fabricated of galvanized steel, bonderized and finished. Units cabinets shall be able to withstand 960 hours per ASTM B117 criteria for seacoast protected models (-BS models)

C. Fan:

1. Each outdoor unit module shall be furnished with one direct drive, variable speed propeller type fan. The fan shall be factory set for operation under 0 in. WG external static pressure, but capable of normal operation under a maximum of 0.24 in. WG external static pressure via dipswitch.
2. All fan motors shall have inherent protection, have permanently lubricated bearings, and be completely variable speed.
3. All fan motors shall be mounted for quiet operation.
4. All fans shall be provided with a raised guard to prevent contact with moving parts.
5. The outdoor unit shall have vertical discharge airflow.

D. Refrigerant

1. R410A refrigerant shall be required for PURY-P-T/Y(S)JMU-A outdoor unit systems.

E. Coil:

1. The outdoor coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.
2. The coil fins shall have a factory applied corrosion resistant blue-fin finish.
3. The coil shall be protected with an integral metal guard.
4. Refrigerant flow from the outdoor unit shall be controlled by means of an inverter driven compressor.
5. The outdoor coil shall include 4 circuits with two position valves for each circuit, except for the last stage.

F. Compressor:

1. Each outdoor unit module shall be equipped with one inverter driven scroll hermetic compressor. Non inverter-driven compressors shall not be allowed.
2. A crankcase heater(s) shall be factory mounted on the compressor(s).
3. The outdoor unit compressor shall have an inverter to modulate capacity. The capacity shall be completely variable with a turndown of 19%-5% of rated capacity, depending upon unit size.
4. The compressor will be equipped with an internal thermal overload.
5. The compressor shall be mounted to avoid the transmission of vibration.
6. Field-installed oil equalization lines between modules are not allowed. Prior to bidding, manufacturers requiring equalization must submit oil line sizing calculations specific to each system and module placement for this project.

G. Electrical:

1. The outdoor unit electrical power shall be 208/230 volts, 3-phase, 60 hertz.
2. The outdoor unit shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz), 207-253V (230V/60Hz).
3. The outdoor unit shall be controlled by integral microprocessors.
4. The control circuit between the indoor units, BC Controller and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

3.3 BRANCH CIRCUIT (BC) CONTROLLERS FOR R2-SERIES SYSTEMS

A. General:

The BC (Branch Circuit) Controllers shall be specifically used with R410A R2-Series systems. These units shall be equipped with a circuit board that interfaces to the M-NET controls system and shall perform all functions necessary for operation. The unit shall have a galvanized steel finish. The BC Controller shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors, with access and service clearance provided for each controller. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of rated capacity.

B. BC Unit Cabinet:

1. The casing shall be fabricated of galvanized steel.
2. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.
3. The unit shall house two tube-in-tube heat exchangers.

C. Refrigerant

1. R410A refrigerant shall be required.

D. Refrigerant valves:

1. The unit shall be furnished with multiple branch circuits which can individually accommodate up to 54,000 BTUH and up to three indoor units. Branches may be twinned to allow more than 54,000 BTUH.
2. Each branch shall have multiple two-position valves to control refrigerant flow.
3. Service shut-off valves shall be field-provided/installed for each branch to allow service to any indoor unit without field interruption to overall system operation.
4. Linear electronic expansion valves shall be used to control the variable refrigerant flow.

E. Integral Drain Pan:

1. An integral condensate pan and drain shall be provided.

F. Electrical:

1. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
2. The unit shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253V (230V/60Hz).
3. The BC Controller shall be controlled by integral microprocessors.
4. The control circuit between the indoor units and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

3.4 PKFY (WALL-MOUNTED) INDOOR UNIT

A. General:

The PKFY shall be a wall-mounted indoor unit section and shall have a modulating linear expansion device and a flat front. The PKFY shall be used with the R2-Series outdoor unit and BC Controller, Y-Series outdoor unit, or S-Series outdoor unit. The PKFY shall support individual control using M-NET DDC controllers.

B. Indoor Unit

The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-

minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

C. Unit Cabinet:

1. All casings, regardless of model size, shall have the same white finish
2. Multi directional drain and refrigerant piping offering four (4) directions for refrigerant piping and two (2) directions for draining shall be standard.
3. There shall be a separate back plate which secures the unit firmly to the wall.

D. Fan:

1. The indoor fan shall be an assembly with one or two line-flow fan(s) direct driven by a single motor.
2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
3. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right).
4. A motorized air sweep louver shall provide an automatic change in airflow by directing the air up and down to provide uniform air distribution.

E. Filter:

1. Return air shall be filtered by means of an easily removable, washable filter.

F. Coil:

1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. Both refrigerant lines to the PKFY indoor units shall be insulated.

G. Electrical:

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz)

H. Controls:

1. This unit shall use controls provided by Mitsubishi Electric to perform functions necessary to operate the system. Please refer to Part 5 of this guide specification for details on controllers and other control options.
2. The unit shall be able to control external backup heat.
3. The unit shall have a factory built in receiver for wireless remote control

3.5 PEFY-NMHU (CEILING-CONCEALED DUCTED) INDOOR UNIT

A. General:

The PEFY shall be a ceiling-concealed ducted indoor fan coil design that mounts above the ceiling with a 2-position, field adjustable return and a fixed horizontal discharge supply and shall have a modulating linear expansion device. The PEFY shall be used with the R2-Series outdoor unit and BC Controller, Y-Series outdoor unit, or S-Series outdoor unit. The PEFY shall support individual control using M-NET DDC controllers.

B. Indoor Unit.

The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

C. Unit Cabinet:

1. The unit shall be, ceiling-concealed, ducted.
2. The cabinet panel shall have provisions for a field installed filtered outside air intake.

D. Fan:

1. PEFY-NMHU models shall feature external static pressure settings from 0.20 to 0.80 in. WG.
2. The indoor unit fan shall be an assembly with one or two Sirocco fan(s) direct driven by a single motor.
3. The indoor fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings.
4. The indoor fan shall consist of three (3) speeds, High, Mid, and Low plus the Auto-Fan function
5. The indoor unit shall have a ducted air outlet system and ducted return air system.

E. Filter:

1. Return air shall be filtered by means of a standard factory installed return air filter.
2. Optional return filter box (rear or bottom placement) with high-efficiency filter shall be available for all PEFY indoor units.

F. Coil:

1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.

4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. The condensate shall be gravity drained from the fan coil.
7. Both refrigerant lines to the PDFY indoor units shall be insulated.

G. Electrical:

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

H. Controls:

1. This unit shall use controls provided by Mitsubishi Electric to perform functions necessary to operate the system. Please refer to Part 5 of this guide specification for details on controllers and other control options.

3.6 PEFY-NMSU (LOW PROFILE CEILING-CONCEALED DUCTED) INDOOR UNIT

A. General:

The PEFY-NMSU (Low Profile) unit shall be a ceiling-concealed ducted indoor fan coil that mounts above the ceiling with a rear return and a fixed horizontal discharge supply and shall have a modulating linear expansion device. The PEFY-NMSU shall be used with the R2-Series outdoor unit and BC Controller, Y-Series outdoor unit, or S-Series outdoor unit. The PEFY-NMSU shall support individual control using M-NET DDC controllers. PEFY (Low Profile) models shall have an extremely compact profile (7-7/8") which requires minimal ceiling space. PEFY-NMSU models shall feature external static pressure settings up to 0.20 in. WG. Units shall have the ability to control supplemental heat via connector CN24 and a 12 VDC output.

B. Indoor Unit.

The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

C. Unit Cabinet:

1. The cabinet shall be space saving, low profile, ceiling-concealed ducted.
2. The cabinet panel shall have provisions for a field installed filtered outside air intake.

D. Fan:

1. The indoor unit fan shall be an assembly with one Sirocco fan direct driven by a single motor.
2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.

3. The indoor fan shall consist of three (3) speeds, High, Mid, and Low.
4. The indoor unit shall have a ducted air outlet system and ducted return air system.

E. Filter:

1. Return air shall be filtered by means of a standard factory installed return air filter.

F. Coil:

1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. The unit shall be provided with an integral condensate lift mechanism able to raise drain water 21 inches above the condensate pan.
7. Both refrigerant lines to the PEFY indoor units shall be insulated.

G. Electrical:

1. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

H. Controls:

1. This unit shall use controls provided by Mitsubishi Electric to perform functions necessary to operate the system. Please refer to Part 4 of this guide specification for details on controllers and other control options.

PART 4 – CONTROLS

4.1 OVERVIEW

A. General:

The CITY MULTI Controls Network (CMCN) shall be capable of supporting remote controllers, schedule timers, system controllers, centralized controllers, an integrated web based interface, graphical user workstation, and system integration to Building Management Systems via BACnet® and LonWorks®.

4.2 ELECTRICAL CHARACTERISTICS

A. General:

The CMCN shall operate at 24VDC. Controller power and communications shall be via a common non-polar communications bus.

B. Wiring:

Control wiring shall be installed in a system daisy chain configuration from indoor unit to ME remote controller to indoor unit, to the BC controller (main and subs, if applicable) and to the outdoor unit. Control wiring to remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.

Control wiring for schedule timers, system controllers, and centralized controllers shall be installed in a daisy chain configuration from outdoor unit to outdoor unit, to system controllers, to the power supply.

Control wiring for the Deluxe MA, Simple MA, and Wireless MA remote controllers shall be from the remote controller to the first associated indoor unit (TB-15) then to the remaining associated indoor units (TB-15) in a daisy chain configuration...

The AG-150A, G-50A and GB-50A system controller shall be capable of being networked with other AG-150A, G-50A and GB-50A system controllers for web based control.

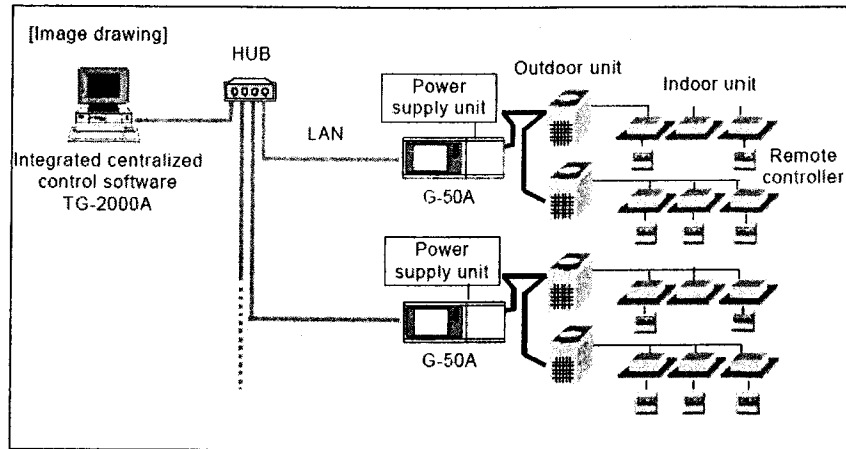
C. Wiring type:

Wiring shall be 2-conductor (16 AWG), twisted shielded pair, stranded wire, as defined by the Design Tool AutoCAD output.

Network wiring shall be CAT-5e with RJ-45 connection.

4.3 CITY MULTI CONTROLS NETWORK

The CITY MULTI Controls Network (CMCN) consists of remote controllers, schedule timers, system controllers, centralized controllers, and/or integrated web based interface communicating over a high-speed communication bus. The CITY MULTI Controls Network shall support operation monitoring, scheduling, error email distribution, personal browsers, tenant billing, online maintenance support, and integration with Building Management Systems (BMS) using either LonWorks® or BACnet® interfaces. The below figure illustrates a sample CMCN System Configuration.



CMCN System Configuration

4.4 CMCN: REMOTE CONTROLLERS

A. Deluxe MA Remote Controller (PAR-21MAA)

The Deluxe MA Remote Controller (PAR-21MAA) shall be capable of controlling up to 16 indoor units (defined as 1 group). The Deluxe MA Remote Controller shall be approximately 5" x 5" in size and white in color with a light-green LCD display. The PAR-21MAA shall support a selection from multiple languages (Spanish, German, Japanese, Chinese, English, Russian, Italian, or French) for display information. The Deluxe MA supports temperature display selection of Fahrenheit or Celsius. The Deluxe MA Remote Controller shall control the following grouped operations: On/Off, Operation Mode (cool, heat, auto (R2-Series only), dry, and fan), temperature set point, fan speed setting, and airflow direction setting. The Deluxe MA Remote Controller shall support timer settings of on/off/temperature up to 8 times in a day in 1-minute increments. The Deluxe MA Remote Controller shall support an Auto Off timer. The Deluxe MA Remote Controller shall be able to limit the set temperature range from the Deluxe MA. The room temperature shall be sensed at either the Deluxe MA Remote Controller or the Indoor Unit dependent on the indoor unit dipswitch setting. The Deluxe MA Remote Controller shall display a four-digit error code in the event of system abnormality/error.

The Deluxe MA Remote Controller shall only be used in the same group with other Deluxe MA Remote Controllers (PAR-21MAA), Wireless MA (PAR-FL32MA / PAR-FA32MA), or Simple MA Remote Controllers (PAC-YT51CRB), with up to two remote controllers per group.

The Deluxe MA Remote Controller shall require no addressing. The Deluxe MA Remote Controller shall connect using two-wire, stranded, non-polar control wire to TB15 connection terminal on the indoor unit. The PAR-21MAA shall require cross-over wiring for grouping across indoor units.

PAR-21MAA (Deluxe MA Remote Controller)			
Item	Description	Operation	Display

PAR-21MAA (Deluxe MA Remote Controller)			
Item	Description	Operation	Display
ON/OFF	Run and stop operation for a single group	Each Group	Each Group
Operation Mode	Switches between Cool/Dry/Auto/Fan/Heat. Operation modes vary depending on the air conditioner unit. Auto mode is in the R2-Series only.	Each Group	Each Group
Temperature Setting	Sets the temperature for a single group. Range of temperature setting Cool/Dry: 67°F-87°F (57°F-87°F for PEFY/PDFY/PFFY-E) Heat: 63°F-83°F (63°F-83°F for PEFY/PDFY/PFFY-E) Auto: 67°F-83°F (63°F-83°F for PEFY/PDFY/PFFY-E)	Each Group	Each Group
Fan Speed Setting	Models with 4 air flow speed settings: Hi/Mid-2/Mid-1/Low Models with 3 air flow speed settings: Hi/Mid/Low Models with 2 air flow speed settings: Hi/Low	Each Group	Each Group
Air Flow Direction Setting	Air flow direction angles 100%-80%-60%-40%, Swing, Louver ON/OFF. Air flow direction settings vary depending on the model.	Each Group	Each Group
Weekly Scheduler	ON/OFF/Temperature setting can be done up to 8 times one day in the week. The time can be set by the 1-minute interval.	Each Group	Each Group
Permit / Prohibit Local Operation	Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter). *1: Centrally Controlled is displayed on the remote controller for prohibited functions.	N/A	Each Group *1
Prohibition / Permission of Specified Mode	Setting via the System Controller, the operation for the following modes is prohibited: Cooling Prohibited: Cool, Dry, Auto Heating Prohibited: Heat, Auto Cooling-Heating Prohibited: Cool, Heat, Dry, Auto	N/A	Each Group
Display Indoor Unit Intake Temp	Measures and displays the intake temperature of the indoor unit when the indoor unit is operating.	N/A	Each Group
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed	N/A	Each Unit
Test Run	Operates air conditioner units in test run mode.	Each Group	Each Group
Ventilation Equipment	Up to 16 indoor units can be connected to an interlocked system that has one LOSSNAY unit. LOSSNAY items that can be set are "Hi", "Low", and "Stop". Ventilation mode switching is not available.	Each Group	Each Group

PAR-21MAA (Deluxe MA Remote Controller)			
Item	Description	Operation	Display
Set Temperature Range Limit	The range of room temperature setting can be limited by the initial setting. The lowest limit temperature can be made higher than the usual (67°F) in cool/dry mode, while the upper limit temperature lower than the usual (83°F) in heat mode. *Function does not work in auto mode setting	Each Group	Each Group
Auto Lock Out Function	Setting/releasing of simplified locking for remote control buttons can be performed. <ul style="list-style-type: none"> • Locking of all buttons • Locking of all buttons except ON/OFF button 	Each Group	Each Group

A. AG-150A Centralized Controller

The AG-150A Centralized Controller shall be capable of controlling a maximum of 50 indoor units across multiple CITY MULTI outdoor units. The AG-150A Centralized Controller shall be approximately 7-1/2"x12" in size and shall be powered from a Power Supply Unit (PAC-SC51KUA). The AG-150A Centralized Controller shall support operation superseding that of the remote controllers, system configuration, daily/weekly scheduling, monitoring of operation status, and malfunction monitoring. The AG-150A Centralized Controller shall have five basic operation controls which can be applied to an individual indoor unit, a group of indoor units (up to 50 indoor units), or all indoor units (collective batch operation). This basic control set of operation controls for the AG-150A Centralized Controller shall include on/off, operation mode selection (cool, heat, auto (R2-Series only), dry, and fan), temperature setting, fan speed setting, and airflow direction setting. Since the AG-150A provides centralized control it shall be able to enable or disable operation of local remote controllers. In terms of scheduling, the AG-150A Centralized Controller shall allow the user to define both daily and weekly schedules with operations consisting of ON/OFF, mode selection, temperature setting, vane direction, fan speed, and permit/prohibit of remote controllers.

AG-150A (Centralized Controller)			
Item	Description	Operation	Display
ON/OFF	Run and stop operation for a single group	Each Group or Collective	Each Group or Collective
Operation Mode	Switches between Cool/Dry/Auto/Fan/Heat. (Group of Lossnay unit: automatic ventilation/vent-heat/interchange/normal ventilation) Operation modes vary depending on the air conditioner unit. Auto mode is in the CITY MULTI R2-Series only.	Each Group or Collective	Each Group

AG-150A (Centralized Controller)			
Item	Description	Operation	Display
Temperature Setting	Sets the temperature for a single group. Range of temperature setting: Cool/Dry: 67°F-87°F (57°F-87°F for PEFY/PDFY/PFFY-E) Heat: 63°F-83°F (63°F-83°F for PEFY/PDFY/PFFY-E) Auto: 67°F-83°F (63°F-83°F for PEFY/PDFY/PFFY-E) * Range of temperature setting varies depending on the model.	Each Group or Collective	Each Group
Fan Speed Setting	Models with 4 air flow speed settings: Hi/Mid-2/Mid-1/Low Models with 3 air flow speed settings: Hi/Mid/Low Models with 2 air flow speed settings: Hi/Low	Each Group or Collective	Each Group
Air Flow Direction Setting	Air flow direction angles 100%-80%-60%-40%, Swing, *1. Louver cannot be set. Air flow direction settings vary depending on the model.	*1 Each Group or Collective	Each Group
Timer Operation	Start/Stop and Enable/Disable can be set 3 times in one day. For a week's schedule, store three start/stop patterns and one enable/disable pattern. *2 When the timer is set, "Timer Enabled" is shown on the operation setting screen of the LCD.	Each Group or Collective	*2 Each Group
Permit / Prohibit Local Operation	Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter). *3: Centrally Controlled is displayed on the remote controller for prohibited functions.	Each Group or Collective	*3 Each Group
Display Indoor Unit Intake Temp	Measures and displays the intake temperature of the indoor unit when the indoor unit is operating.	N/A	Each Group
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed *4 When an error occurs, the LED flashes. The operation monitor screen shows the abnormal unit by flashing it. The error monitor screen shows the abnormal unit address, error code and source of detection. The error log monitor screen shows the time and date, the abnormal unit address, error code and source of detection	N/A	*4 Each Unit or Collective
Test Run	Operates air conditioner units in test run mode.	Each Group	Each Group

AG-150A (Centralized Controller)			
Item	Description	Operation	Display
Ventilation Equipment	This interlocked system settings can be performed by the master system controller. When setting the interlocked system, use the ventilation switch the free plan LOSSNAY settings between "Hi", "Low" and "Stop". When setting a group of only free plan LOSSNAY units, you can switch between "Normal ventilation", "Interchange ventilation" and "Automatic ventilation".	Each Group	Each Group
External Input / Output	By using accessory cables you can set and monitor the following. Input By level: "Batch start/stop", "Batch emergency stop" By pulse: "batch start/stop", "Enable/disable remote controller" Output: "start/stop", "error/Normal" *5: Requires the external I/O cables (PAC-YG10HA-E) sold separately.	*5 Collective	*5 Collective

- B. All AG-150A Centralized Controllers shall be equipped with one RJ-45 Ethernet port to support interconnection with a network PC via a closed/direct Local Area Network (LAN).

The AG-150A Centralized Controller shall be capable of performing initial settings via the 9" high-resolution, backlit, color touch panel on the controller or via a PC using the AG-150A Centralized Controller's initial setting browser.

Optional software functions shall be available so that the building manager can securely log into each AG-150A via the PC's web browser to support operation monitoring, scheduling, error email, personal browser for PCs and MACs, and online maintenance diagnostics. Additional optional software functions of Tenant Billing shall be available but shall require TG-2000 Integrated System software in conjunction with AG-150A Centralized Controllers. BACnet[®] interface shall be available through software operating on a dedicated PC and a AG-150A license. The optional software functions shall require advance purchasing and can only be activated upon receipt of a license number from Mitsubishi Electric HVAC.

4.5 CMCN: SYSTEM INTEGRATION

The CMCN shall be capable of supporting integration with Building Management Systems (BMS) via our LonWorks[®] and BACnet[®] interfaces.

- A. LMAP03U: LonWorks[®] Interface

The Mitsubishi Electric HVAC LonWorks[®] interface, LMAP03U, shall support up to fifty indoor units with a variety of network variables on a per indoor unit basis. Input variables include, but are not limited to, on/off, operation mode, fan speed, prohibit remote controller, and filter sign reset. Output variables include, but are not limited to, model size, alarm state, error code, and error address.

4.6 POWER SUPPLY (PAC-SC51KUA)

- A. The power supply shall supply 24VDC (TB 3) for the AG-150 centralized controller and 24VDC (TB 2) voltage for the central control transmission.

4.7 MR. SLIM M-SERIES AND P-SERIES CONTROL

- A. The CMCN shall have the capability of controlling and monitoring the Mitsubishi Electric Mr. Slim MSY and MSZ units through the use of an adaptor to allow the MSY and MSZ units to communication on the M-Net communication bus.
- B. The CMCN shall have the capability of controlling and monitoring the Mitsubishi Electric Mr. Slim PUY and PUZ units through the use of an adaptor to allow the PUY and PUZ units to communication on the M-Net communication bus.

END OF SECTION

SECTION 26 00 10

BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE

- A. This section supplements all sections of this division and shall apply to all phases of work hereinafter specified, shown on the drawings, or required to provide a complete installation of electrical systems for the Project. The work required under this division is not limited to the electrical specifications and drawings. Refer to all bid documents including Site, Architectural, Structural, and Mechanical documents which may designate Work to be accomplished. The intent of the Specifications is to provide a complete and operable electrical system which shall include all documents which are a part of the Contract.
 - 1. Work included: Furnish all labor, material, tools, equipment, facilities, transportation, skilled supervision necessary for, and incidental to, performing operations in connection with furnishing, delivery, and installation of the work in this division complete as shown or noted on the Drawings and specified herein.
- B. Related Work Specified Elsewhere:
 - 1. Refer to all sections in the general contract conditions, Contract Requirements and Division 1, General Requirements.
- C. Work Installed but Furnished by Others:
 - 1. The electrical work includes the installation or connection of certain materials and equipment furnished by others. Verify installation details. Foundations for apparatus and equipment will be furnished by others unless otherwise noted or detailed.

1.2 GENERAL REQUIREMENTS

- A. Guarantee See General Conditions:
 - 1. Except as may be specified under other Sections in the specification, guarantee equipment furnished under the specifications for a period of one year, except for equipment required to have a longer guarantee period, from date of final completion. Guarantee all work against defective workmanship, material, and improper installation. Upon notification of failure, correct deficiency immediately and without additional cost to the Owner.
 - 2. Standard warranty of manufacturer shall apply for replacement of parts after expiration of the above period. Manufacturer shall furnish replacement parts to the Owner or his service agency as approved. Furnish to the Owner, through the Architect, printed manufacturer's

warranties complete with material included and expiration dates, upon completion of project. Conform to Division 01.

- B. **Equipment Safety:** All electrical materials and equipment shall be new and shall be listed by Underwriter's Laboratories and bear their label, or listed and certified by a nationally recognized testing authority where UL does not have an approval. Custom made equipment must have complete test data submitted by the manufacturer attesting to its safety.
- C. **Codes and Regulations:**
 - 1. Design, manufacturer, testing and method of installation of all apparatus and materials furnished under the requirements of these specifications shall conform to the latest publications or standard rules of the following:
 - a. Institute of Electrical and Electronic Engineers - IEEE
 - b. National Electrical Manufacturers' Association - NEMA
 - c. Underwriters' Laboratories, Inc. - UL
 - d. National Fire Protection Association - NFPA
 - e. American Society for Testing and Materials - ASTM
 - f. American National Standards Institute - ANSI
 - g. California Electrical Code – CEC, Title 24, Part 3
 - h. California Code of Regulations, Title 8, Subchapter 5
 - i. California Building Code-CBC, Title 24 Parts 1 &2
 - j. State & Municipal Codes in Force in the Specific Project Area
 - k. Occupational Safety & Health Administration – OSHA
 - l. California State Fire Marshal.
 - m. California Fire Code- CFC, Title 24 Part 9
 - 2. The term "Code", when used within the specifications, shall refer to the Publications, Standards, ordinances and codes, listed above. In the case where the codes have different levels of requirements the most stringent rules shall apply.
- D. **Requirements of Regulatory Agencies:**
 - 1. **Codes, Permits, and Fees:** Where the Contract Documents exceed minimum requirements, the Contract Documents take precedence. Where code conflicts occur, the most stringent shall apply. The most stringent condition shall be as interpreted by the Engineer.
 - a. Comply with all requirements for permits, licenses, fees and Code. Permits, licenses, fees, inspections and arrangements required for the Work shall be obtained by the Contractor at his expense, unless otherwise specified.
 - b. Comply with the requirements of the applicable utility companies serving the Project. Make all arrangements with the utility companies for proper coordination of the Work.
- E. **Shop Drawings:**
 - 1. See Division 01 for additional requirements.

2. Time Schedules for Submission and Ordering: The Contractor shall prepare, review and coordinate his schedule of submissions carefully, determining the necessary lead time for preparing, submitting, checking, ordering and delivery of materials and equipment for timely arrival. The Contractor shall be responsible for conformance with the overall construction schedule.
 3. Submittals will be checked for general compliance with specifications only. The Contractor shall be responsible for deviations from the drawings or specifications and for errors or omissions of any sort in submittals.
 4. Submit a complete list of materials and equipment proposed for the job, including manufacturers names and catalog numbers.
 5. Shop drawings shall be submitted in completed groups of materials (i.e., lighting fixtures or switchgear). The Contractor shall add and sign the following paragraph on equipment and materials submitted for review. "It is hereby certified that the (equipment) (material) shown and marked in this submittal is that proposed to be incorporated into the project; is in compliance with the Contract Drawings and specifications and can be installed in the allocated spaces". Failure to add the above written statement for compliance will result in return of submittals without review.
 - a. Bind catalog cuts, plate numbers, descriptive bulletins and drawings, 11" x 17" or smaller, in sets with covers neatly showing titles.
 - b. The Contractor shall verify dimensions of equipment and be satisfied as to Code compliance for fit prior to submitting shop drawings for approval.
 - c. Where current limiting devices are specified, submit technical data to substantiate adequate protection of equipment cascaded downstream. Submittals shall not be reviewed unless supporting calculations and data are submitted therewith.
 - d. Include complete catalog information such as construction, ratings, insulation systems, as applicable.
 - e. For any material specified to meet UL or trade standards, furnish the manufacturer's or vendor's certification that the material furnished for the work does in fact equal or exceed such specifications.
 - f. Reference listings to the specifications' Sections and Article to which each is applicable.
 - g. Equipment Floor Plans: After approval of material is secured prepare a floor plan of each electrical and communication equipment space, room or yard, drawn to scale at 1/2 inch equals 1 foot and submit for approval in the same manner as for shop drawings. The layout drawings shall be exact scale.
 6. Contractor shall prepare coordinated drawings when required by Division 01.
- F. Interpretations: Requests for interpretations of drawings and specifications must be made by the Contractor through DCGA. Any such requests made by equipment manufacturers or suppliers will be referred to the Contractor.

G. Standard of Quality

1. The contract Drawings and Specifications establish the "MINIMUM STANDARD OF QUALITY" each product and/or system must meet to be considered acceptable. Products of other manufactures will be considered if the product and/or system meet or exceed the "MINIMUM STANDARD OF QUALITY" established by this Contract Document.

H. Submit comprehensive material list, shop drawings and complete technical data for the following equipment and materials:

1. General Requirements:

- a. Transformers
- b. Panelboards.
- c. Conduits
- d. Conductors, include all selected insulation types.
- e. Fuses
- f. Disconnect switches
- g. Control devices, standard and special receptacles, switches, outlets and finish device plates.

J. Record Drawings: Refer to Division 01 and 1.3 of this section.

K. Work Responsibilities:

1. The drawings indicate diagrammatically the desired locations or arrangement of conduit runs, outlets, junction boxes and equipment and are to be followed. Execute the work so as to secure the best possible installation in the available space and to overcome local difficulties due to space limitations. The Contractor is responsible for the correct placing of his work. Where conflicts occur in plans and/or specifications, the most stringent application shall apply and shall be part of the base bid.
2. Locations shown on architectural plan or on wall elevations shall take precedence over electrical plan locations, but where a major conflict is evident, notify DCGA.
3. In the event minor changes in the indicated locations or arrangement are necessary due to developed conditions in the building construction or rearrangement of furnishings or equipment or due to interference with other trades, such changes shall be made without extra cost.
4. Verify dimensions and the correct location of Owner-Furnished equipment before proceeding with the roughing-in of connections.
5. All scaled and figured dimensions are approximate of typical equipment of the class indicated. Before proceeding with work carefully check and verify dimensions and sizes with the drawings to see that the furnished equipment will fit into the spaces provided without violation of applicable Codes.
6. Should any changes to the work indicated on the drawings or described in the specifications be necessary in order to comply with the above requirements, notify DCGA.

7. Contractor shall be responsible for coordination of coordinated drawings when required by the DCGA.
 8. Replace or repair, without additional compensation any work which does not comply with or which is installed in violation of any of these requirements.
- L. Installation General: For special requirements, refer to specific equipment under these requirements.
1. Unless otherwise specified elsewhere in the specifications, do all excavating necessary for the proper installation of the electrical work.
 2. Locations of Openings: Locate chases, shafts and openings required for the installation of the electrical work during framing of the structure. Do any additional cutting and patching required. Cutting or drilling in any structural member is prohibited without approval of the Architect. Furnish all access panels to make all boxes, connections and devices accessible as required by CEC.
 3. Location of Sleeves: Where conduits pass through concrete walls, suspended slabs or metal deck floors, install sleeves of adequate size to permit installation of conduit. Sleeves shall be installed prior to pouring of concrete and shall have ends flush with the wall or extend 2 inches above floor surfaces. Verify locations.
 4. Type of Sleeves: Sleeves shall be steel pipe.
 5. Finish Around Sleeves: Rough edges shall be finished smooth. Space between conduit and sleeves where conduit passes through exterior walls shall be sealed to permit movement of conduit, but prevent entrance of water. Space between conduit and sleeves where conduit passes through fire rated interior walls and slabs shall be sealed with approved materials to provide a fire barrier conforming to the requirements of the governing authorities having jurisdiction, using UL Approved Firestopping Systems.
 6. Wherever conduit extends through roof, install flashings in accordance with drawings and details.
 7. Contractor shall be responsible for cutting and patching which may be required for the proper installation of the electrical work.
 8. Protect work, materials and equipment cause whatever and provide adequate and proper storage facilities during the progress of the work. Storage outdoors shall be weather protected and shall include space heaters to prevent condensation. Provide for the safety and good condition of all work until final acceptance of the work. Replace all damaged or defective work, materials and equipment before requesting final acceptance.
 9. Conduit and Equipment to be Installed: Clean thoroughly to remove plaster, spattered paint, cement and dirt on both exterior and interior. All underground conduit shall be mandrelled prior to pulling wire.
 10. Conduit and Equipment to be Painted: Clean conduit exposed to view in completed structure by removing plaster and dirt. Remove grease, oil and similar material from conduit and equipment by wiping with clean rags and suitable solvents in preparation for paint.

11. Items with Factory Finish: Remove cement, plaster, grease and oil, and leave surfaces, including cracks and corners, clean and polished. Touch up scratched or bare spots to match finish.
12. Site Cleaning: Remove from site all packing cartons, scrap materials and other rubbish on a weekly basis. Vacuum out all cabinets, switchgear and panels prior to pulling any conductors.
13. Electrical equipment and materials exposed to public and in finished areas shall be finish-painted after installation in accordance with the Painting Section. All exposed screw-type fasteners, exterior, or interior in restrooms, shall be vandal-resistant spanner type; include tool.

M. Excavation, Cutting and Patching:

1. Excavating, trenching and backfilling required for the work of this Division in accordance with the applicable requirements of Division 02. Excavating and backfilling connected with electrical work, repaving cuts and providing and maintaining protective measures for the electrical work excavation required by the governing authorities having jurisdiction shall be performed as a part of the work of this Division.
2. Verify openings indicated on the drawings. Provide all cutting, patching and reinforcement of the construction of the building as required to install electrical work.

N. Tests

1. Equipment and systems for which the National Electrical Testing Association (NETA) has an approved or recommended procedure, shall be tested in accordance with that procedure. Test values shall equal values recommended by NETA. Copies of test reports shall be submitted as required under shop drawing submittals.
2. Resistance to ground tests shall be accomplished by a qualified independent testing firm to measure resistance to ground at grounding electrodes. Make tests before slabs or affected areas are poured in order that corrective measures, if required, may be taken. Submit a report showing the results of these measurements. If the resistances exceed values specified elsewhere or NETA test procedure recommendations, perform corrective measures required to reduce resistance to acceptable values.
3. Prior to energizing any motor, measure the service voltage for phase balance and report if unbalance exceeds 1% from mean.
4. Measure the three-phase voltage at no load and at maximum load conditions and submit to the engineer a report showing the results of these measurements.
5. Upon completion of the work and adjustment of all equipment, conduct an operating test. Conduct the test in the presence of an authorized representative of the Architect. Demonstrate system and equipment to operate in accordance with requirements of the Contract Documents and to be free from electrical and mechanical defects. Provide systems free from short circuits and grounds and show an insulation resistance between phase conductors and ground not less than the requirements of the governing electric code. Test circuits for proper neutral connection.

6. Complete tests prior to final inspection of project, including corrective work based on the results of the tests.
 7. Perform special tests on systems and equipment as specified herein using personnel qualified to perform such tests.
- O. Protection: Protect finish parts of the materials and equipment against damage during the progress of the work and until final completion and acceptance. Cover materials and equipment in storage and during construction in such a manner that no finished surfaces will be damaged or marred. Keep moving parts clean, dry and lubricated.
- P. Cleaning Up:
1. Upon completion of the work and at various time during the progress of the work, remove from the building all surplus materials, rubbish and debris resulting from the work of this Division.
 2. Thoroughly clean switchgear including busses, apparatus, exposed conduit, metal work including the exterior and interior, and accessories for the work of this Division, of cement, plaster and other deleterious materials; remove grease and oil spots with cleaning solvent; carefully wipe surfaces and scrape cracks and corners clean.
 3. Thoroughly polish chromium or plated work. Remove dirt and stains from lighting fixtures.
 4. Leave the entire installation in a clean condition.
- Q. Completion:
1. The work will not be reviewed for final acceptance until operating and maintenance data, manufacturer's literature, panel directories and nameplates specified herein have been approved and properly posted or installed and final cleaning of equipment and premises has been completed.
 2. When the installation is complete and adjustments have been made, operate the system for a period of one week, during which time demonstrate that systems are completed and operating in conformance with the specifications.
- R. Operating and Maintenance Data: Submit complete and at one time, prior to acceptance of the installation, 4 copies of manufacturer's instructions for operation and maintenance of electrical equipment, including replacement parts lists, As specified in Division 01.
- S. Inspection and Acceptance Procedures: DCGA will submit observation reports periodically during the construction phase detailing Contract deficiencies. The Contractor is responsible for making corrections immediately. Notice of Completion of the project will not be made until all items have been corrected.
- T. Final Completion of Electrical Systems:
1. Prior to Final Completion of operating electrical systems, the Contractor shall:

- a. Provide materials of the type and quality specified and as necessary for proper operation, tested and ready for use.
- b. Deliver to DCGA, the Project Record Drawings per Division 01 and 1.3 below minimum.
- c. Furnish the required Operating and Maintenance Data/Manuals.
- d. Clean up of the project pertaining to this Division of the work.
- e. After installation has been completed and adjustments made, operate the system for a period of one week, during which time, demonstrate to DCGA that systems are complete and operating in conformance with Contract Documents.
- f. Conduct tests required and as specified in this Division and submit test reports and corrective actions taken.
- g. Submission of warranties and guarantees.

2. Final Completion of Work Shall be Contingent On:

- a. Contractor replacing defective materials and workmanship.
- b. Upon completion of work and adjustments made, Contractor shall conduct an operating test for each system for approval at such time as DCGA directs. Conduct test in presence of authorized representative of DCGA and demonstrate that systems and equipment do operate in accordance with requirements of the Contract Documents and are free from electrical and mechanical defects.
- c. Contractor shall provide the necessary training programs and instructions to the Owner's representative. Number of hours shall be a minimum of four (4) hours for each system or days as required under separate Sections of these Specifications. Complete operation and maintenance manuals shall be provided at least two (2) weeks prior to training.
- d. Submit copies of manufacturer's instructions and maintenance of electrical equipment including replacement parts lists. Each set shall include one set of shop drawings of equipment installed.

U. Submittals for Change Orders: When changes are made during the construction phase, deletions and additions shall be presented in a manner that will indicate the cost of each item of material and corresponding labor. Markup shall be then added in accordance with the requirements of the General Conditions as modified by the Supplementary Conditions.

V. The Contractor at a time convenient to the Owner shall provide instruction to the Owner's operating personnel in the proper operation and maintenance of all equipment and systems. The instructors shall have received factory training and shall be thoroughly familiar with the equipment installed. The operating personnel shall receive the number of days instruction as indicated in other sections.

1.3 ELECTRICAL PROJECT RECORD DOCUMENTS

A. Record Drawings: CAD: Use a computer aided drafting (CAD) system in the preparation of record drawings for this Project. Acceptable CAD systems shall be capable of producing files in AutoCAD Version 2004 compatible DWG or DXF

format. Owner's consultant will furnish CAD backgrounds for use by the Contractor after construction is 90% complete except where prohibited by Contract.

- B. At all times when the work is in progress, maintain at the workplace, fabrication shop or Project Site as applies, a complete separate, clean, undamaged set of the latest stamped, actioned submittals. As work progresses, maintain records of "as installed" conditions on this set in suitable ink or chemical fluid. Update the set daily. After successful completion of Project Site testing specified herein, and after completion of Punch List corrections, copy all records of "as installed" conditions on to originals.
- C. Quantity:
 - 1. Review sets: As for Shop and Field Drawings.
 - 2. Record set: Three (3) blackline.
One (1) mylar.
- D. Format: Record Drawings:
 - 1. Pencil, permanent ink or permanent photographic process.
 - a. Front face only of Mylar at least 3.0 mils thick.
 - b. Appliqué film or lettering prohibited.
 - c. Suitable for microfilming. Lettering 1/8" (.8 mm) high minimum.
 - 2. Disk copy of Record Drawings - 1 copy of each drawing file in format noted above, CD-ROM.
- E. Content: All drawings required under "Field and Shop Drawings". Show "as installed" condition. Where room designations according to Project permanent signage differ from construction designations in the Contract Documents, show both designations.
- F. Warranty Certificates: Comply with Division 01.

PART 2 - PRODUCTS

Not Used

PART3 - EXECUTION

Not Used

END OF SECTION

SECTION 26 01 11

CONDUIT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Rigid metal conduit and fittings.
- B. Intermediate metal conduit and fittings.
- C. Electrical metallic tubing and fittings.
- D. Flexible metal conduit and fittings.
- E. Non-metallic conduit and fittings.
- F. Intermediate metal conduit and fittings.

1.2 REFERENCES

- A. ANSI C80.1 - Rigid Steel Conduit, Zinc Coated.
- B. ANSI C80.3 - Electrical Metallic Tubing, Zinc Coated.
- C. ANSI/NEMA FB 1 - Fittings and Supports for Conduit and Cable Assemblies.
- D. ANSI/NFPA 70 - National Electrical Code.
- E. CEC - California Electrical Code..
- F. NEMA RN 1 - Polyvinyl Chloride (PVC) Externally-Coated Galvanized Rigid Steel Conduit and Electrical Metallic Tubing.
- G. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.
- H. FS-WW-C-581 - Specification for Galvanized Rigid Conduit.
- I. FS-WW-C-566 - Specification for Flexible Metal Conduit.
- J. FS-WC-1094A - Electrical Non-Metallic Conduit.
- K. NEMA-TC-2 - Electrical Plastic Tubing and Conduit.

1.3 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect, and handle Products to site under provisions of Section 260010.

- B. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.
- C. Protect PVC conduit from sunlight.

1.4 PROJECT CONDITIONS

- A. Verify that field measurements are as shown on Drawings.
- B. Verify routing and termination locations of conduit prior to rough-in.
- C. Conduit routing is shown on Drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

PART 2 - PRODUCTS

2.1 CONDUIT REQUIREMENTS

- A. Minimum Size: 1/2 inch for above ground and 1 inch minimum for underground installations unless otherwise specified.
- B. Conduit Installation Schedule:
 - 1. Underground conduit more than five feet from foundation wall shall be concrete encased non-metallic PVC Schedule 40 heavy wall rigid conduit.
 - 2. Underground conduit under four inch minimum concrete floor slab shall be PVC Schedule 40 heavy wall rigid conduit.
 - 3. All telecommunication conduit in conduit shall use rigid type, no flexible conduit is permitted.
 - 4. Conduit installed in concrete or masonry, exposed outdoor locations, damp locations, hazardous locations, or where subject to mechanical injury shall be galvanized rigid steel or intermediate metal conduit.
 - 5. Conduit installed in concealed dry interior locations such as walls or ceiling of the building shall be electrical metallic tubing or flexible type.
 - 6. Conduit installed in exposed dry interior locations above eight feet shall be electrical metallic tubing.
 - 7. Conduit installed to supply power to all mechanical equipment and rotating electric equipment shall be waterproof flexible steel conduit. Conduit shall be 12" minimum in length for 2" conduit and smaller; 18" minimum length for conduit larger than 2". Conduit shall be 36" maximum in length.
 - 8. Flexible steel conduit shall be used for power and lighting fixture connections only.

2.2 METAL CONDUIT

- A. Rigid Steel Conduit: Galvanized rigid steel; ANSI C80.1: Standard weight that is not dipped, galvanized, electrogalvanized or sheradized, both inside and out, with threaded connections and couplings is not permitted.

2.3 PVC COATED METAL CONDUIT

- A. Description: NEMA RN 1; rigid steel conduit with external PVC coating, 20 mil thick, and internal galvanized surface.
- B. Fittings and Conduit Bodies: ANSI/NEMA FB 1; threaded type, material to match conduit.

2.4 FLEXIBLE METAL CONDUIT

- A. Description: Conduit - Manufactured from single strap standard weight steel, galvanized on all four sides prior to conduit fabrication. Lightweight flexible steel conduit and aluminum flexible conduit are not acceptable. Include ground conductor in all runs.
- B. Fittings: ANSI/NEMA FB 1; Die-cast fittings of the type that screw into the inside of the conduit with threaded edges at 90 degrees to the fitting body.

2.5 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

- A. Description: Interlocked steel construction with moisture and oil-proof PVC jacket.
- B. Fittings: ANSI/NEMA FB 1: liquid tight; integral insulated throat; provisions for ground continuity.

2.6 ELECTRICAL METALLIC TUBING (EMT)

- A. Description: ANSI C80.3; galvanized tubing;
- B. Fittings and Conduit Bodies: ANSI/NEMA FB 1; steel raintight, compression, steel locking ring type with integral insulated throat.

2.7 NONMETALLIC CONDUIT

- A. Description: NEMA TC 2; Federal Spec. WC-1094A; Schedule 40 PVC.
- B. Fittings and Conduit Bodies: NEMA TC 3 to match conduit.

2.8 INNERDUCT, MULTI-CHAMBER

- A. Drawing and spec reference: Fiberoptic, Innerduct.
- B. Construction:
 - 1. Multi-Chamber or Single-Chamber 1" Innerduct shall be installed within Conduit per manufacturer's recommendation, and as described elsewhere herein.
 - 2. Shall provide independent interior chambers each with a capacity equal to a trade size conduit referenced above.

- C. Approvals:
 - 1. ASTM D2239 (1985) Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
- D. Acceptable, subject to the above:
 - 1. Aeroquip FODuct System (800) 445-2192: (Design Basis) Provide in combinations to meet scheduled requirement.
 - a. 3ID1 - Provide one (1) FoDuct PE5004 3 chamber innerduct in one-half of a 4" diameter conduit.
 - b. 2ID1.25 - Provide one (1) FODUCT PE5007 2 chamber innerduct in one-half of a 4" diameter conduit.
 - 2. North Supply Multi-Guard Multi-Cell Conduit.
 - 3. Approved equal by Tamaqua.
- E. Acceptable - Independent InnerDuct runs in overall GRC conduit - Multiple runs of single chamber inner duct may be provided in lieu of single, multiple chamber innerduct provided above. Contractor bears burden of selected innerduct quantity to provide an exact match of cross-sectional area of each chamber of multi-chamber assembly and to resize overall conduit to accommodate this use.
 - 1. Allied.
 - 2. Approved equal.

2.9 CONDUIT SUPPORTS

- A. Conduit clamps, straps, and supports: Steel or malleable iron, two-hole straps.

PART 3 - EXECUTION

3.1 CONDUIT SIZING, ARRANGEMENT AND SUPPORT

- A. The size of the conduits for the various circuits shall be as indicated on the drawings and as required by Code for the size and number of conductors to be pulled therein. Where fill is not shown on drawings, size conduit for conductor type installed or for Type THW conductors, whichever is larger; 1/2 inch minimum size. Open ends shall be capped with approved manufactured conduit seals as soon as installed and kept capped until ready to pull in conductors. Where running thread connections are necessary, only approved manufactured conduit unions shall be used. Do not embed aluminum conduit in concrete or masonry construction, nor electrical metallic tubing in slabs on grade. Do not install any conduit in any concrete slab.
- B. Arrange conduit to maintain headroom and present a neat appearance.
- C. Route exposed conduit and conduit above accessible ceilings parallel and perpendicular to walls and adjacent piping.

- D. Maintain minimum 6 inch clearance between conduit and piping. Maintain 12 inch clearance between conduit and heat sources such as flues, steam pipes, and heating appliances.
- E. Arrange conduit supports to prevent distortion of alignment by wire pulling operations. Fasten conduit using galvanized straps, lay-in adjustable hangers, clevis hangers, or bolted split stamped galvanized hangers. Maintain 12" distance minimum between main conduit runners and ceiling system grid.
- F. Group conduit in parallel runs where practical and use conduit rack constructed of steel channel with conduit straps or clamps. Provide space for 25 percent additional conduit.
- G. Do not fasten conduit with wire or perforated pipe straps. Remove all wire used for temporary conduit support during construction, before conductors are pulled.
- H. Support conduits 1 inch and larger with pipe clamps either suspended from structural slabs with a rod with adjustable pipe ring, or mounted on wall from channel supports. Attach to concrete by expansion anchors. Powder actuated fastening devices are not permitted. Where two or more conduits 1-1/2 inch and larger or where 3 or more 3/4 inch conduits are suspended from ceiling, use trapeze type hanger from rods.
- I. Firmly support and fasten conduit in place. Support rigid metal conduit and electrical cabinet and fitting. Support flexible metal conduit at maximum intervals of 4 feet and within 12 inch of every outlet box and fitting except for lengths of not over 2 feet at connections where flexibility is required.
- J. Secure exposed conduit runs of concrete, plaster or other construction in place with cast conduit clamps affixed with expansion anchors or cadmium plated machine or lag screws.
- K. Do not strap or fasten rigid or electrical metallic tubing to mechanical equipment or to equipment subject to vibration or mounted on shock absorbing bases, including sprinkler or pneumatic pipe or tubing.
- L. Provide independent support for conduit rising from floor for motor connection if over 18 inches above floor. Do not attach to motors, ductwork or mechanical equipment.
- M. Conduits 1 inch and smaller which are installed above suspended ceilings shall not be secured to ceiling support wires. Support electrical, communication conduits and fixtures independent of ceiling suspension systems.
- N. Exposed conduits to view shall be installed parallel to and perpendicular to the building structure.
- O. Tag empty conduits at each accessible end with a permanent tag identifying the purpose of the conduit and the location of the other end. In wet, corrosive outdoor or underground locations, use brass, bronze, or copper 16 gage tags or lead tags secured to conduit ends with #16 or larger galvanized wire. Inscribe on the tags with steel punch dies clear and complete identifying information.

P. Bends:

1. Raceways for Sound System, Telephone System, LAN, and Video System cables shall be designed for the installation of Fiber Optic cable.
2. All bends or elbows shall have a minimum radius as follows:

Conduit Size (inches)	Min. Radius (inches)
3/4	12
1	12
1-1/4	18
1-1/2	
2	24
2-1/2	24
Conduit Size (inches)	Min. Radius (inches)
3	36
3-1/2	36
4	48
5	48
6	48

- 3.2 Use factory ells at conduit bends 1-1/4" and larger. Alternative method: Use of precision conduit bending machine equivalent to Greenlee 'One Shot' or 'Smart Bender'.
- A. Boxes where the cable changes direction shall be large enough to allow cables in the box to have a 12" minimum radius.
 - B. Make bends and offsets so the inside diameter is not effectively reduced. Make bends in parallel or banked runs from the same center line so that the bends are parallel.

3.3 CONDUIT INSTALLATION

- A. Cut conduit square using a saw or pipe cutter; de-burr cut ends.
- B. Bring conduit to the shoulder of fittings and couplings and fasten securely.
- C. Use conduit hubs or sealing locknuts for fastening conduit to cast boxes, and for fastening conduit to sheet metal boxes in damp or wet locations.
- D. Install no more than the equivalent of three 90-degree bends between boxes. Keep bends and offsets in conduit runs to an absolute minimum. For the serving utilities, make large radius bends to meet their requirements. Replace deformed, flattened or kinked conduit.
- E. Use conduit bodies to make sharp changes in direction, as around beams.
- F. Use hydraulic one-shot conduit bender or factory elbows for bends in conduit larger than 2 inch size.
- G. Avoid moisture traps where possible; where unavoidable, provide junction box with drain fitting at conduit low point.

- H. Use suitable conduit caps to protect installed conduit against entrance of dirt and moisture.
- I. Provide No. 12 AWG insulated conductor or suitable pull string or rope in empty conduit, except sleeves and nipples.
- J. Install expansion-deflection joints where conduit crosses building expansion or seismic joints and between building and walkway covers.
- K. Where conduit penetrates fire-rated walls and floors, provide mechanical firestop fittings with UL listed fire rating equal to wall or floor rating.
- L. Route conduit through roof openings for piping and ductwork where possible; otherwise, route through roof jack with pitch pocket.
- M. Do not install conduit in slabs above grade.
- N. PVC conduit shall not be used in any locations above grade.
- O. From each panel or cabinet which is flush mounted in wall, stub from top of the panel a minimum of 5-3/4 inch conduits to the nearest accessible ceiling space or other accessible location and cap for future use unless noted otherwise on the drawings.
- P. Flexible steel conduit is permitted in concealed dry interior locations at power and lighting fixture connections only.
- Q. Seal conduit from exterior outlets at first interior junction to prevent moisture from entering the building through the conduit.
- R. Use insulating fittings on conduits where entering pullboxes, junction boxes, outlet boxes, cabinets and similar enclosures, and for signal and telephone conduits terminated in cabinets or backboards.
- S. Conduit risers and ell's through concrete shall be PVC Schedule 80 minimum.

3.4 UNDERGROUND DUCTBANK INSTALLATION

- A. Install top of duct bank minimum 24 inches below finished grade. Adjust depth to avoid interference with gravity flow systems of any kind. Maintain minimum 12 inch clearance between duct bank and any gravity flow system.
- B. Duct lines shall have a continuous slope downward toward manholes and away from buildings with a pitch of not less than 4 inches in 100 feet. Changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 25 feet, except that manufactured bends may be used at ends of short runs of 100 feet or less, and then only at or close to the end of run.
- C. Terminate conduit in end bell at manhole and pullbox entries.
- D. Use suitable separators and chairs installed not greater than 4 feet on centers. Band conduit together with suitable banding devices. Securely anchor conduit to prevent movement during concrete or slurry placement.

- E. Provide minimum 3 inch concrete cover at bottom, top, and sides of duct bank. Refer to Trenching section for additional information.
- F. Provide two No. 4 steel reinforcing bars in top of bank under paved areas.
- G. Encase non-metallic primary and secondary feeders, telephone, fire alarm communications and data conduit installed underground 2 inches or larger in a concrete or 2 sack slurry duct bank unless noted otherwise in the Contract Documents. Space the external surfaces of conduit within a bank a minimum of 3 inches apart except that sound, telephone, data and intercommunication circuits contained within non-metallic conduit shall have a minimum separation of 12 inches from any light or power circuits that parallel them within a bank. Use appropriate manufactured plastic spacers to insure the minimum required concrete or 2-sack slurry coverage. All concrete or slurry duct power banks shall contain a yellow warning strip 12" above ductbank. Refer to Division 02 for additional requirements.
- H. Numbers and sizes of ducts shall be as indicated. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Manufactured steel 90-degree duct bends shall be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius shall be 18 inches for ducts of less than 3-inch diameter, and 36 inches for ducts 3 inches in diameter 48 inches for ducts or greater in diameter unless noted otherwise in the Contract Documents. Long sweep bends having a minimum radius of 25 feet shall be used for a change of direction of more than 5 degrees, horizontally or vertically. Both curved and straight sections shall be used to form long sweep bends as required, but the maximum curve used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells whenever duct lines terminate in manholes, pullboxes or handholes. Duct line markers shall be provided at the ends of long duct line stubouts or for other ducts whose locations are indeterminate because of duct curvature or terminations at completely below-grade structures. In lieu of markers, a 5-mil brightly colored plastic tape not less than 3 inches in width and suitably inscribed at not more than 10 feet on centers with a continuous metallic backing and a corrosion resistant 1-mil metallic foil core to permit easy location of the duct line, shall be placed approximately 12 inches below finished grade levels of such lines.
- I. Ducts shall be kept clean of concrete or slurry, dirt or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. After a duct line is completed, a standard flexible mandrel shall be used for cleaning followed by a brush with stiff bristles. Mandrels shall be at least 12 inches long and have diameters 1/4 inch less than the inside diameter of the duct being cleaned. Pneumatic rodding may be used to draw in lead wires. A coupling recommended by the duct manufacturer shall be used whenever an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

END OF SECTION

SECTION 26 01 23
BUILDING WIRE AND CABLE

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Building wire and cable.
- B. Wiring connectors and connections.

1.2 REFERENCES

- A. ANSI/NFPA 70 - National Electrical Code.
- B. C.E.C. - California Electrical Code.

1.3 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years documented experience.

1.4 REGULATORY REQUIREMENTS

- A. Conform to requirements of C.E.C.
- B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

1.5 PROJECT CONDITIONS

- A. Verify that field measurements are as shown on Drawings.
- B. Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet Project Conditions.
- C. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

1.6 COORDINATION

- A. Determine required separation between cable and other work.
- B. Determine cable routing to avoid interference with other work.

PART 2 - PRODUCTS

2.1 BUILDING WIRE AND CABLE

- A. Description: Single conductor insulated wire, new, manufactured not more than 6 months prior to installation, with size, type of insulation, voltage rating and manufacturer's name permanently marked on outer covering at regular intervals.
- B. Conductor: Copper.
- C. Insulation Voltage Rating: 600 volts.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that interior of building has been protected from weather.
- B. Verify that mechanical work likely to damage wire and cable has been completed.

3.2 PREPARATION

- A. Completely and thoroughly swab raceway before installing wire.

3.3 WIRING METHOD

- A. Type THHN/THWN insulation for dry interior locations, in raceway.
- B. Type THWN for exterior or wet locations, in raceway.
- C. Type XLP for conductors protected by branch circuit GFI breakers.

3.4 INSTALLATION

- A. Provide conductors continuous from outlet to outlet routed through conduit and splice only at outlet or junction boxes.
- B. Circuit all feeders and branch circuits as shown on the drawings. Suggested deviation from the plans must be provided by the Architect.
- C. Install products in accordance with manufacturers instructions.
- D. Use solid conductor for feeders and branch circuits 10 AWG and smaller.
- E. Use stranded conductors for control circuits.
- F. Use conductor not smaller than 12 AWG for power and lighting circuits.
- G. Use conductor not smaller than 16 AWG for control circuits.
- H. Low voltage control wiring shall be No. 18 AWG minimum, insulated cable for each conductor. Voltage rating of cable shall be suitable for either Class I or

Class II, remote control or signal circuit, as determined by the code and the actual installation.

- I. Use 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 75 feet.
- J. Use 10 AWG conductors for 20 ampere, 277 volt branch circuits longer than 200 feet.
- K. Install all conductors in a single raceway at one time, insuring that conductors do not cross one another while being pulled into raceway. Leave sufficient cable at all fittings or boxes and prevent conductor kinks. Keep all conductors within the allowable tension and exceeding the minimum bending radius.
- L. Use suitable wire pulling lubricant for building wire 4 AWG and larger. Lubricants for wire pulling shall conform to UL requirements for the insulation and raceway material.
- M. Provide conductor supports as required by Code and recommended by the cable manufacturer. Where required, provide cable supports in vertical conduits similar to OZ Gedney Type CMT and provide the lower end of conduit with oZ Gedney Type KVF ventilators.
- N. No splicing or joints will be permitted in either feeder or branch circuits except at outlet or accessible junction boxes.
- O. Neatly train and lace wiring inside boxes, equipment, and panelboards.
- P. Clean conductor surfaces before installing lugs and connectors.
- Q. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise. Keep splices in underground junction boxes, handholes, and manholes to an absolute minimum. Where splices are necessary, use resin pressure splices and resin splicing kits manufactured by the 3M Company to totally encapsulate the splice. Arrange the splicing kit to minimize the effects of moisture.
- R. Use split bolt connectors for copper conductor splices and taps, 6 AWG and larger. Tape uninsulated conductors and connector with electrical tape to 150 percent of insulation rating of conductor.
- S. Use solderless pressure connectors with insulating covers for copper conductor splices and taps, 8 AWG and smaller.
- T. Use insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.
- U. Provide all power and control conductors, that terminate on equipment or terminal strips, with solderless lugs or tork and flanged tongue terminals. Provide T & B "Sta-kon" tongue terminal. This type conductor termination is not required when the equipment is provided with solderless connectors.

3.5 INTERFACE WITH OTHER PRODUCTS

- A. Identify wire and cable under provisions of Section 260195.
- B. Identify each conductor with its circuit number or other designation indicated on Drawings.
- C. Conductor Identification: All branch circuit conductors (No. 10 AWG and smaller) throughout the project shall be routed through conduit and shall be provided with color coded insulation as follows:

<u>208Y/120V</u>	<u>Phase</u>
Black	A
Red	B
Blue	C
White	Neutral
Green	Ground

- D. Conductors No. 8 and larger shall be black with bands of colored nonaging, plastic tape to color code the conductors, utilizing the same scheme as for branch circuits. The bands shall occur within each enclosure where a tap, splice or termination is made.
- E. Color code all control wire insulation and label each termination.

3.6 FIELD QUALITY CONTROL

- A. Inspect wire for physical damage and proper connection.
- B. Measure tightness of bolted connections and compare torque measurements with manufacturer's recommended values.
- C. Verify continuity of each branch circuit conductor.

END OF SECTION

SECTION 26 01 30

BOXES

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Wall and ceiling outlet boxes.
- B. Pull and junction boxes.

1.2 REFERENCES

- A. ANSI/NEMA FB 1 - Fittings and Supports for Conduit and Cable Assemblies..
- B. ANSI/NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- D. C.E.C.- California Electrical Code.

1.3 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 01.
- B. Accurately record actual locations and mounting heights of outlet, pull and junction boxes.

1.4 REGULATORY REQUIREMENTS

- A. Conform to requirements of C.E.C.
- B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

1.5 PROJECT CONDITIONS

- A. Verify field measurements are as shown on drawings.
- B. Electrical boxes are shown on drawings in approximate locations unless dimensioned. Install at location required for box to serve intended purpose.
- C. Exact location of all outlet boxes shall be as indicated on architectural elevations. Outlets not shown shall be coordinated with the Engineer prior to rough-in. Any outlets not coordinated, which are mounted in locations not accepted by the Engineer and Owner, shall be relocated at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 OUTLET BOXES

- A. Sheet Metal Outlet Boxes: ANSI/NEMA OS 1; galvanized steel, 4" x 4" x 1-1/2" minimum size.
 - 1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; include 1/2 inch male fixture studs where required.
- B. Cast Boxes: NEMA FB 1, Type FD, cast ferrous alloy. Provide gasketed cover by box manufacturer. Provide threaded hubs.
- C. Floor boxes: Shall be flush steel shallow type as manufactured by Wiremold RFB4 with proper mounting hardware and covers.

2.2 PULL AND JUNCTION BOXES

- A. Sheet Metal Boxes: NEMA OS 1; galvanized steel.
- B. Surface-Mounted Cast Metal Box: NEMA 250; Type 4, flat-flanged, surface-mounted junction box.
 - 1. Material: Galvanized cast iron.
 - 2. Cover: Furnish with ground flange, neoprene gasket, and stainless steel cover screws.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install electrical boxes as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections, and compliance with regulatory requirements.
- B. Install electrical box to maintain headroom and to present a neat appearance.
- C. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.
- D. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6 inches from ceiling access panel or from removable recessed luminaire.
- E. Install boxes to preserve fire resistance rating of partitions and other elements, as allowed by NFPA.
- F. Align adjacent wall-mounted outlet boxes for switches, thermostats and similar devices with each other.
- G. Use flush mounting outlet boxes in finished area.

- H. Do not install flush mounting boxes back-to-back in walls; provide minimum 6 inch separation. Provide minimum 24 inches separation in acoustic rated walls and fire-rated walls.
- I. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness. Outlet boxes on metal studs shall be attached to metal hangers, tack welded or bolted to studs; on wood studs attachment shall be with wood screws, nails are not acceptable.
- J. Use stamped steel bridges to fasten flush mounting outlet box between studs.
- K. Install flush mounting box without damaging wall insulation or reducing its effectiveness.
- L. Use adjustable steel channel fasteners for hung ceiling outlet box.
- M. Do not fasten boxes to ceiling support wires.
- N. Support boxes independently of conduit, except cast box that is connected to two rigid metal conduits both supported within 12 inches of box.
- O. Use gang box where more than one device is mounted together. Do not use sectional box.
- P. Use gang box with plaster ring for single device outlets.
- Q. Use cast outlet box in exterior locations exposed to the weather and wet locations.
- R. Large Pull Boxes: Boxes larger than 100 cubic inches in volume or 12 inches in any dimension.
 - 1. Interior Dry Locations: Use hinged enclosure under provisions of Section 260160.
 - 2. Other Locations: Use surface-mounted cast metal box.
- S. Open knockouts in outlet boxes only where required for inserting conduit.
- T. All boxes and panels/cabinets shall be covered with cardboard and duct tape to keep plaster and dirt from entering box or panels. All boxes shall be vacuum cleaned prior to pulling wires.
- U. All pull and junction boxes shall be clearly and permanently marked indicating the panel and circuit numbers of conductors within the box.
- V. Coordinate with architectural drawings for tackable wall covers and provide special extension rings for flush finish fit to comply with CEC 370-20.

3.2 INTERFACE WITH OTHER PRODUCTS

- A. Coordinate mounting heights and locations of outlets mounted above counters, benches and backsplashes. The Contractor shall be responsible for cut-outs in tile or counter splashes where outlet boxes are to be installed.
- B. Position outlet boxes to locate luminaires as shown on reflected ceiling plan.

3.3 ADJUSTING

- A. Adjust flush-mounting outlets to make front flush with finished wall material.
- B. Install knockout closures in unused box openings.

END OF SECTION