SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pre-TAB test data for AC-Systems.
2. Balancing Air Systems:
   a. Variable-air-volume systems.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 SUBMITTALS

A. Pre-Tab test results. Within 15 days of Contractor's Notice to Proceed, submit pre-TAB test data.

B. Strategies and Procedures Plan: Within 15 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

C. Certified TAB reports.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC or NEBB.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC or NEBB.
2. TAB Technician: Employee of the TAB contractor and who is certified by AABC or NEBB as a TAB technician.

B. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

C. TAB Report Forms: Use standard TAB contractor's forms approved by Owner's Representative.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation." All instruments shall have been calibrated and certified within 6-months of use.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

K. Examine operating safety interlocks and controls on HVAC equipment.

L. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Automatic temperature-control systems are operational.
3. Equipment and duct access doors are securely closed.
4. Balance, smoke, and fire dampers are open.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.

2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Pre-Tab Test Data: Prior to beginning any work including ordering equipment and demolition of existing equipment, the contractor shall take TAB "pre-read" test information for each AC-System. The pre-read test data shall include as a minimum:

1. Supply fan total airflow CFM and total static pressure. Tests shall be accomplished with zone VAV override to identify the system total airflow capacity. Include fan CFM, total static pressure, discharge static pressure, fan RPM, fan size and type, and motor data including HP, rated amps and running amps and amps. Include fan curves with submitted data.

2. Return/Relief fan total airflow CFM and total static pressure. Tests shall be accomplished with zone VAV and economizer at 100% OSA override to identify the system total airflow capacity. Include fan CFM, total static pressure, discharge static pressure, fan RPM, fan size and type, and motor data including HP, rated amps and running amps and amps. Include fan curves with submitted data.

3. Static pressure at AC-unit discharge and return air connections to establish total system external static pressure requirements.

4. Static pressure and airflow CFM at supply and return air ducts at 1-foot above roof penetration.

5. Submit Pre-TAB data for each AC-system. Obtain approval of Pre-TAB data prior to submittal of AC-submittal data.

B. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

C. Prepare schematic diagrams of systems' "as-built" duct layouts.

D. For variable-air-volume systems, develop a plan to simulate diversity.

E. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

F. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

G. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

H. Verify that motor starters are equipped with properly sized thermal protection.

I. Check dampers for proper position to achieve desired airflow path.

J. Check for airflow blockages.

K. Check condensate drains for proper connections and functioning.

L. Check for proper sealing of air-handling-unit components.

M. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

3.5 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust AC-Units to provide airflow and pressures equal to existing Pre-TAB airflow and pressure requirements.

B. Pressure-Independent, Variable-Air-Volume Systems: Re-balance and testing of existing terminal systems within building are not required.

a. Adjust the fan and balance the return/relief air to maintain minimum OSA and economizers.

2. Measure static pressure at supply and return air ducts.
3. Record final fan-performance data.

3.6 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.7 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Verify sequencing of compressor units.

D. Record compressor data.

3.8 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air for cooling coils.
3. Airflow.
4. Air pressure drop.

B. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.9 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.10 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 10 percent, minus 0 percent.
2. Air Outlets and Inlets: Existing to remain.
3. Outside air flow: Plus or Minus 5 percent.

3.11 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare progress reports to describe completed procedures, procedures in progress, and scheduled procedures a. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare report for each system after installation of each AC-Unit.

3.12 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Engineer's name and address.
6. Contractor's name and address.
7. Report date.
8. Signature of TAB supervisor who certifies the report.
9. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
10. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

11. Nomenclature sheets for each item of equipment.
12. Notes to explain why certain final data in the body of reports vary from indicated values.
13. Test conditions for fans performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Fan drive settings including settings and percentage of maximum pitch diameter.
    e. VFD settings for variable-air-volume systems.
    f. Settings for supply-air, static-pressure controller.
    g. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Duct, outlet, and inlet sizes.
3. Pipe and valve sizes and locations.
4. Terminal units.
5. Balancing stations.
6. Position of balancing devices.

3.13 ADDITIONAL TESTS

A. Within 30 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment. All commissioning activities and reporting shall be accomplished by the contractor. The County's Representative may witness the commissioning activities.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase controls coordination meeting.

C. Attend testing, adjusting, and balancing review and coordination meeting.

D. Participate in HVAC&R systems and equipment maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.5 CxA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

1.6 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, equipment, and controls including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, and equipment to be verified and tested.
4. Certificate of readiness, signed by the Contractor, certifying that HVAC&R systems and equipment and associated controls are ready for testing.
5. Test and inspection reports and certificates.
6. Corrective action documents.
7. Verification of testing, adjusting, and balancing reports.

1.7 SUBMITTALS

A. Certificates of readiness.

B. Certificates of completion of installation, prestart, and startup activities.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that HVAC&R systems and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 TESTING AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.

1. The CxA will notify testing and balancing Contractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
2. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes, other than sound, a deviation of more than 5 percent. Failure of more than 5 percent of selected items shall result in rejection of final testing, adjusting,

and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.

4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test. The contractor shall arrange for tests to demonstrate the entire sequence of operation including emergency shutdown and failure sequence modes. Provide additional testing as directed by the CxA.

B. Scope of HVAC&R testing shall include new AC-Unit systems and related controls including interface with related existing HVAC systems and controls. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The Contractor, along with the testing and balancing Contractor, and HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment. All testing plans shall be submitted for review and approval to the County Representative.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the project, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

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

A. HVAC&R Instrumentation and Control System Testing: Prepare testing plans. Provide technicians, instrumentation, tools, and equipment to test performance of systems and equipment at the direction of the CxA.

B. Energy Supply System Testing: Prepare testing plans. Provide technicians, instrumentation, tools, and equipment to test performance of energy systems and equipment at the direction of the CxA. Include testing of airflow systems associated with the new AC-Units.

C. Refrigeration System Testing: Prepare testing plans. Provide technicians, instrumentation, tools, and equipment to test performance of refrigerant compressors and condensers, packaged rooftop AC-Units, and other refrigeration systems.

D. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

END OF SECTION 230800

SECTION 23 09 00 - HVAC INSTRUMENTATION AND CONTROLS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, General Requirements, apply to this Section.

1.2 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for heating and cooling units supplied with factory-wired controls. This section includes:

1. Control equipment.
2. Software.
3. Sensors.
4. Control Instruments.
5. Controllers.
6. Wiring and conduit in connection with HVAC Instrumentation and Controls in accordance with Division 26.
7. Power supply to HVAC Instrumentation and Controls unless otherwise specified under Division 26.
8. Duct smoke detectors.
9. Commissioning of HVAC Instrumentation and Controls.
10. Trending and coordination with other trades for Commissioning of HVAC Systems.

B. Related Divisions include the following:

1. Division 23: Heating, Ventilating and Air Conditioning
2. Division 26: Electrical

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

B. LAN: Local area network.

C. MS/TP: Master-slave/token-passing.

D. BAS: Building Automation System

E. BACnet: Building Automation and Control Network Protocol by ASHRAE

F. BTL: BACnet Test Laboratory

G. PIO: Proportional Plus Integral Plus Derivative

H. PICS: Protocol Implementation Conformance Statement

I. RTD: Resistance Temperature Detection

J. BIBBS: BACnet Interoperability Building Blocks

K. XML: Extensible Mark-up Language

L. OBIX: Open Building Information Exchange

M. SOAP: Simple Object Access Protocol

1.4 REFERENCES

A. NFPA 90 – Installation of Air Conditioning and Ventilating Systems.

B. UL 864 – Control Units for Fire Protective Signaling Systems.

C. UL 916 – Energy Management.

D. NFPA 91A – Recommended practice for smoke control systems.

E. ADA – Americans with Disabilities Act.

F. UL 508A – Manufacturer listed control panel.

G. EIA/TIA-568 – Commercial Building Wiring Standard.

H. ASHRAE – American Society of Heating Refrigerating and Air Conditioning Engineers

I. ANSI/ASHRAE Standard 135-2008 BACnet

J. EMC Directive 89/336/EEC (European CE Mark)

1.5 SYSTEM DESCRIPTION

A. Control system consists of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

B. A distributed control system, complete with all software and hardware functions, shall be provided and installed. System shall be completely based on ANSI/ASHRAE Standard 135-2008, BACnet. This system is to control mechanical equipment specified using native BACnet-compliant components. Non-BACnet-compliant or proprietary equipment or systems shall not be acceptable and are specifically prohibited.

C. The system shall provide capability through web services. The web services shall perform through the Niagara AX Platform. Refer to Division 25.

D. Control system includes coordination with other trades from conception to completion of project to allow for a Commissioning and Operating HVAC Control System.

E. Control System includes wiring and conduit in connection with HVAC Instrumentation and Controls.

F. Control System includes the electrical power supply to HVAC Instrumentation and Controls, unless otherwise specified under Division 26. Coordinate with Electrical Contractor and other trades. Provide a complete and operational control system.

1.6 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display Time: Display graphic with minimum 20 dynamic points with current data within 10 seconds.

2. Graphic Refresh Time: Update graphic with minimum 20 dynamic points with current data within 8 seconds.

3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.

4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.

5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

9. The requirements here are stated for verification and measurement purposed and do not reduce the accuracy requirements of sensors and other components specified.

   a. Dew Point Temperature: Plus or minus 3 deg F.
   b. Relative Humidity: Plus or minus 5 percent.
   c. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
   d. Airflow (Terminal): Plus or minus 10 percent of full scale.
   e. Air Pressure (Ducts): Plus or minus 0.1-inch wg.

1.7 SUBMITTALS

A. Provide a complete and comprehensive submittal package. Partial submittals shall not be accepted. Upon completion submit all compliance data and project record documents.

B. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

   1. Each control device labeled with setting or adjustable range of control.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

   1. Wiring diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring. Indicate LAN/ BACnet and or Gateway connections.

   2. Details of control panel faces, including controls, instruments, and labeling.

   3. Written description of packaged unit sequence of operation.

   4. A floor plan indicating location of concealed duct static pressure sensors used for controlling air moving equipment.

D. BACnet PICS statements for each air handling unit controller. Indicate which points are proposed to be integrated.

E. Commissioning of building automation system.

F. Installation verification of building automation system.

G. Software and Firmware Operational Documentation: Include the following:

   1. Software operating and upgrade manuals.

   2. Program Software Backup: On a magnetic media or compact disc, complete with data files.

3. Device address list.

4. Printout of software application and graphic screens.

5. Software license required by and installed for DDC workstations and control systems.

6. Domain, Subnet, & Channel ID's.

H. Software Upgrade Kit: For Owner to use in modifying software to suit future system revisions or monitoring and control revisions.

I. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

J. Maintenance Data: For systems to include in maintenance manuals specified in Division 1. Include the following:

1. Maintenance instructions and lists of spare parts for each type of control device.

2. Interconnection wiring diagrams with identified and numbered system components and devices.

3. Keyboard illustrations and step-by-step procedures indexed for each operator function.

4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

5. Calibration records and list of set points.

K. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors. Revise Shop Drawings to reflect actual installation and operating sequences. Provide an updated floor plan indication the actual installed location of room temperature sensors and duct static pressure sensors.

L. Seventy-two (72) hour trend data.

M. HVAC Instrumentation and Controls training program.

1.8 QUALITY ASSURANCE

A. Installing Company Qualifications:

1. Five years of experience in installation of similar systems for similar projects.

2. Experience in completing a minimum of three local projects of similar size with the type of DDC system specified for this project within the last five years.

3. A Building Automation Service Department within Riverside County with a 2-hour minimum response time for emergency service.

4. Authorized Factory Representative for submitted BACnet controls product.

B. Manufacturer Qualifications: A firm experienced in manufacturing automatic temperature-control systems and with a record of successful in-service performance. The manufacturer's DDC control hardware and software shall have BACnet conformance approval from the BACnet Test Laboratory. The control system architecture shall consist of the components of one manufacturer regularly engaged in the production of open control systems and shall be the manufacturer's latest standard of design at the time of the bid.

C. Control Engineer Qualifications: A control Engineer shall oversee the design and installation of the DDC system. The Control Engineer shall have a minimum of five (5) years experience with the installing company at an equal level of responsibility. The Control Engineer shall have completed factory training for certification for the design, installation, start-up, and commissioning of the DDC components to be installed. The Control Engineer shall have experience in completing a minimum of two projects of similar size with the type of DDC system specified for this project. Removal or replacement of Control Engineer shall be subject to the owner's approval.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use. All DDC controllers for this project shall be manufactured by single manufacturer. A mixture of DDC controllers by various manufacturers shall not be allowed. All DDC controllers, building controllers and application controllers shall communicate via BACnet LAN.

E. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."

F. Comply with ASHRAE 135 for DDC system control components.

G. Control panels and cabinets installed in this project shall be UL 508A listed as a complete assembly. All electronic components and devices shall be enclosed in NEMA rated enclosures.

H. All system levels shall be compliant with the BACnet Standard 135-2008. Upon completion of commissioning process and prior to acceptance, contractor shall provide a protocol analyzer and demonstrate that all system components that communicate within the system utilize the BACnet protocol. Contractor may at their expense hire a qualified, independently registered engineer to perform test. Any components that do not fully comply with the BACnet standard shall be replaced until entire system architecture is re-tested and compliant. Conflict resolution shall be submitted to BTL (www.BACnetassociation.org) at contractor's expense and BTL determination shall be final.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

1.10 COORDINATION

A. Coordinate location of room temperature sensors, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with existing fire alarm to achieve compatibility with equipment that interfaces with that system.

C. Coordinate supply of conditioned electrical circuits for control units and operator workstation.

D. Coordinate chiller control network requirements with chiller control requirements and control system components provided with the chiller equipment.

E. Coordinate equipment to achieve compatibility with motor starters and annunciation devices.

F. Coordinate with Division 26 for Electrical Power Supply to Control Equipment and Device. Unless otherwise specified under Division 26, provide and install all the electrical wiring/conduit and components for a complete and operational control system.

1.11 WARRANTY

A. The system shall include all hardware and software components warranty for a period of one year following the substantial completion date. Provide a five-year warranty for all actuators.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. DDC Manufacturer: Subject to compliance with requirements, installing company qualifications, and manufacturer's qualifications, provide products by the following. The manufacturer shall provide DDC control hardware and software with BACnet conformance approvals from the BACnet Test Laboratory.

1. Factory Mounted Electric, Electronic, and DDC Systems for DX Packaged Units:

a. Trane, BACnet Systems (858) 576-2500
b. Climatec, BACnet Systems (858) 625-0118
c. Or approved equal vendor by County of Riverside

2.2 FRONT END COMPUTER AND GRAPHICAL USER INTERFACE

A. Computer: Provide one desktop computer for each building (total of two computers). Coordinate the specific location of the computer station for each building with Facility Management.

B. Workstation Hardware: IBM-compatible microcomputer with minimum configuration as follows. Locate workstation in the existing maintenance shop in the existing building.

1. Processor: Intel Pentium, maximum speed available at the time of installation. Minimum of 3 GHz.

2. Random-Access Memory: 8 GB RAM.

3. Hard-Disk Drive: 1 TB.

4. Tape Backup System (800 GB compressed.)

5. CD-RW Rom: 48x read and 24x write with DVD-writing capabilities.

6. Full color 21-inch flat screen.

7. I/O: 2 serial, 1 parallel, and 4 USB ports.

8. Video: Minimum 1 GB VGA or HDMI.

9. Keyboard: Expanded keyboard.

10. Mouse: 3-button optical mouse with mousepad.

11. Full color 40" wall mounted flat screen

12. Sound: Sound card with speakers.

13. Printers: Color laser printer for event logging. Minimum 25 pages per minute.

14. Accessories: 120 volt terminal strip with surge protection.

15. UPS & Emergency Battery backup for 2 hours with automatic shutoff.

C. Provide a local laptop to host the AX Web Supervisor software, trending database, and facility Graphical User Interface (GUI). The server shall support all JAVA Application Control Engines (JACE) connected to the customer's network whether local or remote.

1. Web Server / GUI Laptop Hardware Requirements:

2. Processor: Intel Quad Core, maximum speed available at the time of installation. Minimum of 3.6 GHz.

3. Random-Access Memory: 8 GB RAM.

4. Hard-Disk Drive: 1 TB – SATA, 7200 RPM.

5. CD-RW Rom: 48x read and 24x write with DVD-writing capabilities.

6. I/O: 2 serial, 1 parallel, and 4 USB ports.

7. 1 GB video card

8. Mouse: 3-button wireless optical mouse with mousepad.

9. Sound: Sound card with speakers.

10. Printers: Color laser printer for event logging. Minimum 25 pages per minute.

11. Accessories: 120 volt terminal strip with surge protection.

2.3 DDC EQUIPMENT AND SOFTWARE

A. Operator Workstation: Refer to Division 25 Integrated Automation, section 250000 Facility Management and Control System.

B. Graphics software: The graphics shall reside on the Niagara AX platform. Refer to Division 25 Integrated Automation, section 250000 Facility Management and Control System.

C. DDC Controllers

1. Communication from JACE's to DDC Controllers shall be via BACnet. Building controller shall incorporate as a minimum, the functions of a 3-way BACnet router. Controller shall route BACnet messages between the high-speed LAN (Ethernet 10/100MHz), master slave token passing (MS/TP) LANs, a point-to-point (PTP – RS-232) connection and modem.

2. Building controller shall be capable of providing global control strategies for the system based on information from any objects in the system regardless if the object is directly monitored by the controller or by another controller. The program that implements these strategies shall be completely flexible and user definable.

3. Programming shall be object-oriented using control function blocks, supporting DDC functions, 1000 Analog Values and 1000 Binary Values. All flowcharts shall be generated and automatically downloaded to controller. Programming tool shall be resident on workstation and the same tool used for all controllers.

4. Provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function may be performed via the operator's workstation or field computer.

5. Building controller shall provide battery-backed real-time (hardware) clock functions.

6. Controller shall have a memory needed to ensure high performance and data reliability. Battery shall retain static RAM memory and real-time clock functions for a minimum of 2 years (cumulative).

D. Application-Specific controllers:

1. Provide one native BACnet application specific controller for each piece of unitary mechanical equipment that adequately covers all objects listed. All controllers shall interface to building controller via MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.

E. Software Capabilities: Update to latest version of software at Project completion. Include and implement the following capabilities from the control units:

1. Units of Measure: Inch-pound and SI (metric).

2. Load Control Programs through DDC: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, and DDC with fine tuning.

3. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.

2.4 CONTROL PANELS

A. Control Panels: Unitized cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels. Provide UL 508A listed panels as a complete assembly.

1. Fabricate panels of 0.06-inch- thick, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.

2. Panel-Mounted Equipment: Temperature and humidity controllers, relays, and automatic switches; except safety devices. Mount devices with adjustments accessible through front of panel.

3. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper-positioning switches, changeover switches, thermometers, and gages.

4. Graphics: Color-coded graphic, laminated-plastic displays on doors, schematically showing system being controlled, with protective, clear plastic sheet bonded to entire door.

2.5 SENSORS AND COMMUNICATION DEVICES

A. Electronic Sensors: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated. Provide a minimum of two static pressure sensors for each packaged AHU located 2/3 downstream of the main ductwork branches.

a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
b. Output: 4 to 20 mA.
c. Duct Static-Pressure Range: 0 to 5 inches wg.

2. Gateways and Direct LAN Connections: Coordinate with HVAC equipment manufacturers, provide and install a complete and operational control Gateway and or Direct LAN connection to the HVAC equipment. Coordinate with equipment manufacturers and other trades to avoid omission or duplication and assure a complete and operating system.

B. Switches and sensors applications:

1. Status Inputs for Fans: Current sensing relay.

2. Provide and install all other components indicated for complete and operational system.

2.6 CONTROL CABLE

A. Electronic and Fiber-Optic Cable for Control Wiring: As specified in Division 26 Section "Control/Signal Transmission Media." Install control wiring in conduit except as specified under Part 3 of this section.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that duct, pipe, and equipment-mounted devices and wiring and piping are installed before proceeding with installation.

C. Obtain the manufacturer data for the proposed HVAC equipment. Verify the electric power supply requirements of control interfaces and connections. Coordinate with electrical and mechanical contractors and other trades.

3.2 INSTALLATION

A. Install DDC Controllers for a complete and operational system. Install all DDC controllers inside NEMA rated control panels.

B. Install in accordance with manufacturer's instructions and full compliance of Division 26.

C. Install control wiring and electrical work in accordance with National Electrical codes and Division 26. In addition to the requirements specified herein, the wiring installation shall meet the requirements of EIA/TIA Standard 568, Commercial Building Standard for telecommunication pathways and spaces.

D. Wiring Inside Rigid Conduit: Outdoor exposed areas and areas exposed to weather. Minimum conduit size 3/4".

E. Plenum Rated Wiring: Concealed areas above ceilings. Coordinate with electrical contractor. Support final connection wiring in accordance to National Electric Code and at every four feet. Diagonal installation shall not be accepted. Provide sleeves for wall penetrations.

F. Identification Standards:

1. Node Identification: All nodes shall be identified by a permanent label fastened to the outside of the enclosure.

2. Cable shall be labeled at a minimum of every 18" with the type of signal carried within the cable.

3. Raceway Identification: All the covers to junction and pull boxes of the control raceways shall be painted with the appropriate color.

4. Wire Identification: All low and line voltage control wiring shall be identified by a number, as referenced to the associated shop drawing and as-built drawing.

5. Control wiring color coding shall be consistent throughout this project. Coordinate with the owner and other trades. Provide communication and control wiring with proper identification and labeling. Clearly label and color code control wiring as follows:

   a. Orange: Local area network wiring.
   b. Blue: Analog and digital, input or output points.
   c. Green: Low voltage power wiring.
   d. White: Line voltage wiring, or per National Electric Codes.

G. Do not install low and line voltage wiring in the same conduit.

H. Provide and install wiring and conduit in connection with HVAC instrumentation and controls for complete operational system.

I. Provide and install electrical power supply to HVAC instrumentation and controls unless otherwise specified under Division 26. Coordinate with Division 26.

J. Install transformers inside NEMA rated control enclosures.

K. Label all control components and instruments.

L. Perform and document comprehensive testing for all control installation. Provide necessary instruments and equipment to document the results.

1. Verify that circuits are continuous and free from short circuits and grounds.

2. Verify that circuits are free from unspecified ground. The resistance to ground of all circuits shall be over 50 megaOhms.

3. Verify that circuits are free from induced voltage.

4. Provide complete testing for all cables used under this contract. Provide all equipment, tools, and personnel as necessary to conduct these tests.

5. Provide for complete grounding of all signal and communication cables, panels, and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

M. Installation Quality Requirements: In addition to the requirements of Division 26, manufacturer's recommendation and National Electric Codes, provide installation quality requirements specified here for a complete and operational control system.

1. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.

2. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

3. Provide firestopping for all penetrations.

4. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.

5. All wiring passing through penetrations, including walls, shall be in conduit or enclosed raceway.

6. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

7. No penetrations in structural elements shall be made before receipt of written approval from the architect.

3.3 HVAC INSTRUMENTATION AND CONTROLS TRAINING PROGRAM

A. Develop a comprehensive effective training program. Submit for approval.

B. Field Training of Operators: In addition to other training requirements specified elsewhere, upon completion of work under this section and upon owner's acceptance provide 16 hours of formal classroom training for owners operators. The training shall be conducted by factory trained control engineers and technicians. This training shall be provided in 8 hour sessions at a time. A factory certified trainer shall be present during the training. Provide handouts and audio visual programs as required.

C. Provide a professionally prepared 2-hour custom digital videotape summarizing the entire training program required for this section of this project. Production and preparation of the video tape shall be by a third party company specializing in commercial training programs. Provide electronic segmentation of the videotape with index for ease of use by the Operators. As a minimum, provide one section for each type of system and each graphic screen of the Operator's Workstation. Each segment shall be three to five minutes.

3.4 COMMISSIONING OF BUILDING AUTOMATION SYSTEM

A. Commissioning per ASHRAE Standards. Commissioning Report shall include the following:

1. Seventy-two (72) hour Trend Data.

2. Installation Verification of Building Automation System.

B. Refer to Mechanical Commissioning Section. Coordinate and provide the required expertise and services for a complete commissioning process. Coordinate with all other trades for a complete commissioned system. Coordinate with the commissioning authority.

C. Documents results in Standard Forms recommended by DDC manufacturer or other established organizations. Comply with the similar standards established by AABC, NEBB or ASHRAE. Obtain approval prior to commencement of the work.

D. Attend the monthly commissioning meeting. Coordinate with the commissioning authority of the project.

E. Provide seasonal simulation to allow for a complete and operating system throughout the year. Provide a comprehensive building automation re-commissioning within 6 months of installation for seasonal adjustment.

F. The Control Contractor's Engineer shall be present on-site for all commissioning activities involving equipment and systems controlled and monitored by the DDC system. In addition, provide no less than 45 working days for on-site support during the functional performance test.

3.5 SEVENTY-TWO (72) HOUR TREND DATA

A. Upon completion after project provide a seventy-two (72) hour data indicating complete operation of DDC System. Final acceptance of the completion of the DDC shall be based upon the seventy-two (72) hour Trend Data. The Trend Data shall be in form of color Trend Graph. Provide Trend Data of all temperatures, air- and water- flow quantities, and equipment status points. This shall include room, outside air, chilled water, heating hot water, condensing water temperatures and set points. Trend data shall also include duct and pipe pressures and set points. The trend data shall also include variable frequency drive speed and frequency. It shall also include outside, return and supply air quantities and position of dampers. Provide trend data for kW meter and chiller operation. Submit specified list of points and graphic format of trending for approval prior to commencement of 72-hour trending. Coordinate with commissioning agent.

B. Provide additional (72) hour trend data as required until full compliance.

C. A factory-trained control technician with minimum of 3 years experience shall be physically present at the jobsite from 8:00 am to 5:00 pm during every 72 hour trending process until final acceptance.

D. Upon completion submit the results indicating compliance in one complete package. Submit 6 sets.

3.6 INSTALLATION VERIFICATION OF BUILDING AUTOMATION SYSTEM

A. CONTROLLER VERIFICATION: Perform verification procedure on each DDC controller prior to software installation and prior to commencement of point to point check-out.

B. Verify installation of labels and nameplates to identify control components according to Division 23.

C. Verify installation of hydronic instrument wells, valves, and other accessories according to Division 23.

D. Document results in Standard Forms recommended by DDC manufacturer or other established organizations. Comply with similar standards established by NEBB or ASHRAE. Obtain approval prior to commencement of the work.

E. Upon completion submit the results indicating compliance.

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.

3. Calibration test electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

B. Engage a factory-authorized service representative to perform startup service.

C. Replace damaged or malfunctioning controls and equipment.

1. Start, test, and adjust control systems.

2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.

3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

D. Verify DDC as follows:

1. Verify software including automatic restart, control sequences, scheduling, reset controls, and occupied/unoccupied cycles.

2. Verify operation of operator workstation.

3. Verify local control units including self-diagnostics.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain control systems and components.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.

2. Provide operator training on data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs. In addition to training requirements specified elsewhere, include a minimum of 32 hours' dedicated factory instructor time on-site.

3. Review data in maintenance manuals. Refer to Division 1 Section "Contract Closeout."

4. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."

5. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.9 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of occupancy date based on the State Fire Marshall Permit, provide up to six Project site visits (up to 8 hours each), when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

END OF SECTION

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Rectangular ducts and fittings.
2. Sheet metal materials.
3. Sealants and gaskets.
4. Hangers and supports.
5. 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.

1.3 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. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems.".

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 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. Elevation of top of ducts.
3. Dimensions of main duct runs from building grid lines.
4. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
5. Supports, including methods for duct and building attachment and seismic restraints,.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

D. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.

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 Duct Seal Class-A and Duct Leakage Class-6. Seal all Joints and longitudinal seams.

B. Provide double wall duct construction with 2-inch insulation between inner and outer walls.

2.2 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: G60 (Z180).
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. 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.

2.3 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.

2.4 HANGERS AND SUPPORTS

A. Hanger Rods: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

2.5 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, 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.

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. 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.

D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.

E. 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. Provide slope top and cross bracing for exterior ducts to assure rain runoff without standing water.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.4 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.

C. 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.

3.5 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."

B. Select seismic-restraint devices with capacities adequate to carry 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.

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.

3.6 CONNECTIONS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

3.8 START UP

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

END OF SECTION 233113

SECTION 237413 - PACKAGED, OUTDOOR, VAV AIRCONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:

1. Direct-expansion cooling.
2. Integral, space temperature controls.
3. Roof curbs.
4. Vibration isolation bases.

B. Related Sections include the following:

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

B. ECM: Electrically commutated motor.

C. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

D. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

E. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

F. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

G. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating

operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

H. VVT: Variable-air volume and temperature.

I. Seismic Performance: RTUs shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

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

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Seismic-Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

D. Manufacturer Seismic Qualification Certification: Submit certification that RTUs, accessories, and components will withstand seismic forces defined in "Performance Requirements" Article."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which RTUs will be attached.
2. Roof openings

3. Roof curbs and flashing.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

H. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. ARI Compliance:

1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with ARI 270 for testing and rating sound performance for RTUs.

B. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1-2007, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1-2010 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2010, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

E. California Title 24 Energy Compliance

F. UL Compliance: Comply with UL 1995.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

H. Unit Design: Packaged Outdoor VAV Air Conditioning Units shall be units specifically design for variable air volume airflow with discharge air temperature control for the refrigeration system.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.

2. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. AAON, Inc.
2. Addison Products Company.
3. Carrier Corporation.
4. Daikin/McQuay International.
5. Trane; American Standard Companies, Inc.
6. YORK International Corporation.

2.2 CASING

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

1. Exterior Casing Thickness: 0.0626 inch thick.

C. Inner Casing Fabrication Requirements:

1. Inside Casing: Galvanized steel, 0.034 inch (0.86 mm).

D. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

1. Materials: ASTM C 1071, Type I.
2. Thickness: 1 inch
3. Liner materials shall have air-stream surface coated with an erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
4. Liner Adhesive: Comply with ASTM C 916, Type I.

E. Condensate Drain Pans: Formed sections of stainless-steel sheet, a minimum of 2 inches (50 mm) deep, and complying with ASHRAE 62.1-2007.

1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
2. Drain Connections: Threaded nipple both sides of drain pan.
3. Pan-Top Surface Coating: Corrosion-resistant compound.

F. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

2.3 FANS

A. Belt-Driven Supply-Air Fans: Plug fan or double width, forward curved orbackward inclined, centrifugal; with permanently lubricated, VFD rated premium efficiency motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

B. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motor.

C. Relief-Air Fan: Belt-driven Forward curved or plug fan centrifugal , shaft mounted on permanently lubricated motor (where indicated) Provide VFD rated premium efficiency motor.

D. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces when fan-mounted frame and RTU-mounted frame are anchored to building structure.

2.4 COILS

A. Supply-Air Refrigerant Coil:

1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Coil Split: Interlaced.
4. Baked phenolic coating.
5. Condensate Drain Pan: Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1-2007

B. Outdoor-Air Refrigerant Coil:

1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Baked phenolic or Cathodic epoxy coating.

2.5 REFRIGERANT CIRCUIT COMPONENTS

A. Number of Refrigerant Circuits: Two

B. Compressor: Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

C. Refrigeration Specialties:

1. Refrigerant: R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.
9. Low-ambient kit high-pressure sensor.
10. Hot-gas bypass solenoid valve with a replaceable magnetic coil.

2.6 AIR FILTRATION

A. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
1. Pleated: Minimum 90 percent arrestance, and MERV 8.

2.7 DAMPERS

A. Minimum Outdoor-Air Damper: Linked damper blades, for 0 to 25 percent outdoor air, with motorized damper. Set damper at existing minimum outdoor airflow.

B. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.

1. Damper Motor: Modulating with adjustable minimum position.
2. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IESNA 90.1-2010, with bird screen and hood.
3. Coordinate relief dampers with relief fan.

2.8 ELECTRICAL POWER CONNECTION

A. Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

B. Coordinate electrical service connection with existing electrical service serving the existing AC-Units.

2.9 CONTROLS

A. Basic Unit Controls:

1. Interface with existing building VAV controls..
2. Control-voltage transformer.
3. Wall-mounted thermostat or sensor with the following features:
   a. Fan on-auto switch.
   b. Fan-speed switch.
   c. Adjustable deadband.
   d. Exposed set point.
   e. Exposed indication.
   f. Degree F indication.
   g. Unoccupied-period-override push button.
   h. Data entry and access port to input temperature set points, occupied and unoccupied periods, and output room temperature, supply-air temperature, operating mode, and status.

4. [Unit]-Mounted Annunciator Panel for Each Unit:

   a. Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
   b. DDC controller or programmable timer and interface with HVAC instrumentation and control system.
   c. Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.

B. DDC Controller:

1. Controller shall have volatile-memory backup.
2. Safety Control Operation:

   a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for fire alarm and provide interface to fire alarm control panel.
   b. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than 40 deg F.

3. Scheduled Operation: Occupied and unoccupied periods on 365-day clock with a minimum of four programmable periods per day.
4. Unoccupied Period:
   a. Cooling Setback: System off.
   b. Override Operation: Two hours.

5. Supply Fan Operation:

   a. Occupied Periods: Run fan continuously.
   b. Unoccupied Periods: Cycle fan to maintain setback temperature.

6. Refrigerant Circuit Operation:

   a. Occupied Periods: Cycle or stage compressors, and operate hot-gas bypass to match compressor output to cooling load to maintain discharge temperature. Cycle

condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.

b. Unoccupied Periods: Compressors off.
c. Switch reversing valve for heating or cooling mode on air-to-air heat pump.

7. Fixed Minimum Outdoor-Air Damper Operation:

a. Occupied Periods: Open to CFM as indicated and set by TAB.
b. Unoccupied Periods: Close the outdoor-air damper.

8. Economizer Outdoor-Air Damper Operation:

a. Occupied Periods: Open to minimum intake, and maximum 100 percent of the fan capacity to comply with ASHRAE Cycle II. Controller shall permit air-side economizer operation when outdoor air is less than 60 deg F. Use mixed-air temperature and select between outdoor-air and return-air enthalpy to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper. During economizer cycle operation, lock out cooling.
b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
c. Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor shall adjust for temperature, and output shall range from 4 to 20 mA.

C. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide [**BACnet**] compatible interface for central HVAC control workstation for the following:

a. Adjusting set points.
b. Monitoring supply fan start, stop, and operation.
c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature.
d. Monitoring occupied and unoccupied operations.
e. Monitoring constant and variable motor loads.
f. Monitoring variable-frequency drive operation.
g. Monitoring cooling load.
h. Monitoring economizer cycles.
i. Monitoring air-distribution static pressure and ventilation air volume.

2.10 ACCESSORIES

A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.

B. Low-ambient kit using staged condenser fans for operation down to 35 deg F.

C. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

D. Coil guards of painted, galvanized-steel wire.

E. Hail guards of galvanized steel, painted to match casing.

2.11 ROOF CURBS

A. Coordinate installation and curb requirements with existing roof installation. Existing curbs may be retained and reused where the new AC-unit dimensions and installation requirements match existing.

B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

a. Materials: ASTM C 1071, Type I or II.
b. Thickness: 1-1/2 inches.

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

a. Liner Adhesive: Comply with ASTM C 916, Type I.
b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
d. Liner Adhesive: Comply with ASTM C 916, Type I.

C. Curb Height: Minimum 14 inches.

D. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for wind-load requirements.

2.12 CAPACITIES AND CHARACTERISTICS – REFER TO SCHEDULE

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Roof Curb: Install on existing curb and seismically brace as required by the delegated seismic design. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction

B. Vibration Base: Install unit level on structural vibration base as required by the delegated seismic design with a minimum 2'' static deflection. Coordinate with existing installation. Secure RTUs to structural support with anchor bolts.

3.3 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

B. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Connect supply ducts to RTUs with flexible duct connectors. Install return-air duct continuously through roof structure.
3. Provide double wall duct with insulation thickness in accordance with ASHRAE 90.1-2010.
4. Cross break the top of outdoor duct to allow for drainage.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Report results in writing.

C. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to compressor, coils, and fans.
3. Inspect internal insulation.
4. Verify that labels are clearly visible.
5. Verify that clearances have been provided for servicing.
6. Verify that controls are connected and operable.
7. Verify that filters are installed.
8. Clean condenser coil and inspect for construction debris.
9. Remove packing from vibration isolators.
10. Inspect operation of barometric relief dampers.
11. Verify lubrication on fan and motor bearings.
12. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
13. Adjust fan belts to proper alignment and tension.
14. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.

15. Inspect and record performance of interlocks and protective devices; verify sequences.
16. Operate unit for an initial period as recommended or required by manufacturer.

17. Calibrate thermostats.

18. Adjust and inspect high-temperature limits.
19. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
20. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F (8 deg C) above return-air temperature:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

21. Inspect controls for correct sequencing of mixing dampers, refrigeration, and normal and emergency shutdown.
22. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.
    b. Return-air volume.
    c. Relief-air volume.
    d. Outdoor-air intake volume.

23. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

24. Verify operation of remote panel including failure modes. Inspect the following:
    a. Low-temperature safety operation.
    b. Filter high-pressure differential alarm.
    c. Economizer to minimum outdoor-air changeover.
    d. Relief-air fan operation.
    e. Smoke and firestat alarms.

25. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.6 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 237413

SECTION 260000

GENERAL PROVISIONS - ELECTRICAL WORK

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 PRINCIPAL WORK IN THIS SECTION

A. This Section covers and applies to all work specified in Division 26.

B. Work Included in This Division: Materials, equipment, fabrication, installation and tests for fully operational and safe systems, including all necessary materials, appurtenances and features whether specified or shown on drawings or not, in conformity with applicable codes and authorities having jurisdiction. Work also includes:

1. Cutting and patching for the Electrical Work.
2. Adjustment and testing of the Electrical Work.
3. Examine the drawings and specifications of other Divisions and provide electrical service for all equipment, devices and controls noted therein, unless work specifically is not included.

1.3 RELATED WORK AND REQUIREMENTS

A. Carefully check the documents of each Section with those of other Sections and Divisions. Ascertain the requirements of any interfacing materials or equipment being furnished and/or installed by those Sections and Divisions, and provide proper installation and/or required interface.

1.4 REFERENCE STANDARDS

A. Published codes, specifications standards, tests or recommended methods of trade, industry or governmental organizations, or local utilities apply to work in this Division where cited below:

1. ANSI - American National Standards Institute.
2. ASTM - American Society of Testing and Materials.
3. CBM - Certified Ballast Manufacturers.
4. CEC - California Electrical Code
5. AEIC - Association of Edison Illuminating Companies.
6. ETL - Electrical Testing Laboratories.
7. ICEA - Insulated Cable Engineers Association.
8. IEEE - Institute of Electrical and Electronics Engineers.
9. NEC - National Electrical Code.
10. NEMA - National Electrical Manufacturer's Association.

11. NFPA - National Fire Protection Association.
12. OSHA - Occupational Safety and Health Act.
13. UBC - Uniform Building Code.
14. UFC - Uniform Fire Code.
15. UL - Underwriters' Laboratories Inc.
16. NFPA 72 and National Fire Codes.
17. State of California Codes.
18. State of California, Cal. OSHA.
19. State of California, California Administrative Code, Title 24.
20. County of Riverside Codes.
21. Local Building Department.
22. Local Fire Department.
23. NETA - National Electrical Testing Association Inc.

B. In addition to complying with all other legal requirements, comply with current provisions of governing Codes and Regulations in effect during the progress of the Work, and with the following:

1. Connect new rooftop air conditioning units and related controls. Upgrade conductor and raceway sizing to accommodate the requirements of the new equipment and controls.
2. Where requirements between governing Codes and Regulations vary, the more restrictive provision shall apply.
3. Nothing contained in Contract Documents shall be construed as authority or permission to disregard or violate legal requirements. The contractor shall immediately draw the attention of the Owner's Representative to any such conflicts noted in the contract documents.

1.5 QUALITY ASSURANCE

A. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture.

B. Supply all equipment and accessories new, free from defects and listed by Underwriters' Laboratories, Inc. or bearing its label.

C. Supply all equipment and accessories in compliance with all applicable national, state and local codes.

D. All items of a given type shall be the products of the same manufacturer. Contractor shall provide same manufacturer's product throughout the project.

E. Fire alarm work shall comply with NFPA 72 and requirements of the authority having jurisdiction.

1.6 SUBMITTALS

A. Submit shop drawings, product data, samples and certificates of compliance for electrical work required to connect new rooftop air conditioning units and related controls. Shop drawings shall be signed by a registered electrical engineer.

B. Submit no later than 20 days after notice of award.

C. Corrections or comments made on the shop drawings during review do not relieve the Contractor from compliance with requirements of the drawings and specifications. Shop drawing checking by the Engineer is only for review of general conformance with the design concept of the project and general compliance with the information given in the contract documents. The Contractor is responsible for:

1. Electrical design to connect the new rooftop air conditioning units and related controls to the existing building electrical systems
2. Confirming and correlating all quantities and dimensions
3. Selecting fabrication processes and techniques of construction
4. Coordinating his work with all other trades
5. Performing his work in a safe and satisfactory manner
6. Provide equipment that can be installed in the available space with all code clearances.

D. Quantity of Submittals Required:

1. Layout and Design Shop Drawings:

   a. Submit one reproducible transparency and electronic PDF file.
   b. Upon review, transparency will be annotated and returned.

2. Product data (brochures):

   a. Submit electronic PDF file format.

E. Layout and Design Shop Drawings Required:

1. Prepare and submit following coordinated layout and design shop drawings on ¼" scale:

   a. Electrical service connections to rooftop air conditioning units and related controls.

F. Operating Instructions, Maintenance Manuals and Parts Lists.

1. After review, furnish five printed and bound sets.

   a. Manufacturer's name, model number, service manual, spare-parts list, and descriptive literature for all components.
   b. Maintenance instructions.
   c. Field test report.
   d. Name, address and phone number of contractors, equipment suppliers and service agencies.

G. Record Drawings:

1.7 DEFINITIONS

A. "Furnish" or "Provide": To supply, install and connect complete and ready for safe and regular operation of particular work referred to unless specifically otherwise noted.

B. "Install": To erect, mount and connect complete with related accessories.

C. "Supply": To purchase, procure, acquire and deliver complete with related accessories.

D. "Work": Labor, materials, equipment, apparatus, controls, accessories and other items required for proper and complete installation.

E. "Wiring": Raceway, fittings, wire, boxes and related items.

F. "Concealed": Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces or in enclosures.

G. "Exposed": Not installed underground or "concealed" as defined above.

H. "Indicated","Shown" or "Noted": As indicated, shown or noted on drawings or specifications.

I. "Equal": Equal in quality, workmanship, materials, weight, size, design and efficiency of specified product, conforming with "Manufacturers".

J. "Reviewed," "Satisfactory," "Accepted," or "Directed": As reviewed, satisfactory, accepted or directed by or to Owner's Representative.

K. "Motor Controllers": Manual or magnetic starters (with or without switches), individual pushbuttons, or hand-off-automatic (HOA) switches controlling the operation of motors.

L. "Control Devices": Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

1.8 ELECTRICAL SYSTEM CHARACTERISTICS

A. Electric distribution: 480V 3Ø 3w with grounded neutral and 208/120v 3Ø4w with grounded neutral.

1.9 JOB CONDITIONS

A. Examine all drawings and specifications in a manner to be fully cognizant of all work required under this Division.

B. Adjoining work of other Divisions shall be examined for interferences and conditions affecting this Division.

C. Examine site related work and surfaces before starting work of any Section.

1. Report to Owner's Representative, in writing, conditions which will prevent proper provision of this work.
2. Beginning work of any Section without reporting unsuitable conditions to Owner's Representative constitutes acceptance of conditions by Contractor.
3. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to Owner.

1.10 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Ship equipment in original packages, to prevent damaging or entrance of foreign matter.

B. Handle and ship in accordance with manufacturer's recommendations.

C. Replace at no expense to Owner, equipment or material damaged during storage or handling, as directed by Owner's Representative.

D. Tag all items with weatherproof tag, identifying equipment by name and purchase order number.

1.11 SEISMIC RESTRAINTS

A. Provide seismic restraints per applicable code. Design and provide restraints to prevent permanent displacement in any direction caused by lateral motion, overturning or uplift. Submit calculations and details to Architect for approval.

B. General: Provide Zone 4 seismic restraints per applicable code and as specified and/or indicated. Design and provide restraints to prevent permanent displacement in any direction caused by lateral motion, overturning or uplift.

C. Equipment: If required to be restrained, the equipment itself must be designed to withstand the required seismic force criteria, including its internal design, components and frame; and must have suitable structural elements to which restraining attachments may be fastened.

D. Rigidly supported equipment: Restrain per SMACNA, NUSIG guidelines where applicable; where not applicable restrain similarly and as recommended by manufacturer of equipment.

E. Design:

1. Prepare designs, including arrangements and sizes indicated or referenced in applicable standards.
2. Where designs, etc., are neither indicated nor referenced, prepare such designs as required by Owner's Representative, together with supporting calculations prepared by a duly licensed engineer registered in the State of California.

1.12 PROTECTION OF MATERIALS

A. Protect from damage, water, dust, etc., material, equipment and apparatus provided under this Division, both in storage and installed, until Notice of Completion has been filed.

B. Provide temporary storage facilities for material and equipment.

C. Arrange with Owner's Representative for storage facilities for materials and equipment.

D. Material, equipment or apparatus damaged because of improper storage or protection will be rejected. Remove from site and provide new, duplicate, material equipment or apparatus in replacement of that rejected.

E. Protect premises and work of other Divisions from damage arising out of installation of work of this Division.

1. Repair or replace, as directed by Owner's Representative, materials and parts of premises which become damaged as result of installation of work of this Division.
2. Remove replaced parts from premises.

1.13 REVIEW OF CONSTRUCTION

A. Work may be reviewed at any time by representatives of Owner.

B. Advise Owner's Representative that work is ready for review at following times:

1. Prior to concealment of work below computer room raised floor, in walls and above ceilings.
2. When all requirements of Contract have been completed.

C. Maintain on site a set of Specifications and Drawings for use by Owner's representatives.

1.14 SCHEDULE OF WORK

A. Arrange work to conform to schedule established or required to comply with Contract Documents.

1.15 PERMITS, LICENSES, AND INSPECTIONS

A. Permits and Licenses: Secure required permits and licenses including payments of all charges and fees.

B. Inspections:

1. Obtain inspections during the Work as required to allow timely progress of these and other trades including final inspection approval from authorities having jurisdiction.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Nameplates:

1. Screwed on engraved white laminated plastic sheet with minimum 3/8 inch to 3/4 inch black lettering for normal system. Provide red laminated plastic with white lettering for emergency system.

2. Inscription: Subject to review, indicating equipment and voltage.
3. Provide nameplates for the following:

   a. Variable frequency drives.
   b. Disconnect switches.
   c. Individually mounted circuit breakers.

B. Supports:

1. Provide cutting and patching required to install additional attachments.
2. Supports from building construction: Inserts, beam clamps, fishplates, cantilever brackets or other means. Submit for review.
3. Where building construction is inadequate: Provide additional framing. Submit for review.

PART 3 EXECUTION

3.1 INSTALLATION

A. Layout and installation of electrical work shall be coordinated with the overall construction schedule and work schedules of various trades, to prevent delay in completion of the Project.

B. Dimensions and information regarding accurate locations of equipment, and structural limitations and finish shall be coordinated and verified with other Division of Work.

C. The drawings do not show off-sets, bends, and special fittings, or junction or pull boxes necessary to meet job conditions. These items shall be provided as required at no additional cost to the Owner.

D. Accessibility and Clearance:

1. Electrical equipment, outlets, junction and pull boxes shall be installed in accessible locations, avoiding obstructions, preserving headroom, and keeping openings and passageways clear.
2. Minor adjustments in the locations of equipment shall be made where necessary, providing such adjustments do not adversely affect functioning of the equipment.

E. Occupied Building: The building will remain occupied and operational during construction. All work will be closely coordinated with Owner's representative to avoid any disruption to day to operation of various systems for the building.

F. Smoke detectors shall report to the existing building fire alarm system. Contractor shall verify existing fire alarm system requirements and reconnect to existing alarm circuits.

1. Existing smoke detectors may be removed and reinstalled where they comply with system requirements.

3.2 STRUCTURAL FITTINGS

A. Furnish and install the necessary sleeves, inserts, hangers, anchor bolts, and related structural items. Install at the proper time.

B. Equipment supports for electrical work shall be fastened to the structure by inserts, anchor bolts, bolting to drilled and tapped structural members.

1. Surfaces damaged by installation of supports shall be touched up with primer to match shop coat. Any drilling of structural members shall be approved by the Owner's Representative.

C. Flashing:

1. Wherever conduits pass through the roof or outer walls, base flashing and counterflashing shall be provided.
2. Such flashing shall be properly installed by skilled workmen, and shall include grouting, mastic or tar application, or other means to insure a permanent, waterproof, neat and workmanlike installation.

D. Anchor bolts and inserts shall be galvanized and of adequate size and strength for installation of electrical work.

E. Cutting and patching:

1. All additional cutting, patching and reinforcement of construction of building, subject to review by the Owner's Representative, shall be performed under this Section.

3.3 NOISE AND VIBRATION

A. Exceeding specified limits or due to faulty equipment or workmanship: Correct as directed without additional charge.

3.4 PAINTING

A. Comply with section "Exterior Painting".

3.5 CLEANING

A. Brush and clean work prior to concealing, painting and acceptance. Perform in stages if directed.

B. Remove dust and debris from inside and outside of material and equipment.

3.6 IDENTIFICATION OF CIRCUITS AND EQUIPMENT

A. Tags shall be attached to feeder wiring in conduits at every point where runs are broken or terminated.

1. Circuit, phase, and function shall be indicated. Tags may be made of pressure sensitive plastic or embossed self-attached stainless steel, brass ribbon or engraved laminated plastic.

2. Branch circuit wiring shall be tagged with numbered adhesive strip.

3.7 CONNECTIONS TO EQUIPMENT

A. Connections to equipment furnished under other Divisions shall be part of the electrical work.

1. Work shall include wiring for equipment without factory fabricated wiring; connection to motors when the motor is supplied as a separate unit; and connections only for equipment furnished with factory installed internal wiring, except as further limited by the drawings and other portions of the specifications.
2. Work shall include furnishing suitable outlets, disconnecting devices, variable frequency drives, starters, control devices, selector switches, conduit, junction boxes, wire and wiring devices necessary for complete electrical installation.
3. Devices and equipment furnished shall be of the same type used elsewhere on the project or as specified herein. Location and electrical requirements of such equipment shall be verified in advance with the Contractor or manufacturer furnishing the equipment.

B. Equipment furnished under other Divisions, and requiring electrical connection under this Division will be set in place by Contractor furnishing the equipment. Provide all work required to modify the existing electrical circuits to serve the new rooftop air conditioning units and related controls including but not limited to engineering and design, and preparation of shop drawings to accommodate the specific equipment models and components provided.

3.8 ADJUSTMENTS AND TESTS

A. The electrical installation shall be tested by a qualified testing laboratory, adjustments made, and defects corrected. Contractor shall submit proof of the qualification of testing agency.

B. Wiring shall be tested for continuity, short circuits, and improper grounds. Insulation resistances shall comply with values stated in the applicable Electrical Code.

C. Devices and equipment shall be checked for correct functional performance in accordance with apparatus ratings, operating sequence and Code requirements.

D. All motors shall be checked and adjusted for correct direction of rotation.

E. Loading of circuits and feeders in panelboards shall be checked and balanced.

F. Repair or replace defective work or equipment, at no cost to Owner.

G. For additional testing see other sections.

END OF SECTION

SECTION 260519

WIRE AND CABLE – 600 VOLTS AND UNDER

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 PRINCIPAL WORK IN THIS SECTION

A. Provide wire and cable complete with accessories.

1.3 QUALITY ASSURANCE

A. Refer to Section "General Provisions – Electrical Work".

B. Size Reference: Comply with the California Electrical Code.

C. Required Testing.

1.4 SUBMITTALS

A. Product Data:

1. Wire and cable.

1.5 GUARANTEES

A. Refer to Section "General Provisions – Electrical Work".

PART 2 PRODUCTS

2.1 600 VOLT WIRE AND CABLE

A. Conductors:

1. Solid copper for sizes #10 and smaller and stranded copper for sizes #8 and larger.

2. For general uses: Minimum size #12. At 120 volts and over 100 feet circuit length, minimum size #10. At 277 volts and over 220 feet circuit length, minimum size #10.

3. Control and alarm wire: Minimum size #14. At 120 volts and over 200 feet circuit length, minimum size #12. (Solid or stranded.)

B. Insulation:

1. Type THWN/THHN: Feeders and branch circuits, except Type XHHW used in raceways located in concrete in direct contact with earth, in raceways direct buried in earth and in raceways in permanently wet locations.

2. Color-coding: Conductors shall be color coded to differentiate the phases, the same color being assigned to the same phase throughout the project.

C. Accessories:

1. Cable supports in risers: Clamping device with insulation wedges or "Kellems" grips.

2. Cable ties five feet on centers for cables in vertical risers of cable tray.

3. Tags:

a. Flameproof linen or fiber in accessible locations.

b. Feeders: Indicate number, size, phase and points of origin and termination. Control or alarm: Indicate type of control or alarm and points of origin and termination.

4. Terminations, splices and taps:

a. Copper conductors No. l0 and smaller: Compression type or twist-on spring loaded connectors and clear nylon insulated covering.

b. Copper conductors No. 8 and larger: Mechanical bolted pressure or hydraulic compression type using manufacturers recommended tooling.

c. Cable lugs and connectors: Compression type of same metal as conductor to match cables with marking indicating size and type.

d. For copper lug connections to bus bars provide anti-seize compound.

PART 3 EXECUTION

3.1 INSTALLATION OF WIRE AND CABLE

A. 600 Volt Cable:

1. Not more than three lighting or convenience outlet circuits in one conduit unless otherwise indicated.

2. Pull no thermoplastic wires at temperatures lower than 32°F.

3. Prior to installation of cables all conduit and wireways shall be thoroughly cleaned and wiped dry. Provide lubricant such as "Polywater J", "Ideal Yellow 77" pull-in compound shall be used. A mechanical wire puller may be used where needed.

4. Unless specifically indicated, separate raceways for conductors of 120/208 and 277/480 volt systems, except 480 volt motor branch circuit wiring and related 120 volt control wiring. Separate raceways for emergency system conductors.

5. Where conductors in conduit pass through exterior walls, a sealing compound of moisture resistant material shall be applied in the ends of the conduits to seal around the conductors.

B. Terminal Identification:

1. Provide all wire and cable terminating in panelboards, junction boxes, terminal panels, pull boxes, etc., and special services with pressure sensitive linen identifying labels.

3.2 TESTS

A. 600 Volt Cable:

1. Visual and mechanical inspection.

a. Inspect for physical damage and proper connection in accordance with single line diagram.

b. Cable connections shall be tightened using a calibrated torque wrench.

2. Electrical tests.

a. Perform insulation resistance test on each cable with respect to ground and adjacent cables. Resistance to ground of all insulated wire and cable to be one megohm or greater.

b. Be aware that terminated cables in some cases cannot be tested unless disconnected from end devices.

c. Test shall be performed on 100% of feeders and motor branch circuits.

3. Test values: Insulation resistance tests shall be performed at 1000 V.D.C. for one (1) minute.

B. Perform: Prior to connecting equipment and in presence of authorized representatives.

C. Submit written report of results.

D. Correct or replace cable testing below manufacturer's standard.

END OF SECTION

SECTION 260533

RACEWAYS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 PRINCIPAL WORK IN THIS SECTION

A. Provide raceways complete with boxes, fittings and accessories.

B. Minimum 3/4" conduit.

1.3 QUALITY ASSURANCE

A. Refer to Section "General Provisions – Electrical Work".

PART 2 PRODUCTS

2.1 RACEWAYS

A. All conduits shall be metallic unless otherwise indicated or noted. Metallic conduit incorporated in the work shall comply with applicable divisions of the National and American Standards Association publications.

1. Rigid steel conduit: Full weight pipe, galvanized, threaded.
2. Electro-metallic tubing (EMT): Thin wall pipe, galvanized, threadless.
3. Flexible metallic conduit: Continuous single strip, aluminum or galvanized steel.

2.2 FITTINGS AND ACCESSORIES

A. Raceway Fittings:

1. Rigid steel and intermediate metal conduits: Non-split, threaded, steel or malleable iron with steel locknuts. Zinc die cast not permitted.
2. Electro-metallic tubing: Compression type. Entering enclosures, boxes, etc., insulated throat type with locknuts.
3. Flexible metallic conduit: Setscrew type with insulated throat.
4. Bushings: Metallic insulated type.
5. Weatherproof or dust tight installations: Liquid-tight with sealing ring and insulated throat suitable for exterior application.

B. Seals:

1. Raceways in waterproof sleeves: O.Z. Type WSK thru wall seal.
2. Raceways in non-watertight sleeves: Sealing compound.

3. Thruwall cable seals: O.Z. Type WSCS.

C. Expansion Fittings:

1. Exposed and in furred spaces: Flexible conduit with external bonding jumper strip.
2. In slab: O.Z. Type AX, AX-8, or Appleton type XJ with ground continuity.

D. Cables in raceways through sleeves: O.Z. type KSC compound or type C series terminators.

E. Fire Sealants - UL listed: Chase Foam, CTC PR-855, 3M Product or equal fire resistant foam sealant.

2.3 BOXES

A. Junction and Pull Boxes:

1. Galvanized sheet steel: Code size and gauge in accordance with voltage parameters.
2. Covers: Screw-on, above ceiling full access.
3. With insulated supports for cables.
4. Locations: Shall be accessible as indicated and where required by code.
5. Outdoors and damp locations: Galvanized cast iron or aluminum with threaded hubs and gaskets.
6. Provide barriers or separate boxes between wiring energized from different systems; 120/208, 277/480 volt wiring, and emergency and normal wiring.

B. Unused openings in boxes, conduit bodies, and fittings shall be blanked off by means of approved metal plugs or plates.

PART 3 EXECUTION

3.1 INSTALLATION

A. Procedure:

1. Raceways shall be installed as complete (total) wiring enclosure system prior to installation of conductors.
2. All conduit joints shall be cut square, threaded, reamed smooth and drawn up tight. Bends or offsets shall be made with standard conduit elbows, field bends made with an approved bender or hickey.
3. Paint male threads of field threaded conduit with homogenized blend of colloidal copper and rust and corrosion inhibitor pipe compound, Thomas and Betts Kopr-Shield or equal. Butt conduit ends.
4. Conduits shall be secured to all boxes, cabinets, panels, and equipment with locknuts and bushings in such manner that each system shall be electrically continuous throughout.
5. Conduits shall be securely fastened in place on maximum 10-foot intervals; hangers, supports, or fastenings shall be provided at each elbow and at end of each straight run terminating at a box or cabinet.
6. Provide pull boxes where required by Code and where necessary in the raceway

system to facilitate conductor installation. Conduit runs of more than 100 feet, or with more than three right-angle bends, shall have a pull box installed at a convenient intermediate accessible location. Support boxes independently of raceways, walls and partitions. Boxes shall have removable hinged and/or screw covers and shall be accessible.

7. All conduits shall be terminated with bushings. Conduits at distribution panels will be terminated with grounding type bushing.
8. All metallic conduits 200 feet or larger shall have an equipment ground conductor and increase size, if required.
9. Protect empty conduit ends from entering debris during construction using push-penny plugs by Thomas and Betts or equally approved fittings and materials.

B. Raceways shall be run concealed, except in electrical, mechanical and similar area.

C. Supports and fastening shall be as follows:

1. U-bolt or pipe straps at each grating level of riser raceways.
2. Raceways shall be secured to support with pipe straps or U-bolts on Channel or Trapeze.
3. Spacing shall be maximum 10 foot on center for metallic conduit and wireways.
4. Perforated straps, wire or hangers with clips are not acceptable.

D. Maintain grounding continuity of interrupted metallic raceways with ground conductor, and in flexible conduit for feeders and motor terminal connections.

E. Fire Sealants:

1. Fire rated approved type sealant equivalent to the rating of the barrier being penetrated.
2. Provide for raceways and wire passing through slots, sleeves or openings in fire-partitioned areas. Add fire barriers tight to conductors from Transformer Vault.
3. Seal all unused penetrations.

F. Rigid Steel Conduits

1. Install rigid steel conduits except in interior building locations.

G. EMT: Install for interior. Not permitted in concrete slabs.

H. Flexible Steel Conduit (with equipment grounding conductor):

1. For short connections (maximum six feet length) of branch circuits only where installation of rigid or EMT conduit is impractical and connection is in a dry location, dry wall, hung ceiling or furred spaces.
2. For final connection to motor terminal box, transformers and other vibrating equipment: With polyvinyl sheathing and grounding conductor. Minimum length: 18 inches with minimum 50% slack. Connect grounding conductor to enclosure or raceway at each end.

I. Outlet Boxes:

1. Set square and true with building finish and secure to building structure by adjustable strap irons.
2. Verify outlet locations in finished spaces with Drawings of interior details and finishes.
3. Provide barriers between switches connected to different phases for voltages exceeding 150 volts to ground.
4. Protect floor boxes from entering debris during construction using removable screw covers.

J. Panel, Junction and Pull Boxes:

1. Location: Clear of other work. Conceal junction and pull boxes in finished spaces and maintain accessibility.
2. Support from building structure, independent of conduit. Provide floor to ceiling channels for mounting on dry wall and lightweight construction.
3. Motor terminal boxes: Coordinate with motor branch circuit conduit and wiring.

3.2 TESTS

A. Continuity:

1. Test resistance of feeder conduits from service to point of final distribution using 1 conductor return.
2. Maximum: 25 ohms resistance.

END OF SECTION

SECTION 262816

LOW VOLTAGE CIRCUIT BREAKER

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 PRINCIPAL WORK IN THIS SECTION

A. The Contractor shall furnish and install the molded case circuit breakers as specified herein.

1.3 QUALITY ASSURANCE

A. Refer to Section "General Provisions – Electrical Work".

1. UL 1066, Low Voltage AC and DC Power Circuit Breakers Used in Enclosures.
2. UL 1087, Molded Case Switches.
3. UL 489, Molded Case Circuit Breakers and Circuit Breaker Enclosures.

B. Qualifications: For the equipment specified herein, the manufacturer shall be ISO 9001 certified.

C. Delivery, storage and handling: Equipment shall be handled and stored in accordance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

1.4 SUBMITTALS

A. Shop Drawings:

1. Device ratings: Voltage, Continuous current, Interrupting ratings.
2. Time-current characteristic curves.
3. Catalog cuts.

PART 2 PRODUCTS

2.1 MATERIALS

1. Molded Case:

a. Thermal-magnetic, 400 amp frame and below.

1) Quick-make quick-break.
2) Auxiliary devices as indicated.

b. Manually operated with insulated trip free handle.
c. Multi-pole types: With internal trip bar.
d. Terminals: UL listed for 75EC and suitable for copper or aluminum cable.
e. Enclosures: Dead front, NEMA Type 3R, except as noted.
f. Frames, interrupting capacity and interchangeable trips as required.
g. Provide current limiting circuit breakers where required.

2.2 MANUFACTURERS

A. General Electric

B. Square D

C. Cutler Hammer

PART 3 EXECUTION

3.1 INSTALLATION

A. Provide protective covering during construction.

B. Tighten all bolted connections prior to energizing.

C. Provide multi-cable lugs where required. Double lugging shall not be permitted.

D. Mounting height shall be maximum 6 feet, 6 inches from floor to top switch unit.

3.2 TESTS

A. Less than 600 Amperes: Visual and mechanical inspection:

1. Inspect for physical, electrical and mechanical condition.
2. Inspect for proper alignment, anchorage and grounding.

3.3 LABELS

A. Provide labels indicating amperage, voltage, phase, disconnect size (as applicable).

END OF SECTION

SECTION 262923

VARIABLE FREQUENCY DRIVE

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 DESCRIPTION

B. This specification is to cover a complete Variable Frequency motor Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor.

C. All VFDs installed on this project shall be from the same manufacturer.

D. VFDs furnished as a part of packaged equipment under other sections shall comply with these requirements.

1.3 QUALITY ASSURANCE

A. Referenced Standards:

1. Standard 519-1992, IEEE Guide for Harmonic Content and Control.
2. UL508C
3. ICS 7.0, AC Adjustable Speed Drives
4. IEC 16800 Parts 1, 2 and 3
5. NEC 430.120, Adjustable-Speed Drive Systems
6. IBC 2006 Seismic – referencing ASC 7-05 and ICC AC-156

B. Qualifications:

1. VFDs and options shall be UL listed as a complete assembly. The base VFD shall be UL listed for 100 KAIC without the need for input fuses.
2. CE Mark – The VFD shall meet product standard EN 61800-3 for the First Environment restricted level. (RFI / EMI Filter spec).
3. The entire VFD enclosure, including the bypass shall be seismically certified and labeled in accordance with the IBC 2006 International Building Code:

   a) VFD manufacturer shall provide Seismic Certification and Installation requirements at time of submittal.
   b) Seismic importance factor of 1.0 rating is required, and shall be based upon actual shake test data as defined by ICC AC-156.
   c) Seismic ratings based upon calculations alone are not acceptable. Certification of Seismic rating must be based on testing done in all three axis of motion by a certified lab.

1.4 SUBMITTALS

A. Submittals shall include the following information:

1. Outline dimensions, conduit entry locations and weight.
2. Customer connection and power wiring diagrams.
3. Complete technical product description including a complete list of options.
4. Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).
   a) The VFD manufacturer shall provide calculations; specific to this installation, showing total harmonic voltage distortion is less than 5%. All VFD's shall include a minimum of 5% impedance reactors, no exceptions.

PART 2 PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES

A. The VFD package as specified herein shall be enclosed in a UL Listed Type enclosure, (enclosures with only NEMA ratings are not acceptable.

1. Environmental operating conditions: 32 to 120^0 F continuous. Altitude 0 to 3300 feet above sea level, less than 95% humidity, non-condensing. All circuit boards shall have conformal coating.
2. Enclosure shall be UL rated.
3. VFD for outdoor application shall be in a NEMA3R enclosure.

B. All VFDs shall have the following standard features:

1. BACnet card with all operating parameters available for monitoring through the building management system.
2. All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.
3. The keypad shall include Hand-Off-Auto selections and manual speed control. There shall be fault reset and "Help" buttons on the keypad. The Help button shall include "on-line" assistance for programming and troubleshooting.
4. The VFD shall have internal 5% impedance reactors to reduce the harmonics to the power line and to add protection from AC line transients.
5. The input current rating of the VFD shall be no more than 3% greater than the output current rating. VFD's with higher input current ratings require the upstream wiring, protection devices, and source transformers to be oversized per NEC 430.120.
6. The VFD shall provide a programmable loss-of-load (broken belt / broken coupling) Form-C relay output. The drive shall be programmable to signal the loss-of-load condition via a keypad warning, Form-C relay output, and / or over the serial communications bus.

C. All VFDs to have the following adjustments:

1. Run permissive circuit - There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad command, input contact closure, time-clock control, or serial communications), the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD digital input and allows VFD motor operation. A minimum of two separate safety interlock inputs shall be provided. When any safety is opened, the motor shall be commanded to coast to stop and the damper shall be commanded to close.
2. The VFD control shall include a programmable time delay for VFD start and a keypad indication that this time delay is active. A Form C relay output provides a contact closure to signal the VAV boxes open. This will allow VAV boxes to be driven open before the motor operates.
3. The VFD shall include a fireman's override input. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands), except customer defined safety run interlocks, and force the motor to run at a preset speed or in a separate PID mode.

D. Serial Communications

1. The VFD shall have an EIA-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2, Siemens Building Technologies FLN, and BACnet MS/TP. The use of third party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority (i.e. BTL Listing for BACnet).

E. EMI / RFI filters. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the entire VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted. No Exceptions.

F. OPTIONAL FEATURES – Optional features to be furnished and mounted by the drive manufacturer. All optional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

G. BYPASS CONTROLLER

1. A complete factory wired and tested bypass system consisting of a door interlocked, padlockable circuit breaker, output contactor, bypass contactor, and fast acting VFD isolation fuses.
2. The bypass enclosure door and VFD enclosure must be mechanically interlocked such that the disconnecting device must be in the "Off" position before either enclosure may be accessed.
3. The VFD and bypass package shall have a UL listed short circuit current rating (SCCR) of 100,000 amps and this rating shall be indicated on the UL data label.
4. The drive and bypass package shall be seismic certified and labeled to the IBC:
    a. Seismic importance factor of 1.0 rating is required, and shall be based upon actual shake test data as defined by ICC AC-156.

5. Drive Isolation Fuses - To ensure maximum possible bypass operation, fast acting fuses, exclusive to the VFD, shall be provided to allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection. This maintains bypass operation capability in the event of a VFD failure. Bypass designs, which have no such fuses will not be accepted.
6. The system (VFD and Bypass) tolerated voltage window shall allow the system to operate from a line of +30%, -35% nominal voltage range. The system shall incorporate circuitry that will allow the drive or bypass contactor to remain "sealed in" over this voltage tolerance at a minimum.
7. The bypass shall maintain positive contactor control throughout the voltage tolerance window of nominal voltage +30%, -35%. This feature is designed to avoid contactor coil failure during brown out / low line conditions and allow for input single phase operation when in the VFD mode. Designs that will not allow input single phase operation in the VFD mode are not acceptable.
8. Motor protection from single phase power conditions - the bypass system must be able to detect a single phase input power condition while running in bypass, disengage the motor in a controlled fashion, and give a single phase input power indication. Bypass systems not incorporating single phase protection in bypass mode are not acceptable.
9. The bypass system shall NOT depend on the VFD for bypass operation. The bypass system shall be designed for stand alone operation and shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the system for repair / replacement. Serial communications shall remain functional even with the VFD removed.
10. Serial communications – the bypass shall be capable of being monitored and / or controlled via serial communications. On-board communications protocols shall include ModBus, Johnson Controls N2, Siemens Building Technologies FLN (P1), and BACnet MS/TP.
11. The bypass control shall include a programmable time delay for bypass start and keypad indication that this time delay is in process. A Form C relay output provides a contact closure to signal the VAV boxes open. This will allow VAV boxes to be driven open before the motor operates at full speed in the bypass mode. The time delay shall be field programmable from 0 – 120 seconds.
12. The user shall be able to select the text to be displayed on the keypad when an external safety opens. Example text display indications include "FireStat", "FreezStat", "Over pressure" and "Low suction". The user shall also be able to determine which of the up to four customer safety contacts is open over the serial communications connection.

2.2 MANUFACTURER

A. ABB

B. Toshiba

C. General Electric

PART 3 EXECUTION

3.1 INSTALLATION

A. Installation shall be the responsibility of the contractor.

B. Power wiring shall be completed by the contractor, to NEC code 430.122 wiring requirements based on the VFD input current.

C. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the VFD installation manual.

3.2 START-UP

A. Certified factory start-up shall be provided for each drive by a factory authorized service center.

3.3 WARRANTY

A. The VFD Product Warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. The warranty shall include all parts, labor, travel time and expenses. A toll free 24/365 technical support line shall be available.

END OF SECTION