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PROJECT MANUAL

VOLUME 2 OF 2
Technical Specifications

DELAWARE TECHNICAL COMMUNITY COLLEGE

Owens Campus, A+S Building HVAC Renovations
BID NO. C900402ASH

ARTS + SCIENCES BUILDING

HVAC Renovations

21179 COLLEGE DRIVE
GEORGETOWN, DELAWARE 19947

PROJECT NO. 18005

ISSUED FOR BIDDING / CONSTRUCTION

DECEMBER 2018

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DIVISION 01 SECTION 019113
GENERAL COMMISSIONING REQUIREMENTS
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SECTION 019113 – GENERAL COMMISSIONING REQUIREMENTS

PART 1. GENERAL

1.1. RELATED DOCUMENTS

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

1.2. SUMMARY

A. This Section includes general requirements that apply to implementation of commissioning without regard to systems, subsystems, and equipment being commissioned.

B. Related Sections include the following:

1. Division 01 Section "HVAC Commissioning Requirements" for specific requirements for commissioning HVAC systems.

2. Division 01 Section "Contract Closeout" for specific requirements for closeout at substantial and final completion.

3. Division 01 Section "Contract Closeout" for Specific Requirements for training and demonstration of systems to Owner.

4. Division 01 Section "Contract Closeout" for Specific Requirements related to the Preparation of systems operation and maintenance manuals.

1.3. DEFINITIONS

A. CxA: Commissioning Authority.

B. OPR: Owner's Project Requirements.

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

D. TAB: Testing, Adjusting, and Balancing.

1.4. COMMISSIONING TEAM

A. Members Appointed by Contractor(s): Individuals, each having authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated actions. The commissioning team shall consist of, but not be limited to, representatives of Contractor, including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.

B. Members Appointed by Owner:

1. CxA: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process.

The CxA for this project shall be performed by Gipe Associates, Inc., 8719 Brooks Drive, Easton, Maryland 21601, (410) 822-8688 - telephone, (410) 822-6306 – fax.

2. All contractor commissioning requirements and costs associated with commissioning the project shall be included in the base bid.

3. Representatives of the facility user and operation and maintenance personnel.

4. Architect and Engineering design professionals.

1.5. OWNER'S RESPONSIBILITIES

A. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities including, but not limited to, the following:

1. Coordination meetings.

2. Training in operation and maintenance of systems, subsystems, and equipment.

3. Testing meetings.

4. Demonstration of operation of systems, subsystems, and equipment.

1.6. CONTRACTOR'S RESPONSIBILITIES

A. Provide utility services required for the commissioning process.

B. Contractor shall assign representatives with expertise and authority to act on behalf of the Contractor and schedule them to participate in and perform commissioning team activities including, but not limited to, the following:

1. Participate in commissioning and construction-phase coordination meetings.

2. Participate in maintenance orientation and inspection.

3. Participate in operation and maintenance training sessions.

4. Participate in final review at acceptance meeting.

5. Certify that Work is complete and systems are operational according to the Contract Documents, including calibration of instrumentation and controls.

6. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.

7. Review and approve final commissioning documentation.

8. Certify that all pre-test work and pre-testing of functional performance tests are complete and operational prior to scheduling performed testing by CxA. Submit completed functional performance test forms with data from pre-testing.

9. During functional performance testing, a representative from the mechanical contractor, controls contractor, and test/balance engineer must be present and participate in testing.

C. Subcontractors shall assign representatives with expertise and authority to act on behalf of subcontractors and schedule them to participate in and perform commissioning team activities including, but not limited to, the following:

1. Pre-test all systems/equipment prior to engaging CxA for Functional Performance Testing.

2. Participate in commissioning and construction-phase coordination meetings.

3. Participate in maintenance orientation and inspection.

4. Participate in procedures meeting for testing.

5. Participate in final review at acceptance meeting.

6. Provide schedule for operation and maintenance data submittals, equipment startup, and testing to CxA for incorporation into the commissioning plan. Update schedule on a weekly basis throughout the construction period.

7. Provide information to the CxA for developing construction-phase commissioning plan.

8. Participate in training sessions for Owner's operation and maintenance personnel.

9. Provide updated Project Record Documents to the CxA on a daily basis.

10. Gather and submit operation and maintenance data for systems, subsystems, and equipment to the CxA, as specified in Division 01 Section "Operation and Maintenance Data."

11. Provide technicians who are familiar with the construction and operation of installed systems and who shall develop specific test procedures and participate in testing of installed systems, subsystems, and equipment.

12. The test/balance subcontractor, mechanical contractor, and automatic temperature controls subcontractor must be on-site and provide assistance during all functional performance testing.

1.7. CXA'S RESPONSIBILITIES

A. Organize and lead the commissioning team.

B. Prepare a construction-phase commissioning plan. Collaborate with Contractor and with subcontractors to develop test and inspection procedures. Include design changes and scheduled commissioning activities coordinated with overall Project schedule. Identify commissioning team member responsibilities, by name, firm, and trade specialty, for performance of each commissioning task.

C. Convene commissioning team meetings for the purpose of coordination, communication, and conflict resolution; discuss progress of the commissioning processes. Responsibilities include arranging for facilities, preparing agenda and attendance lists, and notifying participants. The CxA shall prepare and distribute minutes to commissioning team members and attendees within five workdays of the commissioning meeting.

D. At a mutually agreed upon time, conduct an initial construction-phase coordination meeting for the purpose of reviewing the commissioning activities and establishing tentative schedules for operation and maintenance submittals; operation and maintenance training sessions; TAB Work; and Project completion.

E. Observe and inspect construction and report progress and deficiencies. In addition to compliance with the Contract Documents, inspect systems and equipment installation for adequate accessibility for maintenance and component replacement or repair.

F. Prepare Project-specific test and inspection procedures and checklists.

G. Schedule, direct, witness, and document tests, inspections, and systems startup.

H. Compile test data, inspection reports, and certificates and include them in the systems manual and commissioning report.

I. Certify date of acceptance and startup for each item of equipment for start of warranty periods.

J. Review Project Record Documents for accuracy. Request revisions from Contractor to achieve accuracy. Project Record Documents requirements are specified in Division 01 Section "Project Record Documents."

K. Review and comment on operation and maintenance documentation and systems manual outline for compliance with the Contract Documents. Operation and maintenance documentation requirements are specified in Division 01 Section "Operation and Maintenance Data."

L. Assemble the final commissioning documentation, including the commissioning report and Project Record Documents.

1.8. COMMISSIONING DOCUMENTATION

A. Commissioning Plan: A document, prepared by CxA, that outlines the schedule, allocation of resources, and documentation requirements of the commissioning process, and shall include, but is not limited to the following:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports. Identification of the relationship of these documents to other functions and a detailed description of submittals that are required to support the commissioning processes. Submittal dates shall include the latest date approved submittals must be received without adversely affecting commissioning plan.

2. Description of the organization, layout, and content of commissioning documentation (including systems manual) and a detailed description of documents to be provided along with identification of responsible parties.

3. Identification of systems and equipment to be commissioned.

4. Description of schedules for testing procedures along with identification of parties involved in performing and verifying tests.

5. Identification of items that must be completed before the next operation can proceed.

6. Description of responsibilities of commissioning team members.

7. Description of observations to be made.

8. Description of requirements for operation and maintenance training, including required training materials.

9. Description of expected performance for systems, subsystems, equipment, and controls.

10. Schedule for commissioning activities with specific dates coordinated with overall construction schedule.

11. Identification of installed systems, subsystems, and equipment, including design changes that occurred during the construction phase.

12. Process and schedule for documenting changes on a continuous basis to appear in Project Record Documents.

13. Process and schedule for completing prestart and startup checklists for systems, subsystems, and equipment to be verified and tested.

14. Step-by-step procedures for testing systems, subsystems, and equipment with descriptions for methods of verifying relevant data, recording the results obtained, and listing parties involved in performing and verifying tests.

B. Test Checklists: CxA, with assistance of Contractor and Subcontractors, shall develop test checklists for each system, subsystem, or equipment including interfaces and interlocks, and include a separate entry, with space for comments, for each item to be tested. Prepare separate checklists for each mode of operation and provide space to indicate whether the mode under test responded as required. Provide space for testing personnel to sign off on each checklist. Specific checklist content requirements are specified in Division 01 Section "HVAC Commissioning Requirements", "Electrical Commissioning Requirements" and "Plumbing System Commissioning Requirements". Test checklists will be jointly developed as the project progresses. Each checklist, regardless of system, subsystem, or equipment being tested, shall include, but not be limited to, the following:

1. Name and identification code of tested item.

2. Test number.

3. Time and date of test.

4. Indication of whether the record is for a first test or retest following correction of a problem or issue.

5. Dated signatures of the person performing test and of the witness, if applicable.

6. Individuals present for test.

7. Deficiencies.

8. Issue number, if any, generated as the result of test.

C. Certificate of Readiness: Certificate of Readiness shall be signed by Contractor, Subcontractor(s), Installer(s), and CxA certifying that systems, subsystems, equipment, and associated controls are ready for testing. Completed test checklists signed by the responsible parties shall accompany this certificate.

D. Test and Inspection Reports: CxA shall record test data, observations, and measurements on test checklists. Photographs, forms, and other means appropriate for the application shall be included with data. CxA shall compile test and inspection reports and test and inspection certificates and include them in systems manual and commissioning report.

E. Corrective Action Documents: CxA shall document corrective action taken for systems and equipment that fail tests. Include required modifications to systems and equipment and revisions to test procedures, if any. Retest systems and equipment requiring corrective action and document retest results.

F. Issues Log: CxA shall prepare and maintain an issues log that describes design, installation, and performance issues that are at variance with the Contract Documents. Identify and track issues as they are encountered, documenting the status of unresolved and resolved issues.

1. Creating an Issues Log Entry:

a. Identify the issue with unique numeric or alphanumeric identifier by which the issue may be tracked.
b. Assign a descriptive title of the issue.
c. Identify date and time of the issue.
d. Identify test number of test being performed at the time of the observation, if applicable, for cross-reference.
e. Identify system, subsystem, and equipment to which the issue applies.
f. Identify location of system, subsystem, and equipment.
g. Include information that may be helpful in diagnosing or evaluating the issue.
h. Note recommended corrective action.
i. Identify commissioning team member responsible for corrective action.
j. Identify expected date of correction.
k. Identify person documenting the issue.

2. Documenting Issue Resolution:

   a. Log date correction is completed or the issue is resolved.
   b. Describe corrective action or resolution taken. Include description of diagnostic steps taken to determine root cause of the issue, if any.
   c. Identify changes to the Contract Documents that may require action.
   d. State that correction was completed and system, subsystem, and equipment is ready for retest, if applicable.
   e. Identify person(s) who corrected or resolved the issue.
   f. Identify person(s) documenting the issue resolution.

3. Issues Log Report: On a periodic basis, but not less than for each commissioning team meeting, CxA shall prepare a written narrative for review of outstanding issues and a status update of the issues log. As a minimum, CxA shall include the following information in the issues log and expand it in the narrative:

   a. Issue number and title.
   b. Date of the identification of the issue.
   c. Name of the commissioning team member assigned responsibility for resolution.
   d. Expected date of correction.

G. Commissioning Report: CxA shall document results of the commissioning process including unresolved issues and performance of systems, subsystems, and equipment. The commissioning report shall indicate whether systems, subsystems, and equipment have been completed and are performing according to the Contract Documents. The commissioning report shall include, but is not limited to, the following:

1. Lists and explanations of substitutions; compromises; variances in the Contract Documents; record of conditions; and, if appropriate, recommendations for resolution. This report shall be used to evaluate systems, subsystems, and equipment and shall serve as a future reference document during Owner occupancy and operation. It shall describe components and performance that exceed requirements of the Contract Documents and those that do not meet requirements of the Contract Documents. It may also include a recommendation for accepting or rejecting systems, subsystems, and equipment.

2. Commissioning plan.

3. Testing plans and reports.

4. Corrective modification documentation.

5. Issues log.

6. Completed test checklists.

7. Listing of off-season test(s) not performed and a schedule for their completion.

8. All commissioning documents must be submitted to the building Owner within 90 days of the date of receipt of the Certificate of Occupancy.

H. Systems Manual: CxA shall gather required information and compile systems manual. Systems manual shall include, but is not limited to, the following:

1. Project Record Documents as specified in Division 01 Section "Project Record Documents."

2. Final commissioning plan.

3. Commissioning report.

4. Operation and maintenance data as specified in Division 01 Section "Operation and Maintenance Data."

1.9. SUBMITTALS

A. Test Checklists and Report Forms: CxA shall submit sample checklists and forms to Contractor quality-control manager and subcontractors for review and comment. Submit two copies of each checklist and report form.

B. Test and Inspection Reports: CxA shall submit test and inspection reports.

C. Corrective Action Documents: CxA shall submit corrective action documents.

1.10. QUALITY ASSURANCE

A. Instructor Qualifications: Factory-authorized service representatives, experienced in training, operation, and maintenance procedures for installed systems, subsystems, and equipment.

B. Test Equipment Calibration: Comply with test equipment manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately whenever instruments have been repaired following damage or dropping. Affix calibration tags to test instruments. Instruments shall have been calibrated within six months prior to use.

1.11. COORDINATION

A. Coordinating Meetings: CxA shall conduct coordination meetings of the commissioning team to review progress on the commissioning plan, to discuss scheduling conflicts, and to discuss upcoming commissioning process activities.

B. Pretesting Meetings: CxA shall conduct pretest meetings of the commissioning team to review startup reports, pretest inspection results, testing procedures, testing personnel and instrumentation requirements, and manufacturers' authorized service representative services for each system, subsystem, equipment, and component to be tested.

C. Testing Coordination: CxA shall coordinate sequence of testing activities to accommodate required quality-assurance and -control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting.

1. Schedule times for tests, inspections, obtaining samples, and similar activities.

D. Manufacturers' Field Services: CxA and Contractor shall coordinate services of manufacturers' field services.

PART 2. PRODUCTS (NOT USED)

PART 3. EXECUTION

3.1. OPERATION AND MAINTENANCE TRAINING REQUIREMENTS

A. Training Preparation Conference: Before operation and maintenance training, CxA shall convene a training preparation conference to include Owner's operation and maintenance personnel, Contractor, and subcontractors. In addition to requirements specified in Division 01 Section "Demonstration and Training," perform the following:

1. Review installed systems, subsystems, and equipment.

2. Review instructor qualifications.

3. Review instructional methods and procedures.

4. Review training module outlines and contents.

5. Review course materials (including operation and maintenance manuals).

6. Inspect and discuss locations and other facilities required for instruction.

7. Review and finalize training schedule and verify availability of educational materials, instructors, audiovisual equipment, and facilities needed to avoid delays.

8. For instruction that must occur outside, review weather and forecasted weather conditions and procedures to follow if conditions are unfavorable.

B. Training Modules: Develop an instruction program that includes individual training modules for each system, subsystem, and equipment as specified in Division 01 Section "Demonstration and Training."

END OF SECTION

DIVISION 01 SECTION 019115
HVAC COMMISSIONING REQUIREMENTS
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SECTION 019115 - HVAC COMMISSIONING REQUIREMENTS

PART 1. GENERAL

1.1. RELATED DOCUMENTS

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

1.2. SUMMARY

A. This Section includes requirements for commissioning the HVAC system and its subsystems and equipment. This Section supplements the general requirements specified in Division 01 Section "General Commissioning Requirements."

B. Related Sections include the following:

1. Division 01 Section "General Commissioning Requirements" for general requirements for commissioning processes that apply to this Section.

C. The following systems and/or equipment shall be commissioned:

1. Air Flow Monitoring Stations.
2. Automatic Temperature Control System.
3. Boilers and burners.
4. Chilled, water system.
5. Condensate overflow alarms.
6. Differential Static Pressure Controllers.
7. Duct detectors.
8. Ductless heat pumps and air conditioning units.
9. Energy recovery ventilators (Including variable frequency drives).
10. Exhaust air systems.
11. Exhaust Fans and ventilation fans.
12. Flow measuring stations.
13. Freeze protection pumps.
14. High temperature alarms.
15. Hot water systems.

16. HVAC controls and sequences of operation.

17. Pumps.

18. Single Zone VAV Units.

19. Supply air systems.

20. Variable frequency drives.

21. Variable refrigerant volume systems (indoor and outdoor units).

22. Variable refrigerant volume system ATC interface and systems integration.

1.3. DEFINITIONS

A. Architect: Includes Architect identified in the Contract for Construction between Owner and Contractor, plus consultant/design professionals responsible for design of HVAC, electrical, communications, controls for HVAC systems, and other related systems.

B. CxA: Commissioning Authority.

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

D. TAB: Testing, Adjusting, and Balancing.

1.4. CONTRACTOR'S RESPONSIBILITIES

A. The following responsibilities are in addition to those specified in Division 01 Section "General Commissioning Requirements."

B. Contractor:

1. Attend procedures meeting for TAB Work.

2. Certify that TAB Work is complete.

3. Assist performing functional performance tests.

C. Mechanical Contractor:

1. Attend TAB verification testing.

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

3. Assist performing functional performance tests.

D. HVAC Instrumentation and Control Contractor: With the CxA, review control designs for compliance with the Contract Documents, controllability with respect to actual equipment to be installed, and recommend adjustments to control designs and sequence of operation descriptions.

E. TAB Subcontractor:

1. Contract Documents Review: With the CxA, review the Contract Documents before developing TAB procedures.

a. Verify the following:
i. Accessibility of equipment and components required for TAB Work.
ii. Adequate number and placement of duct balancing dampers to allow proper balancing while minimizing sound levels in occupied spaces.
iii. Adequate number and placement of balancing valves to allow proper balancing and recording of water flow.
iv. Adequate number and placement of test ports and test instrumentation to allow reading and compilation of system and equipment performance data needed to conduct both TAB and commissioning testing.
v. Air and water flow rates have been specified and compared to central equipment output capacities.
b. Identify discontinuities and omissions in the Contract Documents.
c. This review of the Contract Documents by the TAB Subcontractor satisfies requirements for a design review report as specified in Division 23 Section "Testing Adjusting & Balancing for HVAC & Plumbing."
d. Assist performing functional performance tests.

2. Additional Responsibilities: Participate in tests specified in Division 23 Sections "Instrumentation & Controls of HVAC & Plumbing Systems."

F. Electrical Contractor:

1. With the Mechanical Contractor, coordinate installations and connections between and among electrical and HVAC systems, subsystems, and equipment.

2. Attend TAB verification testing.

1.5. COMMISSIONING DOCUMENTATION

A. The following are in addition to documentation specified in Division 01 Section "General Commissioning Requirements."

B. Test Checklists: CxA with assistance of Contractor shall develop test checklists for HVAC systems, subsystems, and equipment, including interfaces and interlocks with other systems. CxA shall prepare separate checklists for each mode of operation and provide space to indicate whether the mode under test responded as required. In addition to the requirements specified in Division 01 Section "General Commissioning Requirements," checklists shall include, but not be limited to, the following:

1. Calibration of sensors and sensor function.

2. Testing conditions under which test was conducted, including (as applicable) ambient conditions, set points, override conditions, and status and operating conditions that impact the results of test.

3. Control sequences for HVAC systems.

4. Strength of control signal for each set point at specified conditions.

5. Responses to control signals at specified conditions.

6. Sequence of response(s) to control signals at specified conditions.

7. Electrical demand or power input at specified conditions.

8. Power quality and related measurements.

9. Expected performance of systems, subsystems, and equipment at each step of test.

10. Narrative description of observed performance of systems, subsystems, and equipment. Notation to indicate whether the observed performance at each step meets the expected results.

11. Interaction of auxiliary equipment.

12. Issues log.

1.6. SUBMITTALS

A. The following submittals are in addition to those specified in Division 01 Section "General Commissioning Requirements."

B. Testing Procedures: CxA shall submit detailed testing plan, procedures, and checklists for each series of tests. Submittals shall include samples of data reporting sheets that will be part of the reports.

C. Certificate of Readiness: CxA shall compile certificates of readiness from Contractor certifying that systems, subsystems, equipment, and associated controls are ready for testing.

D. Certificate of Completion of Installation, Prestart, and Startup: CxA shall certify that installation, prestart, and startup activities have been completed. Certification shall include completed checklists provided by TAB Subcontractor as specified in Division 23 Section "Testing Adjusting & Balancing for HVAC & Plumbing."

E. Test and Inspection Reports: CxA shall compile and submit test and inspection reports and certificates, and shall include them in systems manual and commissioning report.

F. Corrective Action Documents: CxA shall submit corrective action documents.

G. Certified TAB Reports: CxA shall submit verified, certified TAB reports.

PART 2. PRODUCTS (NOT USED)

PART 3. EXECUTION

3.1. TESTING PREPARATION

A. Prerequisites for Testing:

1. Certify that HVAC systems, subsystems, and equipment have been completed, calibrated, and started; are operating according to the Contract Documents; and that Certificates of Readiness are signed and submitted.

2. Certify that HVAC instrumentation and control systems have been completed and calibrated; are operating according to the Contract Documents; and that pretest set points have been recorded.

3. Certify that TAB procedures have been completed, and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.

4. Test systems and intersystem performance after approval of test checklists for systems, subsystems, and equipment.

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

6. Verify each operating cycle after it has been running for a specified period and is operating in a steady-state condition.

7. Inspect and verify the position of each device and interlock identified on checklists. Sign off each item as acceptable, or failed. Repeat this test for each operating cycle that applies to system being tested.

8. Check safety cutouts, alarms, and interlocks with duct detectors and life-safety systems during each mode of operation.

9. Annotate checklist or data sheet when a deficiency is observed.

10. Verify equipment interface with monitoring and control system and TAB criteria; include the following:

    a. All temperature alarms.
    b. All pump status alarms.
    c. Supply and return flow rates for single zone VAV and constant volume systems in each operational mode.
    d. Operation of heat pump units in both heating and cooling cycles.
    e. Minimum outdoor-air intake in each operational mode and at minimum and maximum airflows.
    f. Total exhaust airflow and total outdoor-air intake.
    g. Minimum outdoor-air intake in each operational mode and at minimum and maximum airflows.
    h. Supply, outside air, exhaust and return air flow rates for ERVs in each operating mode.
    i. Pump flow rates, pressure and amperage at each operating mode.
    j. 100% outside air water source heat pump air and water flow rates and temperatures in each operating mode.
    k. Sequences of operation of all HVAC equipment.
    l. Ductless heat pumps and air conditioning units with air flow rates, fluid flow rates, and temperatures.
    m. Variable speed drive parameters at each operated mode.
    n. Boiler temperatures, flow rates, low water cut-off interlock, flame failure interlocks, and amperage.
    o. Supply and return air flow rates for all HVAC equipment.
    p. Operation/Accuracy of flow measuring stations at various flow rates.
    q. Operation of variable refrigerant flow systems in all modes.
    r. Fluid flow rates and temperature for all hydronic equipment.
    s. Set point and operation of “high temperature” alarms.
    t. Test freeze protection pumps.

11. Verify proper responses of monitoring and control system controllers and sensors to include the following:

    a. For each controller or sensor, record the indicated monitoring and control system reading and the test instrument reading. If initial test indicates that the test reading is outside of the control range of the installed device, check calibration of the installed device and adjust as required. Retest malfunctioning devices and record results on checklist or data sheet.
    b. Report deficiencies and prepare an issues log entry.

12. Verify that HVAC equipment field quality-control testing has been completed and approved. CxA shall direct, witness, and document field quality-control tests, inspections, and startup specified in individual Division 23 Sections.

B. Testing Instrumentation: Install measuring instruments and logging devices to record test data for the required test period. Instrumentation shall monitor and record full range of operating conditions and shall allow for calculation of total capacity of system for each mode of operation. For individual room cooling tests, provide temporary heaters to impose a cooling load. Operational modes include the following:

1. Heating/Cooling Mode.
2. Occupied and unoccupied.
3. Warm up and cool down.
4. Economizer cycle.
5. Life-safety and safety systems.
6. Duct detectors.
7. Fire safety.
8. Temporary upset of system operation.
9. Partial occupancy conditions.
10. Special cycles.
11. ERV/Single Zone VAV Unit supply/exhaust air flow at partial CO2 levels.
12. Variable refrigerant volume units in heating/cooling modes.
13. Lead/Standby modes where redundant equipment is indicated.
14. Lead/Lag modes where parallel pump operation is indicated.
15. All alarms.
16. Flow switch shut-down and alarm.
17. Condensate overflow safety switch shut-down and alarm.
18. Condensate pump operation.

3.2. TAB VERIFICATION

A. TAB Subcontractor shall coordinate with CxA for work required in Division 23 Section "Testing Adjusting & Balancing for HVAC & Plumbing." TAB Subcontractor shall copy CxA with required reports, sample forms, checklists, and certificates.

B. Contractor, HVAC Contractor, and CxA shall witness TAB Work.

C. TAB Preparation:

1. TAB Subcontractor shall provide CxA with data required for "Pre-Field TAB Engineering Reports" specified in Division 23 Section "Testing Adjusting & Balancing for HVAC & Plumbing."

a. CxA shall use this data to certify that prestart and startup activities have been completed for systems, subsystems, and equipment installation.

D. Verification of Final TAB Report:

1. CxA shall select, at random, 10 percent of report for field verification.

2. CxA shall notify TAB Subcontractor 10 days in advance of the date of field verification; however, notice shall not include data points to be verified. The TAB Subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.

3. Failure of an item is defined as follows:

a. For all readings a deviation of more than 10 percent.

4. Failure of more than 10 percent of selected items shall result in rejection of final TAB report.

E. If deficiencies are identified during verification testing, CxA shall notify the HVAC Contractor and Architect, and shall take action to remedy the deficiency. Architect shall review final tabulated checklists and data sheets to determine if verification is complete and that system is operating according to the Contract Documents.

F. CxA shall certify that TAB Work has been successfully completed.

3.3. TESTING

A. Test systems and intersystem performance after test checklists for systems, subsystems, and equipment have been approved.

B. Perform tests using design conditions whenever possible.

1. Simulate conditions by imposing an artificial load when it is not practical to test under design conditions and when written approval for simulated conditions is received from CxA. Before simulating conditions, calibrate testing instruments. Set and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

2. Alter set points when simulating conditions is not practical and when written approval is received from CxA.

3. Alter sensor values with a signal generator when design or simulating conditions and altering set points are not practical. Do not use sensor to act as signal generator to simulate conditions or override values.

C. Scope of HVAC Contractor Testing:

1. Testing scope shall include entire HVAC installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. It shall include measuring capacities and effectiveness of operational and control functions.

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

D. Detailed Testing Procedures: CxA, with HVAC Contractor, TAB Subcontractor, and HVAC Instrumentation and Control Contractor, shall prepare detailed testing plans, procedures, and checklists for HVAC systems, subsystems, and equipment.

E. HVAC Instrumentation and Control System Testing:

1. Field testing plans and testing requirements are specified in Division 23 Section "Instrumentation & Controls of HVAC & Plumbing Systems". The CxA, HVAC Contractor, Equipment Provider/Manufacturer and the HVAC Instrumentation and Control Contractor shall collaborate to prepare testing plans.

2. CxA shall convene a meeting of appropriate entities to review test report of HVAC instrumentation and control systems.

F. Energy Supply System Testing: HVAC Contractor shall prepare a testing plan to verify performance of gas systems and equipment. Plan shall include the following:

1. Sequence of testing and testing procedures for each equipment item and pipe section to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in system testing plan.

2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

G. Heat-Generation System Testing: HVAC Contractor shall prepare a testing plan to verify performance of energy recovery ventilators, variable refrigerant volume units, unit heaters, existing boilers, and single zone VAV units. Plan shall include the following:

1. Sequence of testing and testing procedures for each item of equipment and section of pipe to be tested, identified by identification marker. Markers shall be keyed to Drawings for each pipe sector showing the physical location of each item of equipment and pipe test section. Drawings shall be formatted to allow each item of equipment and section of piping to be physically located and identified when referred to in the system testing plan.

2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

3. Variable refrigerant flow equipment volts, amps, temperatures, fluid flow rates, and modes of operation.

H. Refrigeration System Testing: HVAC Contractor shall prepare a testing plan to verify performance of variable refrigerant volume systems, ductless units, and other refrigeration systems. Plan shall include the following:

1. Sequence of testing and testing procedures for each item of equipment and section of pipe to be tested, identified by identification marker. Markers shall be keyed to Drawings showing the physical location of each item of equipment and pipe test section. Drawings shall be formatted to allow each item of equipment and section of piping to be physically located and identified when referred to in the system testing plan.

2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

3. Variable refrigerant flow equipment volts, amps, temperatures, fluid flow rates, and modes of operation.

I. HVAC Distribution System Testing: HVAC Contractor shall prepare a testing plan to verify performance of ERV unit supply and exhaust, single zone VAV units and other distribution systems. Include HVAC terminal equipment and unitary equipment. Plan shall include the following:

1. Sequence of testing and testing procedures for each item of equipment and section of pipe to be tested, identified by identification marker. Markers shall be keyed to Drawings showing the physical location of each item of equipment and pipe test section. Drawings shall be formatted to allow each item of equipment and section of piping to be physically located and identified when referred to in the system testing plan.

2. Tracking checklist for managing and ensuring that all pipe sections have been tested.

3. Equipment, air flow rates, air temperatures, fluid flow rates, safeties, freeze protection pump operation, and demand controlled ventilation.

J. Deferred Testing:

1. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, the deficiency shall be documented and reported to Owner. Deficiencies shall be resolved and corrected by appropriate parties and test rescheduled.

2. If the testing plan indicates specific seasonal testing, appropriate initial performance tests shall be completed and documented and additional tests scheduled.

K. Testing Reports:

1. Reports shall include measured data, data sheets, and a comprehensive summary describing the operation of systems at the time of testing.

2. Include data sheets for each controller to verify proper operation of the control system, the system it serves, the service it provides, and its location. For each controller, provide space for recording its readout, the reading at the controller's sensor(s), plus comments. Provide space for testing personnel to sign off on each data sheet.

3. Prepare a preliminary test report. Deficiencies will be evaluated by Architect to determine corrective action. Deficiencies shall be corrected and test repeated.

END OF SECTION

DIVISION 07 SECTION 078413
FIRE PROTECTION, HVAC & PLUMBING PENETRATION FIRESTOPPING
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SECTION 078413 FIRE PROTECTION, HVAC & PLUMBING PENETRATION FIRESTOPPING

PART 1. GENERAL

1.1. SUMMARY

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

B. Section includes:

1. Through-penetration firestopping in fire rated construction.

2. Through-penetration smoke-stopping in smoke partitions.

C. Related items:

1. Fire dampers and manufactured devices: Refer to Division 23 Section HVAC Air Distribution.

1.2. REFERENCES

A. Underwriters Laboratories

1. UL Fire Resistance Directory

a. Through-penetration firestop devices (XHCR)
b. Fire resistance rating (BXUV)
c. Through-penetration firestop systems (XHEZ)
d. Fill, void, or cavity material (XHHW)

B. American Society for Testing and Materials Standards:

C. ASTM E 814-88: Standard Test Method for Fire Tests of Through-Penetration Firestops.

1.3. DEFINITIONS

A. Assembly: Particular arrangement of materials specific to given type of construction described or detailed in referenced documents.

B. Barriers: Time-rated fire walls, smoke barrier walls, time-rated ceiling/floor assemblies and structural floors.

C. Firestopping: Methods and materials applied in penetrations and unprotected openings to limit spread of heat, fire, gasses and smoke.

D. Penetration: Opening or foreign material passing through or into barrier or structural floor such that full thickness of rated materials is not obtained.

E. System: Specific products and applications, classified and numbered by Underwriters Laboratories, Inc. to close specific barrier penetrations.

F. Sleeve: Metal fabrication or pipe section extended through thickness of barrier and used to permanently guard penetration. Sleeves are described as part of penetrating system in other sections and may or may not be required.

1.4. SYSTEM DESCRIPTION

A. Design Requirements

1. Fire-rated construction: Maintain barrier and structural floor fire resistance ratings including resistance to cold smoke at all penetrations.

2. Smoke barrier construction: Maintain barrier and structural floor resistance to cold smoke at all penetrations.

1.5. SUBMITTALS

A. Submit in accordance with Division 01 Section Submittal Procedures, unless otherwise indicated.

B. Product data: Manufacturer's specifications and technical data including the following:

1. Detailed specification of construction and fabrication.

2. Manufacturer's installation instructions.

C. Shop drawings: Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, plus the following specific requirements.

1. Details of each proposed assembly identifying intended products and applicable UL system number, or UL classified devices.

2. Manufacturer or manufacturer's representative shall provide qualified engineering judgment and drawings relating to non-standard applications as needed.

D. Quality control submittals:

1. Statement of qualifications.

E. Applicators' qualifications statement:

1. List past projects indicating required experience.

1.6. QUALITY ASSURANCE

A. Installer's qualifications: Fire experienced in installation or application of systems similar in complexity to those required for this project, plus the following:

1. Acceptable to or licensed by manufacturer, State or local authority where applicable.

2. At least 2 years experience with systems.

3. Successfully completed at least 5 comparable scale projects using this system.

B. Local and State regulatory requirements: Submit forms or acceptance for proposed assemblies not conforming to specific UL Firestop System numbers, or UL classified devices.

C. Materials shall have been tested to provide fire rating at least equal to that of the construction.

1.7. DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:

1. Deliver products in original unopened packaging with legible manufacturer's identification.

2. Coordinate delivery with scheduled installation date, allow minimum storage at site.

B. Storage and protection: Store materials in a clean, dry, ventilated location. Protect from soiling, abuse, moisture and freezing when required. Follow manufacturer's instructions.

1.8. PROJECT CONDITIONS

A. Existing condition:

1. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.

2. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.

B. Environmental requirements:

1. Furnish adequate ventilation if using solvent.

2. Furnish forced air ventilation during installation if required by manufacturer.

3. Keep flammable materials away from sparks or flame.

4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.

1.9. WARRANTY

A. Submit copies of written warranty agreeing to repair or replace joint sealers which fail in joint adhesion, extrusion resistance, migration resistance, or general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated. The warranty period shall be two (2) years from date of substantial completion unless otherwise noted.

PART 2. PRODUCTS

2.1. THROUGH-PENETRATION FIRESTOPPING OF FIRE-RATED CONSTRUCTION

A. Systems of devices listed in the UL Fire Resistance Directory under categories XHCR and XHEZ may be used, providing that it conforms to the construction type, penetrant type, annular space requirements and fire rating involved in each separate instance, and that the system be symmetrical for wall applications. Systems or devices must be asbestos-free.

1. Additional requirements: Withstand the passage of cold smoke either as an inherent property of the system, or by the use of a separate product included as a part of the UL system or device, and designed to perform this function.

2. Acceptable manufacturers and products.

a. Those listed in the UL Fire Resistance directory for the UL System involved and as further defined in the System and Applications Schedule in Part 3.6 of this section.

3. All firestopping products must be from a single manufacturer. All trades shall use products from the same manufacturer unless otherwise noted.

2.2. SMOKE-STOPPING AT SMOKE PARTITIONS

A. Through-penetration smoke-stopping: Any system complying with the requirements for through-penetration firestopping in fire-rated construction, as specified in The Systems and Applications Schedule in Part 3.6 of this section, is acceptable, provided that the system includes the specified smoke seal or will provide a smoke seal. The length of time of the fire resistance may be disregarded.

2.3. ACCESSORIES

A. Fill, void or cavity materials: As classified under category XHHW in the UL Fire Resistance Directory.

B. Forming materials: As classified under category XHKU in the UL Fire Resistance Directory.

PART 3. EXECUTION

3.1. EXAMINATION

A. Verification of conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.

1. Verify barrier penetrations are properly sized and in suitable condition for application of materials.

2. Do not proceed until unsatisfactory conditions have been corrected.

B. Coordinate an inspection of all Mechanical Firestopping systems with the Fire Marshal prior to installation of ceilings, walls, etc.

3.2. PREPARATION

A. Clean surfaces to be in contact with penetration seal materials of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.

3.3. INSTALLATION

A. Install penetration seal materials in accordance with printed instructions of the UL Fire Resistance Directory and in accordance with manufacturer's instruction.

B. Seal holes or voids made by penetrations to ensure an effective smoke barrier.

C. Protect materials from damage on surfaces subject to traffic.

D. When large openings are created in walls or floors to permit installation of pipes, ducts, or other items, close unused portions of opening with firestopping materials tested for the application. See UL Fire Resistance Directory or Section 3.6 of this document.

1. Install smoke stopping as specified for firestopping.

3.4. FIELD QUALITY CONTROL

A. Examine penetration sealed areas to ensure proper installation before concealing or enclosing areas.

B. Keep areas of work accessible until inspection by applicable code authorities.

C. Perform under this section patching and repairing of firestopping caused by cutting or penetration by other trades.

D. ADJUSTING AND CLEANING

E. Clean up spills of liquid components.

F. Neatly cut and trim materials as required.

G. Remove equipment, materials and debris, leaving area in undamaged, clean condition.

3.5. SYSTEMS AND APPLICATION SCHEDULES*

PENETRATING ITEM	CONCRETE	GYPSUM	WOOD FLOOR/CEILING
Metal Pipe	CAJ1001 CP25S/L, CP25N/S CAJ1006 CS-195+, FS-195+ CAJ1007 FS-195+, 1-inch& 2-inch Wide CAJ1009 2000, 2000+, 2003 CAJ1010 2000, 2000+, 2003 CAJ1012 2000, 2000+, 2003 CAJ1013 2000, 2000+, 2003 CAJ1014 2000, 2000+, 2003 CAJ1015 2000, 2000+, 2003 CAJ1017 FD 150 CAJ1021 FD 150 CAJ1027 MPS-2+ CAJ1044 CP 25WB+ CAJ1052 CP 25S/L, CP 25N/S CAJ1058 2000, 2000+, 2003 CAJ1060 2000, 2000+, 2003 CAJ1063 2000, 2000+, 2003 CAJ1066 CP 25N/S,CP 25S/L, CP 25WB+ CAJ1091 CP 25N/S,CP 25S/L, CP 25WB+ CAJ1092 CP 25WB+ CAJ1112 FS-195+ CAJ1160 CP 25S/L, CP 25N/S CAJ1175 CP 25WB+ CAJ1176 CP 25WB+ CAJ1188 2000+ CBJ1020 CS-195+, FS-195+ CBJ1021 CS-195+, MPS-2+ CBJ1031 2001 CBJ1032 2001 FA1002 CP 25WB+ WJ1010 CP25WB+ WJ1023 2001	WL1001 CP 25 WL1002 FS-195+ WL1003 CP 25WB+,CP 25N/S WL1008 2000+ WL1009 2000+ WL1010 2000+ WL1016 CP 25WB+ WL1017 CP 25WB+,CP 25N/S WL1032 CP 25WB+,CP 25N/S WL1036 FD 150 WL1037 CS-195+,FS-195+ WL1067 CP 25N/S WL1073 CP 25WB+ WL1080 MPS2+ WL1082 2000+	FC1002 CP 25 FC1003 2000,2000+,20003 FC1006 CP 25WB+
Non-Metallic	CAJ2001 FS-195+, 1-inch& 2-inch WIDE, PPD'S CAJ2002 FS-195+ CAJ2003 CS-195+, FS-195+ CAJ2005 FS-195 CAJ2006 FS-195+ CAJ2013 FS-195+ CAJ2019 2000, 2000+, 2003 CAJ2027 FS-195+, CP 25N/S, CP 25S/L, CP 25WB+ CAJ2028 FS-195, MPS-2+ CAJ2029 FS-195+, PPD'S CAJ2030 CS-195+, FS-195+ CAJ2040 FS-195+, CP 25WB+ CAJ2044 FS-195+, CP 25N/S, CP 25S/L CP 25 WB+ CAJ2090 FS-195+ CAJ2177 FS-195+, PPD'S FA2001 FS-195+, PPD'S FS2002 CS-195+, FS-195+, MPS-2+, PPD'S FA2011 FS-195+ WJ2012 FS-195+ 1-inch WIDE	WL2002 FS-195+, PPD'S WL2003 FS-195+ WL2004 FS-195+ WL2005 FS-195+ 4' WIDE WL2006 FS-195+ WL2013 FS-195+ WL2031 CS-195+, FS-195+ WL2032 CS-195+, FS-195+ WL2033 FS-195+ WL2073 FS-195+ 1-inch WIDE	FC2002 FS-195+, PPD'S FC2007 FS-195+, PPD'S FC2008 FS-195+ FC2009 FS-195+, PPD'S FC2024 FS-195 FC2026 FS-195+ FC2028 FS-195, 1' & 2-inch WIDE, PPD'S

PENETRATING ITEM	CONCRETE	GYPSUM	WOOD FLOOR/CEILING
Insulated Metallic Pipe	CAJ5001 CP 25N/S, CP 25S/L, CP 25WB+ CAJ5002 FS-195+ CAJ5003 FS-195+ CAJ5005 MPS-2+ CAJ5009 2000+, 2003 CAJ5017 FS-195+, CP 25 CAJ5022 FS-195+ CAJ5024 FS-195+ CAJ5030 CS-195+, FS-195+ CAJ5041 2000, 2000+, 2003 CAJ5060 CP 25WB+ CAJ5074 2000+ CBJ5002 CP 25 CBJ5003 FS-195+ FA5001 FS-195+, CP 25WB+	WL5001 FS-195+ WL5002 FS-195+ WL5009 FS-195+ WL5010 FS-195+ WL5011 CP 25WB+ WL5032 2000+ WL5038 CP 25WB+ WL5039 CP 25WB+ WL5040 CP 25WB+ WL5045 CP 25WB+ WL5053 2000+	FC5002 FS-195+ FC5008 FS-195+
Miscellaneous Mechanical HVAC Ducts	CAJ7001 CP 25N/S CP 25S/L CAJ7003 CP 25WB+ CAJ7009 DUCT WRAP, BULK PUTTY		FC7001 CP 25S/L, CP 25N/S
Mixed Penetrating Items Combos	CAJ8001 CS-195+ FS-195 CAJ8003 2000, 2000+, 20003 CAJ8004 2000, 2000+, 20003 CAJ8006 2001 CAJ8013 FS-195+, CP 25 CBJ8004 CS-195, FS-195+ CBJ8005 CS-195+, MPS-2+ CBJ8008 2001 FA8001 FS-195+, CP 25WB+	WL8002 CS-195+, FS-195+	

*Underwriter's Laboratories, Inc., Fire Resistance Directory.

END OF SECTION

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COMMON WORK RESULTS FOR FIRE PROTECTION
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SECTION 210500 - COMMON WORK RESULTS FOR FIRE PROTECTION

PART 1. GENERAL

1.1. SUMMARY

A. All work under Division 21 is subject to the Division 01, General Conditions and Special Requirements for the entire contract.

B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all mechanical work.

C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.

D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with Submittals specified below. The right is reserved to make reasonable changes in location of equipment, and piping up to the time of rough-in or fabrication.

E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.

F. Coordinate the work under Division 21 with the work of all other construction trades.

G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.

1.2. PERMITS AND FEES

A. Obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.

B. Permits and fees shall comply with the Division 01, General Requirements of the specification.

1.3. EXAMINATION OF SITE

A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner will be permitted for Contractors failure to do so.

B. Examine and verify specific conditions described in individual specifications sections.

C. Verify that utility services are available, of the correct characteristics, and in the correct locations.

1.4. CONTRACTOR QUALIFICATION

A. Any Contractor or Subcontractor performing work under Division 21 shall be fully qualified and acceptable to the Architect and Owner. Submit the following evidence when requested:

1. A list of not less than five comparable projects which the Contractor completed.

2. Letter of reference from not less than three registered professional engineers, general contractors or building owners.

3. Local and/or State License, where required.

4. Membership in trade or professional organizations where required.

B. A Contractor is any individual, partnership, or corporation, performing work by contract or subcontract on this project.

C. Acceptance of a Contractor or Subcontractor will not relieve the Contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work, of various trades.

1.5. MATERIALS AND EQUIPMENT

A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality. Existing items of equipment are being relocated under another Division of these specifications. The Contractor shall be responsible for connecting all utilities as shown on the drawings, to equipment identified as existing.

B. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or its equal, subject to approval by Engineer. Substituted items shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of substituted items, for approval.

C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Substituted items, including items other than first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application. Contractor, by providing other than the first named manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation. Adjustments and modifications shall include but not be limited to electrical, structural, support, and architectural work.

D. Substitution will not be permitted for specified items of material or equipment where noted.

E. All items of equipment furnished shall have a service record of at least five (5) years.

1.6. FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA and ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.7. REFERENCED STANDARDS, CODES AND SPECIFICATIONS

A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.

B. ASTM - American Society for Testing and Materials

C. FM - Factory Mutual

D. IBC - International Building Code

E. IEEE - Institute of Electrical and Electronics Engineers

F. MSSP - Manufacturers Standards Society of the Valve and Fittings Industry

G. NEC - National Electrical Code

H. NEMA - National Electrical Manufacturers Association

I. NFPA - National Fire Protection Association

J. UL - Underwriters' Laboratories

K. State of Delaware Fire Protection Requirements.

L. All equipment materials, piping and installation shall comply with the codes and standards listed in the enforceable edition of the Applicable National Fire Protection Association Pamphlets.

M. Fire Protection Systems design, equipment and installation shall comply with the Delaware State Fire Prevention Regulations, latest edition including all Annexes and Addendums.

1.8. SUBMITTALS, REVIEW AND ACCEPTANCE

A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Architect to be in best interest of Owner.

B. After acceptance of Material and Equipment List, submit six (6) copies or more as required under General Conditions of complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.

C. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.

D. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.

E. Identify submittals, indicating intended application, location and service of submitted items. Refer to specification sections or paragraphs and drawings where applicable. Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For substituted items, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The contractor shall be responsible for corrective action and maintaining the specification requirements if differences have not been clearly indicated in the submittal.

F. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Call attention, in writing, to deviation from contract requirements.

G. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted. Use only final or corrected submittals and data prior to fabrication and/or installation.

H. For any submittal requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

I. For resubmissions, the Contractor must address in writing all of the Engineer’s comments on the original submission to verify compliance.

1.9. SHOP DRAWINGS

A. Prepare and submit shop drawings for all mechanical equipment, specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.

B. Submit data and shop drawings including but not limited to the list below, in addition to provisions of the paragraph above. Identify all shop drawings by the name of the item

and system and the applicable specification paragraph number and drawing number.

C. Every submittal including, but not limited to the list below, shall be forwarded with its own transmittal as a separate, distinct shop drawing. Grouping of items/systems that are not related shall be unacceptable.

D. Items and Systems

1. Access Doors/Panels including layout and location

2. Coordinated Drawings

3. Drip Pans

4. Exterior Equipment/Piping Supports

5. Fire Protection System including Hydraulic Calculations, Equipment and Devices

6. Fire Stopping - Methods and Materials

7. Identification System

8. Material and Equipment List

9. Operations and Maintenance Manuals

10. Pipe Materials Including Itemized Schedule

11. Preliminary Pipe Pressure Tests

12. Pressure Relief Valves

13. Pressure Gauges

14. Test Certificates

15. Thermal Insulation Materials

16. Valves

17. Wiring Diagrams, Flow Diagrams and Operating Instructions

E. Contractor, additionally, shall submit for review any other shop drawings as required by the Architect. No item shall be delivered to the site, or installed, until the Contractor has received a submittal from the Engineer marked Reviewed or Comments Noted. After the proposed materials have been reviewed, no substitution will be permitted except where approved by the Architect.

F. For any shop drawing requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold

contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

1.10. SUPERVISION AND COORDINATION

A. Provide complete supervision, direction, scheduling, and coordination of all work under the Contract, including that of subcontractors.

B. Coordinate rough-in of all work and installation of sleeves, anchors, and supports for piping, equipment, and other work performed under Division 21.

C. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for fire protection installations.

D. Coordinate electrical work required under Division 21 with that under Division 26. Coordinate all work under Division 21 with work under all other Divisions.

E. Supply services of an experienced (10 years minimum) and competent Project Manager to be in constant charge of work at site.

F. Where a discrepancy exists within the specifications or drawings or between the specifications and drawings, the more stringent (or costly) requirement shall apply until clarification can be obtained from the Engineer. Failure to clarify such discrepancies with the Engineer will not relieve the Contractor of the responsibility of conforming to the requirements of the Contract.

G. Failure of contractor to obtain a full and complete set of contract documents (either before or after bidding) will not relieve the contractor of the responsibility of complying with the intent of the contract documents.

H. Coordinate installation of large equipment requiring positioning before closing in building.

1.11. CUTTING AND PATCHING

A. Accomplish all cutting and patching necessary for the installation of work under Division 21. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, perform work in neat and workmanlike manner. Restore disturbed work to match and blend with existing construction and finish, using materials compatible with the original. Use mechanics skilled in the particular trades required.

B. Do not cut structural members without approval from the Architect or Structural Engineer.

1.12. PENETRATION OF WATERPROOF CONSTRUCTION

A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are

necessary, furnish and install all necessary curbs, sleeves, flashings, fittings and caulking to make penetrations absolutely watertight.

B. Where pipes penetrate roofs, flash pipe with Stoneman Stormtite, Pate or approved equal, roof flashing assemblies with skirt and caulked counter flashing sleeve.

C. Furnish and install pitch pockets or weather tight curb assemblies where required.

D. Furnish and install curbs, specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions. The Contractor shall be responsible for sleeve sizes and locations. All roof penetrations shall be installed in accordance with manufacturer's instructions, the National Roofing Contractors Association, SMACNA, and as required by other divisions of these specifications.

1.13. CONNECTIONS AND ALTERATIONS TO EXISTING WORK

A. Unless otherwise noted on the drawings, where existing fire protection work is removed, pipes, valves, etc., shall be removed, including hangers, to a point below finished floors or behind finished walls and capped. Such point shall be far enough behind finished surfaces to allow for installation of normal thickness of required finish material.

B. Where work specified in Division 21 connects to existing equipment and piping, etc., Contractor shall perform all necessary alterations, cuttings, fittings, etc., of existing work as may be necessary to make satisfactory connections between new and existing work, and to leave completed work in a finished and workmanlike condition.

C. Where the work specified under Division 21, or under other Divisions, requires relocation of existing equipment, piping, etc., Contractor shall perform all work and make necessary changes to existing work as may be required to leave completed work in a finished and workmanlike condition.

D. Where the relocation of existing equipment is required for access or the installation of new equipment, the contractor shall temporarily remove and/or relocate and re-install as required to leave the existing and new work in a finished and workman like condition.

1.14. DEMOLITION

A. Unless otherwise noted all existing equipment, piping, etc., shall remain.

B. Where existing equipment is indicated to be removed, all associated piping, conduit, power, controls, insulation, hangers, supports and housekeeping pads, etc. Patch, paint and repair walls/roof/floor to match existing and/or new finishes.

C. Provide necessary piping, valves, temporary feeds, etc., as required. Drain and refill piping systems as often as necessary to accommodate phasing and to minimize time lengths of outages.

D. The Contractor shall be responsible for visiting the site and determining the existing conditions in which the work is to be performed.

E. Refer to phasing plans for additional requirements.

F. Where any abandoned pipes in existing floors, walls, pipe tunnels, ceilings, etc., conflict with new work, remove abandoned pipes as necessary to accommodate new work.

G. The location of all existing equipment, piping, etc., indicated is approximate only and shall be checked and verified. Install all new fire protection work to connect to or clear existing work as applicable.

H. Maintain egress at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and the authorities having jurisdiction.

I. Make provisions and include in bid all costs associated with confined entry/space requirements in and all other applicable OSHA regulations.

J. Where required to maintain the existing systems in operation, temporarily backfeed existing systems from new equipment. Contractor shall temporarily extend existing piping systems to new piping systems with the appropriate shut-off valves and tamper switches.

K. At completion of project all temporary piping, valves, controls, etc., shall be removed in their entirely.

L. Existing piping, equipment, materials, etc., not required for re-use or re-installation in this project, shall be removed from the project site.

M. Deliver to the Owner, on the premises where directed, existing equipment and materials which are removed and which are desired by the Owner or are indicated to remain the property of the Owner.

N. All other materials and equipment which are removed shall become property of the Contractor and shall be promptly removed, from the premises, and disposed of by the Contractor, in an approved manner.

O. Where piping is removed, remove all pipe hangers which were supporting the removed piping. Patch the remaining penetration voids with like materials and paint to match existing construction.

P. Where required, provide and coordinate removal and re-installation of existing equipment. Take care to protect materials and equipment indicated for reuse. Contractor shall repair or replace items which are damaged. Contractor shall have Owner's representative present to confirm condition of equipment prior to demolition.

Q. Before demolition begins, and in the presence of the Owners representative, test and note all deficiencies in all existing systems affected by demolition but not completely removed by demolition. Provide a copy of the list of system deficiencies to the Owner and the Engineer. Videotape existing conditions in each space prior to beginning demolition work.

R. The Owner shall have the first right of refusal for all devices and equipment removed by

the Contractor.

S. All devices and equipment designated by the Owner to remain the property of the Owner shall be moved and stored by the Contractor at a location on site as designated by the Owner. It shall be the Contractor's responsibility to store all devices and equipment in a safe manner to prevent damage while stored.

T. All existing equipment refused by the Owner shall become the property of the Contractor and shall be removed from the site by the Contractor in a timely manner and disposed of in a legal manner.

U. Work Abandoned in Place: cut and remove underground pipe a minimum of 2 inches beyond face of adjacent construction. Cap and patch surface to match existing finish.

V. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.

W. Terminate services and utilities in accordance with local laws, ordinances, rules and regulations.

1.15. VIBRATION ISOLATION

A. Furnish and install vibration isolators, flexible connections, supports, anchors and/or foundations required to prevent transmission of vibration from equipment, or piping to building structure. See Division 23 Section, "Vibration Control for HVAC Plumbing and Fire Protection Equipment".

1.16. DEFINITIONS

A. Approve - to permit use of material, equipment or methods conditional upon compliance with contract documents requirements.

B. Furnish and install or provide means to supply, erect, install, and connect to complete for readiness for regular operation, the particular work referred to.

C. Contractor means the mechanical contractor and any of his subcontractors, vendors, suppliers, or fabricators.

D. Piping includes pipe, all fittings, valves, hangers, insulation, identification, and other accessories relative to such piping.

E. Concealed means hidden from sight in chases, formed spaces, shafts, hung ceilings, embedded in construction.

F. Exposed means not installed underground or concealed as defined above.

G. Invert Elevation means the elevation of the inside bottom of pipe.

H. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above

ceiling, unexcavated spaces, crawl spaces, and tunnels.

I. Review - limited observation or checking to ascertain general conformance with design concept of the work and with information given in contract documents. Such action does not constitute a waiver or alteration of the contract requirements.

J. Building Line: Exterior wall of building.

PART 2. ELECTRICAL REQUIREMENTS

2.1. GENERAL MOTOR AND ELECTRICAL REQUIREMENTS

A. Furnish and install control and interlock wiring for the equipment furnished. In general, power wiring and motor starting equipment will be provided under Division 26. Carefully review the contract documents to coordinate the electrical work under Division 21 with the work under Division 26. Where the electrical requirements of the equipment furnished differ from the provisions made under Division 26, make the necessary allowances under Division 21. Where no electrical provisions are made under Division 26, include all necessary electrical work under Division 21.

B. All electrical work performed under Division 21 shall conform to the applicable requirements of Division 26 and conforming to the National Electrical Code. All wiring, conduit, etc., installed in ceiling plenums must be plenum rated per NFPA and the IBC.

C. Provide wiring diagrams with electrical characteristics and connection requirements.

D. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than five (5) horsepower.

E. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering. For extended outdoor storage, remove motors from equipment and store separately.

F. All motors shall be furnished with visible nameplate indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor and efficiency.

G. Nominal efficiency and power factor shall be as scheduled at full load and rated voltage when tested in accordance with IEEE 112.

H. Brake horsepower load requirement at specified duty shall not exceed 85 percent of nameplate horsepower times NEMA service factor for motors with 1.0 and 1.15 service factors.

I. All single phase motors shall be provided with thermal protection: Internal protection shall automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature ratings of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range, unless otherwise indicated.

2.2. WIRING DIAGRAMS

A. The Contractor is responsible for obtaining and submitting wiring diagrams for all major items of equipment.

B. Wiring diagrams shall be provided with shop drawings for all equipment requiring electric power.

PART 3. EXECUTION

3.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.

B. Install equipment according to approved submittal data. Portions of the work are shown only in diagrammatic form. Refer conflicts to Architect.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. Install fire protection equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

E. Install equipment giving right of way to piping installed at required slope.

F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

G. Do not install equipment or piping over electrical gear, electrical panels, motor controllers, and similar electrical equipment. Install equipment and piping to maintain clear space above and in front of all electrical components per the National Electric Code.

3.2. SUPPORTS, HANGERS AND FOUNDATIONS

A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workmanlike manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.

B. Supports, hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For un-insulated copper piping provide copper hanger to prevent contact of dissimilar metals. All exterior hangers shall be constructed of galvanized steel utilizing galvanized rods, nuts, washers, bolts, etc. At contractor's option stainless steel may be utilized for exterior hangers, rods, nuts, washers, bolts, etc.

3.3. DEMONSTRATION AND TRAINING VIDEO RECORDINGS

A. General: Record demonstration and training video recordings. Record each training module separately.

1. At beginning of each training module, record each chart containing learning objective and lesson outline.

B. Video Recording Format: Provide high-quality color video recordings with menu navigation in format acceptable to Engineer

C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.

D. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.

E. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

3.4. PROVISIONS FOR ACCESS

A. The contractor shall provide access panels and doors for all concealed equipment, valves, strainers, controls, control devices, and other devices requiring maintenance, service, adjustment, balancing or manual operation.

B. Where access doors are necessary, furnish and install manufactured painted steel door assemblies consisting of hinged door, key locks, and frame designed for the particular wall or ceiling construction. Properly locate each door. Door sizes shall be a 12 inches x 12 inches for hand access, 18 inches x 18 inches for shoulder access and 24 inches x 24 inches for full body access where required. Review locations and sizes with Architect prior to fabrication. Provide U.L. approved and labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, Mifab, or approved equal.

1. Acoustical or Cement Plaster: Style B

2. Hard Finish Plaster: Style K or L

3. Masonry or Dry Wall: Style M

C. Where access is by means of liftout ceiling tiles or panels, mark each ceiling grid using small color-coded and numbered tabs. Provide a chart or index for identification. Place markers within ceiling grid not on ceiling tiles.

D. Access panels, doors, etc. described herein shall be furnished under the section of specifications providing the particular service and to be turned over to the pertinent trade for installation. Coordinate installation with installing contractor. All access doors shall be painted in baked enamel finish to match ceiling or wall finish.

E. Submit shop drawings indicating the proposed location of all access panels/doors. Access doors in finished spaces shall be coordinated with air devices, lighting and

sprinklers to provide a neat and symmetrical appearance.

F. Where access doors are installed in wet locations (i.e. shower rooms, toilet rooms, kitchens, dishwasher rooms, can wash rooms, and similar spaces, etc.) provide aluminum access doors/frames.

3.5. PAINTING AND FINISHES

A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc. shall be stainless steel.

B. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.

C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.

D. Protect all finishes and restore any finishes damaged as a result of work under Division 21 to their original condition.

E. The preceding requirements apply to all work, whether exposed or concealed.

F. Remove all construction marking and writing from exposed equipment, piping and building surfaces. Do not paint manufacturer's labels or tags.

G. All exposed piping, equipment, etc. shall be painted. Colors shall be as stated in this division or as selected by the Architect and conform to ANSI Standards.

H. All exposed piping, equipment, etc. in finished spaces shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.

3.6. CLEANING OF SYSTEMS

A. Thoroughly clean systems after satisfactory completion of pressure tests and before permanently connecting equipment, and other accessory items. Blow out and flush piping until interior surfaces are free of foreign matter.

B. Flush piping to remove cutting oil, excess pipe joint compound, solder slag and other foreign materials. Do not use system pumps until after cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling, the residual alkalinity shall not exceed 300 parts per million. Submit a certificate of completion to Engineer stating the name of Service Company used.

C. Pay for labor and materials required to locate and remove obstructions from systems that are clogged with construction refuse after acceptance. Replace and repair work disturbed during removal of obstructions.

D. Leave systems clean, and in complete running order.

3.7. COLOR SELECTION

A. Color of finishes shall be as selected by the Architect.

B. Submit color of factory-finished equipment for acceptance prior to ordering.

3.8. PROTECTION OF WORK

A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

B. Cover temporary openings in piping and equipment to prevent the entrance of water, dirt, debris, or other foreign matter. Deliver pipes and tubes with factory applied end caps.

C. Cover or otherwise protect all finishes.

D. Replace damaged materials, devices, finishes and equipment.

E. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, where stored inside.

3.9. OPERATION OF EQUIPMENT

A. Clean all systems and equipment prior to initial operation for testing, or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.

B. Where specified, or otherwise required, provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment. Where factory start-up of equipment is not specified, provide field start-up by qualified technician.

C. Submit factory start-up sheets or field start-ups sheets for all equipment.

3.10. IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS

A. Contractor shall submit for approval working fire protection drawings of each piping system installed in the building. Diagrams shall indicate the location and the identification number of each valve in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under safety glass and hung in each Mechanical Room where directed. Contractor shall deliver the tracing or sepia from which the diagrams were reproduced to the Owner.

B. All valves shall be plainly tagged. For any bypass valves, install sign indicating valve position as “Normally Open” or “Normally Closed” as required.

C. All items of equipment, including disconnects shall be furnished with white on black

plastic permanent identification cards. Lettering shall be a minimum of ¼ inch high. Identification plates shall be secured, affixed to each piece of equipment, starters, disconnects, panels by screw or adhesive (tuff bond #TB2 or as approved equal). Equipment identification and room name or area served shall be on each label.

D. Provide six (6) copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the Operation and Maintenance Booklet as hereinafter specified.

E. All piping installed under this contract shall be stenciled with direction of flow arrows and with stenciled letters naming each pipe and service. Refer to Division 21 Section, "Fire Protection Piping, Fittings, Valves, Etc". Color code all direction of flow arrows and labels. In finished spaces omit labeling and direction of flow arrows. Paint in color as selected by Architect.

F. Submit list of wording, symbols, letter size, and color coding for fire protection identification. Submit samples of equipment identification cards, piping labels, and valve tags to Engineer for review prior to installation.

G. Provide at least eight (8) hours of straight time instruction to the operating personnel. Time of instruction shall be designated by the Owner.

H. Contractor shall demonstrate Sequences of Operation of all fire protection equipment in presence of Owner's representative, and Fire Marshal.

3.11. WALL AND FLOOR PENETRATION

A. All penetrations of partitions, ceilings, roofs and floors by piping or conduit under Division 21 shall be sleeved, sealed, and caulked airtight for sound and air transfer control.

B. All penetration of fire rated assemblies shall be sleeved, sealed, caulked and protected to maintain the rating of the wall, roof, or floor. Fire Marshal approved U.L. assemblies shall be utilized. See Division 07 Section, "Fire Protection, HVAC and Plumbing Protection Firestopping".

C. Where piping extends through exterior walls or below grade, provide waterproof pipe penetration seals, as specified in another division of these specifications.

D. Provide pipe escutcheons for sleeved pipes in finished areas.

E. Piping sleeves:

1. Galvanized steel pipe, standard weight where pipes are exposed and roofs and concrete and masonry walls. On exterior walls provide anchor flange welded to perimeter.

2. Twenty-two (22) gauge galvanized steel elsewhere.

F. Extend all floor sleeves through floor at least 2-inches above finished floor, caulk sleeve

the entire depth and furnish and install floor plate.

3.12. RECORD DRAWINGS

A. Upon completion of the mechanical installations, the Contractor shall deliver to the Architect one complete set of prints of the fire protection drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings.

B. Contractor shall incorporate all sketches, addendums, value engineering, change orders, etc., into record drawings prior to delivering to Architect.

3.13. WARRANTY

A. Contractor's attention is directed to warranty obligations contained in the GENERAL CONDITIONS.

B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of equipment manufacturer's warranties shall be included in the operations and maintenance manuals.

C. The contractor guarantees for a two year period from the time of final acceptance by the Owner.

1. That the work contains no faulty or imperfect material or equipment or any imperfect, careless, or unskilled workmanship.

2. That all work, equipment, machines, devices, etc. shall be adequate for the use to which they are intended, and shall operate with ordinary care and attention in a satisfactory and efficient manner.

3. That the contractor will re-execute, correct, repair, or remove and replace with proper work, without cost to the Owner, any work found to be deficient. The contractor shall also make good all damages caused to their work or materials in the process of complying with this section.

4. That the entire work shall be water-tight and leak-proof.

3.14. LUBRICATION

A. All bearings, motors, and all equipment requiring lubrication shall be provided with accessible fittings for same. Before turning over the equipment to the Owner, the Contractor shall fully lubricate each item of equipment, shall provide one year's supply of lubricant for each, and shall provide Owner with complete written lubricating instructions, together with diagram locating the points requiring lubrication. Include this information in the Operations and Maintenance Booklet.

B. In general, all motors and equipment shall be provided with grease lubricated roller or ball bearings with Alemite or equal accessible or extended grease fittings and drain plugs.

3.15. OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall have prepared six (6) hardcopies and one (1) electronic copy of the Operation and Maintenance Manuals and deliver these copies of the manuals to the Owner. The manuals shall be as specified herein. The manuals must be approved and will not be accepted as final until so stamped.

B. The manuals shall be bound in a three ring loose-leaf binder similar to National No. 3881 with the following title lettered on the front: Operations and Maintenance Manuals – DTCC Arts & Science Building HVAC Renovation – Fire Protection. No sheets larger than 8-1/2 inches x 11 inches shall be used, except sheets that are neatly folded to 8-1/2 inches x 11 inches and used as a pull-out. Provide divider tabs and table of contents for organizing and separating information.

C. Provide the following data in the booklet:

1. As first entry, an approved letter indicating the starting/ending time of Contractor's warranty period.

2. Maintenance operation and lubrication instructions on each piece of equipment furnished.

3. Manufacturer's extended limited warranties on equipment.

4. Chart form indicating frequency and type of routine maintenance for all fire protection equipment. The chart shall also indicate model number of equipment, location and service.

5. Provide sales and authorized service representatives names, address, and phone numbers of all equipment and subcontractors.

6. Provide supplier and subcontractor's names, address, and phone number.

7. Catalog data of all equipment, valves, etc. shall include wiring diagrams, parts list and assembly drawing.

8. Provide and install in locations as directed by the Owner, valve charts including valve tag number, valve type, valve model number, valve manufacturer, style, service and location. Each valve chart shall be enclosed in a durable polymer based frame with a cover safety glass.

9. Access panel charts with index illustrating the location and purpose of access panels.

10. Approved Fire Protection Certificates.

11. Start-up reports for equipment.

D. Submit Operations and Maintenance Manuals prior to anticipated date of substantial completion for Engineer review and approval. Substantial completion requires that

Operations and Maintenance Manuals be reviewed and approved.

3.16. INSTALLATION AND COORDINATION DRAWINGS

A. Prepare, submit, and use composite installation and coordination drawings to assure proper coordination and installation of work. Drawings shall include, but not be limited, to the following:

1. Complete Plumbing, Sprinkler and HVAC Piping Drawings showing coordination with lights, electrical equipment, HVAC equipment and structural amenities.

B. Draw plans to a scale not less than 3/8-inch equals one foot. Include plans, sections, and elevations of proposed work, showing all equipment, and piping in areas involved. Fully dimension all work including lighting fixtures, conduits, pullboxes, panelboards, and other electrical work, walls, doors, ceilings, columns, beams, joists and other architectural and structural work.

C. Identify all equipment and devices on wiring diagrams and schematics. Where field connections are shown to factory-wired terminals, include manufacturer's literature showing internal wiring.

3.17. PIPING SYSTEMS TESTING

A. The entire new fire protection piping systems shall be tested hydrostatically before insulation covering is applied and proven tight under the following gauge pressures for a duration of four (4) hours. Testing to be witnessed by Owner's representative and documented in writing.

SYSTEM	TEST PRESSURE
Fire Protection (Refer to NFPA)	200 psi

B. Testing and acceptance thereof shall be in accordance with local requirements and shall meet approval of authority having jurisdiction. Submit certificates and approved permits and insert one (1) copy in the Operations and Maintenance Manuals.

3.18. PHASING

A. Refer to Architectural Specifications and contract drawings for any required phasing.

B. Maintain building egress and traffic ways at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and Authorities having jurisdiction.

C. Provide dust barriers/partitions, penetration closures, etc., to ensure safety of building occupants and protection of existing surroundings.

D. The Building shall remain watertight at all times.

E. Refer to phasing plans for additional requirements.

F. Provide necessary piping, valves, etc. as required. Drain and refill piping systems as often as necessary to accommodate phasing and to minimize time length of outages. Temporarily feed new systems with existing system where required.

G. Within thirty days of Award of Contract, the Contractor shall submit a minimum of six (6) copies of the proposed Phasing Plan (Drawings and detailed written description) to the Architect for review and approval based on the general and specific requirements indicated on the Drawings and Specifications. The phasing plan shall reflect the work of all trades. The phasing plan shall be updated as often as needed (i.e. major deviations and/or modified sequence of events) and reviewed during each progress meeting so the facility and Architect can be aware of the areas of construction and progress as it relates to the approved schedule.

H. Due to phased construction, some systems must be operated until later phases are completed.

I. While work is in progress, except for designated short intervals during which connections are made, continuity of service shall be maintained to all existing systems. Interruptions shall be coordinated with the Owner as to time and duration. The contractor shall be responsible for any interruptions to service and shall repair any damages to existing systems caused by his operations.

J. After demolition of ceilings install aluminum inverted pie plates above each sprinkler head (as heat trap). Maintain throughout construction phase. Remove with the installation of new ceilings. Submit to Fire Marshall for review and approval.

3.19. OUTAGES

A. Provide a minimum of fourteen (14) days' notice to schedule outages. The Contractor shall include in their bid outages and/or work in occupied areas to occur on weekends, holidays, or at night. Coordinate and get approval of all outages with the Owner.

B. Submit Outage Request form, attached at end of this Section, to Owner for approval.

END OF SECTION

OUTAGE REQUEST

DATE APPLIED: _____BY: _____

DATE FOR OUTAGE: _____ FIRM: _____

START OUTAGE-TIME: _____ DATE:_____

END OUTAGE -- TIME: _____ DATE:_____

AREAS AND ROOMS: _____

FLOOR(S): _____

AREA(S): _____

ROOM(S): _____

WORK TO BE PERFORMED: _____

SYSTEM(S): _____

REQUEST APPROVED BY: _____

(FOREMAN OR OTHER PERSON IN CHARGE)

(FOR OWNER'S USE ONLY):

APPROVED: _____

YES _____ NO ____ BY: _____DATE: _____

DATE/TIME-AS REQUESTED: _____ OTHER: _____

OWNER'S PRESENCE REQUIRED: _____

YES: ____ NO: ____ NAME: _____

POINT OF CONTACT: _____ PHONE:

DIVISION 21 SECTION 210505
FIRE PROTECTION PIPING, FITTINGS & VALVES
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SECTION 210505 - FIRE PROTECTION PIPING, FITTINGS AND VALVES

PART 1. GENERAL

1.1. SUMMARY

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

1.2. SYSTEM DESCRIPTION CONDITIONS

A. Provide all labor and materials necessary to furnish and install all piping systems on this project as herein specified and/or shown on the drawings.

B. All piping and insulation installed in ceiling plenums must be plenum rated and comply with NFPA and the authority having jurisdiction.

C. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

D. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

E. Use non-conducting dielectric connections whenever jointing dissimilar metals in open systems.

F. Provide pipe hangers and supports in accordance with ASTM B31.9, MSS SP69 and NFPA-13 unless indicated otherwise.

G. Use 3/4 inch (20 mm) ball valves with cap and chain for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

1.3. QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. To assure uniformity and compatibility of piping components in grooved piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

C. If the product is available domestically it shall be supplied as such.

1.4. DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to site under as hereinbefore specified.

B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

C. Provide temporary protective coating on cast iron and steel valves.

D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed systems.

1.5. ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.6. EXTRA MATERIALS

A. Provide one (1) repacking kit for each size valve.

1.7. ALTERNATES

A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. PIPE MATERIALS

A. All materials, unless otherwise specified, shall be new and of the best quality of their respective kinds, and shall conform to the requirements and ordinances of local, state and insurance authorities having jurisdiction.

1. Fire Protection Piping (NFPA-13):

a. Piping Above Grade (Inside): Steel, schedule 40, ASTM A53, black pipe. Piping 4 inches and smaller shall be ASTM A120, black steel pipe. Sizes 4-inches and above shall be standard weight, black, cast iron with screwed fittings, schedule 10 steel piping shall be acceptable when approved by the authority having jurisdiction.

b. Wet Pipe Fittings: Steel fittings shall be ASME B16.9, wrought steel, butt welded. Cast iron fittings shall be ASME 16.1, flanges and flanged fittings. Malleable iron fittings shall be ASME B16.3, threaded fittings. Mechanical grooved couplings shall be malleable iron housing clamps to engage and lock C shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe. Mechanical formed fittings shall be carbon steel housing with integral pipe stop and O-ring and O-ring uniformity compressed into permanent mechanical engagement onto pipe.

c. Victaulic, Grinnell, or approved equal, grooved end fittings and mechanical couplings shall be used for wet pipe and dry pipe systems 2" and larger. Couplings and fitting shall be UL listed and FM approved. Fittings shall be ASTM A536 ductile iron, ASTM A234 forged steel or ASTM A53 fabricated steel with factory grooved ends designed to accept

Victaulic couplings.

d. Victaulic, Grinnell, or approved equal, mechanical couplings shall consist of two ASTM A536 ductile iron housings, pressure-responsive, synthetic rubber gasket and plated steel bolts and nuts.

i. Rigid Type: Housings shall be cast with offsetting, angle-pattern bolt pads to provide system rigidity and support and hanging in accordance with NFPA-13. Tongue and recess rigid type couplings shall only be used if the contractor uses a torque wrench for installation. Required torque shall be in accordance with the manufacturer's latest recommendation.

1) 1-1/4" through 8": "Installation Ready" stab-on rigid coupling, designed for direct 'stab' installation onto grooved end pipe without prior field disassembly and no loose part. Victaulic FireLock EZ Style 009H (1-1/4" – 4") and Victaulic QuickVic Style 107H (2"-8").

1) 2" and Larger: Standard rigid coupling design. Victaulic Style 07 Zero-Flex.

ii. Flexible Type: use in seismic areas and where required by NFPA-13.

Fire Protection Service	Temperature Range	Gasket Recommendation
Water/Wet Systems	Ambient	Grade EPDM, Type A-C Shaped, FireLock EZ, or QuickVic Design

e. Gate Valves: 2-1/2 inches & larger - listed 175 lb. OS&Y, flanged. 2 inches & smaller - UL/FM listed 175 lb., bronze, screwed. Furnish all sprinkler control valves with slow close manual operator and position indicator. Tamper switches furnish under Division 21.

f. Grooved End Gate Valves: 2-1/2inches and Larger – UL listed/FM approved, 250 psi maximum pressure rating, OS&Y, ductile iron body, bronze mounted, grooved ends. Victaulic FireLock Series 771.

g. Grooved End Butterfly Valves: 2 inches & Larger: UL listed/FM approved, up to 365 psi maximum pressure rating, ductile iron body, nickel-plated ductile iron disc, Nitrile seat, weather-proof actuator with two pre-wired supervisory switches. Victaulic FireLock Series 765 or Series 705.

h. Globe Valves: 2 inches & smaller - 175 lb., bronze, screwed, UL/FM listed.

i. Check Valves: 2-1/2 inches & smaller - UL/FM listed 175 lb., flanged swing check. 2 inches & smaller - listed 175 lb., bronze swing check, screwed.

j. Grooved End Check Valves: 2 inches and Larger: UL listed/FM approved, up to 365 psi maximum pressure rating, ductile iron body, spring-loaded stainless steel or EPDM coated ductile iron disc, nickel-plated or welded-in nickel seat. Victaulic FireLock Series 717H or Series 717.

k. Finish: All exposed fire protection piping shall be primed and painted with epoxy red paint. White letters shall indicate pipe and indicate direction of flow. Painting shall be provided under Division 09.

l. Special Requirements: All fire protection piping, valves, fittings and joints shall comply with applicable National Fire Protection Pamphlets (NFPA) local codes, building codes, Fire Marshal, Owner's Insurance Underwriter, and the authority having jurisdiction.

B. Steel pipe shall be similar and equal to National Allied Tube or Wheatland black or zinc-coated (galvanized) as hereinafter specified. Pipe shall be free from all defects which may affect the durability for the intended use. Each length of pipe shall be stamped with the manufacturer's name.

C. Copper pipe shall be Revere, Anaconda or Chase with approved solder fittings.

D. Welding fittings for steel pipe shall meet the requirements of ASTM Standard A-23 and shall be standard catalog products. Fittings fabricated by metering and notching pipe will not be accepted.

2.2. PIPE HANGERS

A. All hangers for metallic piping shall be adjustable, wrought clevis type, or adjustable malleable split ring swivel type, having rods with machine threads. Hangers shall be Grinnell Company's Figure 260 for pipe ¾-inch and larger, and Figure 65 for pipe 2-inches and smaller, or approved equal. Adjustable pipe stanchion with U-bolt shall be Grinnell Company's Figure 191. Pipe roller supports shall be Grinnell's Figure 181 or Figure 271. Exterior pipe hangers shall be galvanized or stainless steel construction. For copper piping in direct contact with the hanger, hanger construction shall be copper coated to prevent contact of dissimilar metals similar to Grinnell's Figure CT-65. Hanger spacing and rod sizes for steel and copper pipe shall not be less than the following:

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
3/4 & 1	6	5	3/8
1 - ½	6	8	3/8
2	8	8	3/8
2 – ½	10	9	½
3	12	10	½
4	14	12	5/8

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
5	14	12	5/8
6	16	14	3/4
8	18	16	7/8

B. Anchors, guides, and roller supports shall be installed in accordance with the contract drawings and manufacturer's recommendations to provide pipe support and control pipe movement for all piping systems. Anchors and guides shall be securely attached to the pipe support structure. Submit shop drawing for proposed pipe support structure for guides and anchors for approval of the Structural Engineer. Pipe alignment guides shall be Fig. 255 Grinnell, or as approved equal. Guides shall be sized to accommodate the pipe with insulation. Guides shall be steel factory, fabricated, with bolted two section outer cylinder and base for alignment of piping and two section guiding spider for bolting to pipe.

C. Hangers for pipe sizes ½ to 1 ½ inch (13 to 38 mm): Carbon steel, adjustable swivel, split ring, comply with NFPA-13.

D. Hangers for pipe sizes 2 to 4 inches (50 to 100 mm): Carbon steel, adjustable, clevis. Comply with NFPA-13.

E. Multiple or Trapeze hangers: Steel channels with welded spacers and hanger rods.

F. Wall support for pipe sizes to 3 inches (76 mm): cast iron hook, comply with NFPA-13.

G. Vertical Support: Steel riser clamp, comply with NFPA-13.

H. Floor support for pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support, comply with NFPA-13.

I. Copper pipe support: Carbon steel ring, adjustable, copper plated, comply with NFPA-13.

J. Hanger rods: Mild steel threaded both ends, threaded one end, or continuous threaded, comply with NFPA-13.

K. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

L. Victaulic Style 009H, 107H, and 07, Grinnell, or approved equal, rigid couplings may be used with IPS steel piping systems, which meet the support and hanging requirements of

NFPA-13. An adequate number of Victaulic Style 177, 75, and 77, Grinnell, or approved equal, flexible couplings shall also be used to compensate for thermal expansion/contraction of the pipe.

2.3. VALVES

A. Provide parts list and assembly drawings (exploded view) for all valves in shop drawing submittals. Provide valves of the same type by the same manufacturer. All valves shall be provided with tamper switches and coordinated with Division 28.

2.4. PRESSURE GAUGES

A. Unless otherwise indicated, pressure gauges shall be the bronze bourdon tube type, 4-1/2-inch dial, stem mounting, cast aluminum adjustable pointer, 1 percent accuracy over middle half of scale range, 1-1/2 percent over balance: Trerice Model 600C; Weksler Instruments, Ernst Gage Co., Miljoco, or as approved equal.

B. Gauges shall have pressure, vacuum, compound, or retard ranges as required, select ranges so that the normal readings are at the approximate midpoint and maximum system pressures do not exceed full scale.

C. Furnish and install a gauge valve at each pressure gauge. Gauge valves shall be Crane Model No. 88, Needle Valve, Ernst Gage Co. FLG 200, Wexler Instrument Corp. Type BBV4, or approved equal, rated for pressure intended.

D. Gauge connections for pressure gauges, thermometers, or control instruments shall be made using tee fittings, except that gauge connections up to 1-inch size in steel may be using threaded extra heavy pipe couplings welded directly to the main, provided that the main is at least 2-inch size for 2-inch connections, 3-inch size for 3/4-inch connections, and 4-inch size for 1-inch connections. Minimum gauge connection shall be 2-inch ips.

E. Provide snubbers on all gauges. Snubbers shall be No. 872 by Trerice, RS1/RS6 by Wexler Instruments, Miljoco or as approved equal.

2.5. PIPING SPECIALTIES

A. Victaulic Style 177, 75, or 77, Grinnell, or approved equal, flexible couplings may be used in lieu of flexible connectors for vibration isolation at equipment connections. Three (3) couplings, for each connector, shall be placed in close proximity to the source of vibration.

2.6. ESCUTCHEONS

A. Provide chromium plated escutcheons properly fitted and secured with set screws on all exposed piping which passes through walls, floors or ceilings of finished spaces.

B. All escutcheon plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface. Plastic escutcheon plates will not be accepted.

2.7. DIELECTRIC CONNECTIONS:

A. Furnish and install electrically insulated dielectric waterway fittings, unions or flanges, as manufactured by EPCO Sales, Inc., or Victaulic Co. at the following locations:

1. Where steel piping systems join copper piping.

2. Avoid the installation of steel nipples, cast iron or steel valves and specialties, or other ferrous components in predominately copper piping systems. Where such installation is necessary, isolate the component with dielectric connections. Do not mix steel pipe and copper tube in the same run of pipe or in the same section of a piping system.

2.8. SLEEVES

A. Sleeves shall be provided around all pipes through walls, floors, ceilings, partitions, roof structure members or other building parts. Sleeves shall be standard weight galvanized iron pipe two sizes larger than the pipe or insulation so that pipe or insulation shall pass through masonry or concrete walls or floors. Provide 20 gauge galvanized steel sheet or galvanized pipe sleeves for all piping passing through frame walls.

B. Sleeves through floors shall be flush with the floor except for sleeves passing through Equipment Rooms which shall extend ¾-inch above the floor. Space between the pipe and sleeve shall be caulked. Escutcheon plates shall be constructed to conceal the ends of sleeves. Each trade shall be responsible for drilling existing floors and walls for necessary sleeve holes. Drilling methods and tools shall be as hereinbefore specified.

C. Sleeves through walls and floors shall be sealed with with a waterproof caulking compound.

D. Firestop at sleeves that penetrate smoke barriers smoke partitions and/or rated walls/floors.

PART 3. EXECUTION

3.1. GENERAL PIPING INSTALLATION REQUIREMENTS

A. All pipes shall be cut accurately to measurements established at the building, and shall be worked into place without springing or forcing, properly clearing all windows, doors and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installation will not be permitted. All pipes shall be so installed as to permit free expansion and contraction without causing damage. All open ends of pipe lines, equipment, etc., shall be properly capped or plugged during installation to keep dirt or other foreign material out of the system. All pipes shall be run parallel with the lines of the building and as close to walls, columns and ceilings as may be practical, with proper pitch. All piping shall be arranged so as not to interfere with removal of other equipment on devices not to block access to doors, windows, manholes, or other access openings. Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment, and installed so that there will be no interference with the installation of the equipment. All valves and

specialties shall be placed to permit easy operation and access and all valves shall be regulated, packed and glands adjusted at the completion of the work before final acceptance. All piping shall be installed so as to avoid air or liquid pockets throughout the work. Ends of pipe shall be reamed so as to remove all burrs.

B. All piping shall be run to provide a minimum clearance of 2-inches between finished covering on such piping and all adjacent work. Group piping wherever practical at common elevations.

C. All valves and other fittings shall be readily accessible.

D. Drain valves with hose connections shall be provided at low points for drainage of piping systems. Blow down valves shall be provided at the ends of all mains and branches so as to properly clean by blowing down the lines throughout in the direction of normal flow.

E. Spring clamp plates (escutcheons) shall be provided where pipes are exposed in the building and run through walls, floors, or ceilings. Plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface.

F. Install all valves with stem upright or horizontal, not inverted.

G. Where pipe support members are welded to structural building framing, scrape, brush clean, weld and apply one coat of zinc rich primer.

H. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

I. All water containing pipes shall be routed clear of combustion air dampers and louvers to prevent freezing condition when dampers are open.

J. Where zone valve assemblies are installed in stairwells, install primed and painted 18 gauge removable mesh screen. Color of paint shall be as selected by Architect.

3.2. PRESSURE GAGE INSTALLATION REQUIREMENTS.

A. Install pressure gages in piping tees with pressure-gage valve located on a pipe at most readable location.

B. Adjust faces of gages to proper angle for best visibility.

C. Clean windows of gages and clean factory-finished surfaces. Replace cracked and broken window, and repair scratched and marred surfaces with manufacturer's touch up paint.

3.3. VALVE INSTALLATION REQUIREMENTS

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

G. Install valves as indicated, according to manufacturer's written instructions.

H. Piping installation requirements are specified in other Division 21 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

I. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

J. Locate valves for easy access and provide separate support where necessary.

K. Install valves in horizontal piping with stem at or above the center of the pipe.

L. Install valves in a position to allow full stem movement.

M. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

3.4. PIPE JOINTS INSTALLATION REQUIREMENTS

A. Screwed Joints: All screwed joints shall be made with tapered threads properly cut. Screwed joints shall be made perfectly tight with a stiff mixture of graphite and oil, applied with a brush to the male threads on the fittings.

B. Grooved Joints: Install in accordance with the manufacturer’s (Victaulic, Grinnell, or approved equal) guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by Victaulic. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. A Victaulic factory-trained field representative shall provide on-site training for contractor’s field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

C. Soldered Joints and Copper Piping: Joints in copper piping shall conform to the following minimum standards.

1. The pipes shall be cut to a length making certain that the ends are square, using a fins hacksaw blade or tube cutter. The ends of all pipes shall be reamed and all burrs removed.

2. The outside end of the pipe and the cut end of the fitting shall be cleaned with steel wool, sand cloth, or steel wire brush. All dark spots shall be removed.

3. The flux shall be applied evenly and sparingly to the outside end of the pipe and the inside of the outer end of the fitting until all surfaces to be jointed are completely covered. The piping and fitting shall be slipped together and reworked several times to insure an even distribution of the flux.

4. The correct amount of solder per joint for each size pipe shall be used in accordance with the manufacturer's recommendations.

5. Solder joints shall be made by using a direct flame from a torch.

6. On pipe sizes larger than ¼-inch, the fittings and valves in the pipe shall be moved or tapped with a hammer when the solder starts to melt to insure an even distribution of the solder.

7. The excess solder shall be removed while it is still in the plastic state leaving a fillet around the cup of the fitting.

8. Solder joints shall be suitable for working pressure of 100 psig and for working temperature of not less than 250 degrees F. The type of solder and flux used will be submitted for approval. Type 95-5 shall be the minimum standard.

D. Where copper piping joins steel piping, approved bronze adapters shall be used.

E. Prohibited Connections: No direct weld, soldered, or brazed connections, without unions or flanges, shall be made to valves, strainers, apparatus, or related equipment. Right and left couplings, long threads, or caulking of pipe threads or gasket joints will not be permitted.

3.5. HANGERS AND SUPPORTS INSTALLATION REQUIREMENTS

A. General: All hangers shall be of an approved type arranged to maintain the required grading and pitching of lines to prevent vibration and to provide for expansion and contraction. Saddles shall be Grinnells Figure 173/273 or approved equal. Provide approved spacers between saddles and pipe where flexible insulation is specified. Provide insulation protection shields for insulated piping without saddles. Shield shall be Grinnell Figure 167 or as approved equal. Comply with NFPA-13.

B. Spacing: Regardless of spacing, hangers shall be provided at or near all changes in direction, both vertical and horizontal, for all piping.

C. Vertical Lines: Shall be supported at their bases, using either a suitable hanger placed in a horizontal line near the riser, or a base type fitting set on a pedestal, foundation or support. All vertical lines extending through more than one floor level shall be supported at each floor with a riser clamp. Riser clamp shall be Grinnell Co.'s Figure 261, or approved equal. All vertical drops to pump suction elbows shall be supported by floor posts.

D. Racks and Brackets: All horizontal piping on vertical walls shall be properly supported by suitable racks securely anchored into the wall construction. Where not practical to obtain ceiling anchorage, all piping near walls shall be supported by approved brackets securely anchored into the wall construction. Washer plates (Fib. 60, 60L) and other miscellaneous attachments, fasteners, etc., shall be Grinnell or as approved equal. All exterior hanger and bracket systems in their entirety shall be galvanized.

E. Pipe Hangers and supports shall be attached to the panel point at the top chord of bar joist or at a location approved by the structural engineer.

F. Select hangers and components for loads imposed. Secure rods with double nuts.

G. Support of horizontal piping shall allow for vertical adjustment after installation of piping.

H. Support overhead piping with clevis hangers.

I. Do not support all parallel piping from the same joist. Stagger all supports in accordance with the structural engineer's recommendations.

J. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

K. Construct concrete anchors of poured in place concrete of dimensions indicated and include embedded fasteners.

L. Refer to structural documents for appropriate connection/attachment materials to building.

3.6. PIPING IDENTIFICATION INSTALLATION REQUIREMENTS

A. All piping shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color code and system identification shall comply with ANSI Standards and piping identification system shall comply with ASME A13.1-81., scheme for the identification of piping systems and ASHRAE Fundamentals Handbook, latest edition.

B. Markings shall be plain block letters, stenciled on pipes, and shall be located near each branch connection, near each valve, and at least every 10 feet on straight runs of pipe. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such manner as to be easily legible from the floor. Pipe identification schedule shall be as follows:

OUTSIDE DIAMETER OF PIPE OR COVERING (INCHES)	LENGTH OF COLOR FIELD (INCHES)	SIZE OF LETTERS (INCHES)
½ to 1 ¼	8	½
1-½ to 2	8	¾
2 ½ to 6	12	1 ¼
8 to 10	24	2 ½
Over 10	32	3 ½

3.7. VALVE IDENTIFICATION REQUIREMENTS

A. All valves shall be tagged with a numbered tag.

B. The tags shall be made of 1-inch diameter brass tags fastened to the valve by means of brass chains. Numbers shall agree with valve numbers on diagrammatic herein before specified.

C. Provide a minimum of six (6) valve charts with valve numbers indicating valve type, size, manufacturer and service.

D. Additional valve charts shall be mounted behind glazed wooden frames and be hung in the main fire protection riser room. Additional copies shall be provided in each copy of the O&M manuals.

END OF SECTION

DIVISION 21 SECTION 211003
WATER BASED FIRE SUPPRESSION SYSTEM – SPRINKLERS
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SECTION 211003 - WATER BASED FIRE SUPPRESSION SYSTEM - SPRINKLERS

PART 1. GENERAL

1.1. REFERENCE

A. The conditions of the Contract and General Requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 21 Section, Common Work Results for Fire Protection and Division 01 Section, General Requirements.

B. Submit complete shop drawings of all equipment utilized with the system in accordance with Division 21 Section, Common Work Results for Fire Protection. Submittals shall include but not be limited to the following fire protection system and accessories:

1. Pressure Sensing Devices, Valves
2. Alarm Check Valves
3. Pressure/Vacuum Gauges
4. Inspector's Test Station
5. Eccentric Reducers
6. Pressure Switches
7. Valves and Piping
8. Flow Switches
9. Tamper Switches
10. Auxiliary Drains

C. Provide sprinklers, piping and associated equipment complete and ready for operation. Equipment materials, installation, workmanship, fabrication, assembly, erection, examination, inspection, and testing shall be in accordance with NFPA-13, NFPA-70, NFPA-72E, and NFPA-101. Devices and equipment for fire protection service shall be U.L listed or FM approved.

D. All of the equipment and devices shall be included within the project Operations and Maintenance Manuals.

E. Refer to Division 21 Section, Fire Protection Pipes, Valves, and Fittings for pipe materials.

F. Fire Protection Systems design, equipment and installation shall comply with the Delaware State Fire Prevention Regulations, latest edition including all Annexes and Addendums.

1.2. DESCRIPTION

A. Provide all facilities, labor, materials, tools, equipment, appliances, transportation, supervision, and related work necessary to complete the work specified in this Section and as shown on the drawings. The work shall be performed by a licensed sprinkler contractor only. All equipment, piping, devices, and valves shall be sized based on hydraulic calculations. Include a 10 psig safety factor with hydraulic calculations.

B. Layout sprinkler system complete and size all fire protection piping in accordance with requirements of the National Fire Protection Association and the State Fire Marshal. System shall be designed for occupancy as required by applicable codes. Conceal fire protection piping in finished spaces unless indicated otherwise. System drains and inspector's test shall not be located in finished spaces.

C. Sprinkler equipment and work shall conform to requirements of National Fire Protection Association Standard No. 13, No.14, and No. 24. In addition, all work shall conform to requirements of all codes and regulations of authorities having jurisdiction over this work, including, but not limited to, State Fire Marshal, County Fire Marshal, Life Safety Codes and International Code, and Insurance Underwriter.

D. Preliminary Shop Drawing: Prior to preparing detailed working drawings for submission to State Fire Marshal, submit preliminary sprinkler system layout to the Architect for review and approval. Show all finished ceilings, light fixtures, air diffusers and other ceiling mounted devices. Coordinate sprinkler head types and locations with ceiling types. All sprinkler heads in acoustic tile ceilings shall be centered in the tile.

E. The fire protection contractor shall prepare dimensioned and detailed working drawings, specifications, and hydraulic calculations and submit same to the State Fire Marshal and/or County Fire Marshal for review and approval. Prior to submission to the Fire Marshal, the Fire Protection Contractor shall have all fire protection drawings, submittals, calculations reviewed and approved by a registered Fire Protection Engineer or a level III Nicet Technician. One set of these approved documents shall be provided to the Engineer for record purposes. All costs related to changes required to obtain the Fire Marshal's or Insurance Underwriters' approval shall be the responsibility of the contractor.

F. Manufactured equipment and materials shall be submitted to the Engineer for review and approval, in accordance with the requirements of Division 21 Section, Common Work Results for Fire Protection.

G. Hydraulic calculations should be based on an available water supply as follows:

Static Pressure =	52 psig
Residual Pressure =	46 psig
Flow =	1061 gpm
Existing Pipe Material	For Hydraulic Calculations Assume Roughness Coefficient C factor = 100 for all Exterior Piping.

H. Hydraulic calculations shall include a 10 psig safety factor to account for pipe aging and deterioration of water supply.

I. Where combustible construction materials are located above ceilings, provide above ceiling fire protection in accordance with N.F.P.A-13.

1.3. DELIVERY, STORAGE AND PROTECTION

A. Refer to Division 01 Section, General Requirements: Transport, handle, store, and protect products.

B. Accept equipment and devices on site in factory packing. Inspect for damage. Comply with manufacturer's rigging and installation instructions for all equipment.

C. Protect components from physical damage including effects of weather, water, and construction debris.

D. Provide temporary inlet and outlet caps, and maintain in place until installation.

1.4. EXTRA MATERIALS

A. Provide extra sprinklers under provisions of NFPA-13. Provide suitable wrenches for each sprinkler type and metal storage cabinet.

1.5. PERMITS FROM THE AUTHORITY HAVING JURISDICTION AND FEES

A. Pay all permits, fees, and charges required for this work.

PART 2. PRODUCTS

2.1. SPECIALTIES

A. All sprinkler heads shall be U.L. listed and shall be of the same manufacturer throughout the building.

B. Piping shall be in accordance with Division 21 Section, Fire Protection Piping, Fittings, and Valves, etc. All exposed fire protection piping in unfinished areas shall be painted with red epoxy paint. White letters shall identify piping and indicate direction of flow. Exposed fire protection piping within finished areas shall be painted in color as determined by the Architect/Engineer.

C. Shut-off valves shall be UL approved O.S. and Y. double disc gate valves or UL/FM approved grooved end butterfly valves.

D. Check valves shall be swing check type or spring-loaded type UL approved for the application.

E. Coordinate the fire protection systems with the fire alarm system specified under Division 26. Provide alarm initiating devices with proper contact arrangement. All electrical wiring shall be furnished and installed under Division 26.

F. Flow control valve, alarm switches and valve supervision shall be furnished and installed under this Division. All wiring shall be accomplished by the electrical contractor, under Division 26. Provide any additional flow control valves, alarm switches, tamper switches and flow switches required by NFPA-13 but not indicated on contract drawings. Coordinate with the alarm system and electrical subcontractor.

G. Pipe and fittings shall meet the requirements of NFPA 13 and NFPA-24.

2.2. SPRINKLER HEADS

A. Suspended or Drywall Ceilings:

1. Manufacturer: Victaulic, Viking, Grinnell, Reliable, or approved equal.

2. All sprinkler heads installed in suspended ceilings and drywall ceilings including bulkheads shall be Victaulic Model V38 concealed quick response sprinkler or approved equal. Cover plate shall be finished with a polyester baked enamel finish. Color selection by Architect. Provide cover assembly with each head. Frangible glass bulb shall be temperature rated for specific area hazard.

B. Exposed Area Type:

1. Manufacturers: Victaulic, Viking, Grinnell, Reliable, or approved equal.

2. Sprinkler heads in unfinished or exposed areas shall be Victaulic Model V27, or approved equal. These sprinklers shall be standard, ½ inch upright, pendant or conventional where required. Provide guards where hereinafter indicated. Sprinklers shall be brass with frangible glass bulb temperature rated for specific area hazard. Provide standard brass, screw on flat escutcheon plate.

C. Sidewall type:

1. Manufacturers: Victaulic, Viking, Grinnell, Reliable, or approved equal.

2. Sidewall sprinklers shall be Victaulic Model V27 semi-recessed horizontal sidewall type with matching screw on escutcheon plate. Sprinkler and escutcheon plate finish shall be chrome plated. Frangible glass bulb shall be temperature rated for specific area hazard.

D. The temperature rating of the sprinklers shall be as required by N.F.P.A.-13 and or the authority having jurisdiction.

E. All sprinkler heads installed in lay-in ceiling tiles shall be located in the center of the tile to provide a symmetrical, aesthetic and neat appearance. All sprinkler heads installed in bulkheads, recesses, and soffits shall be centered to provide a symmetrical, aesthetic and neat appearance.

F. Provide extended escutcheons in rooms with surface mounted lighting fixtures.

G. Additional heads shall be furnished as required by NFPA-13. The heads shall be in a cabinet designed to hold the heads and include one sprinkler head wrench for each type of sprinkler. Cabinet shall be mounted where indicated in the field.

H. Head guards shall be provided in mechanical spaces, penthouses, janitors' closets, electrical rooms, above auditorium ceiling, and storage areas. Finish for head guards in finished spaces shall be selected by Architect.

I. Sprinkler escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler, by the sprinkler manufacturer.

J. Provide high temperature sprinkler heads for use adjacent to skylights, heaters, lights, or

other high temperature areas.

2.3. FLEXIBLE SPRINKLER DROPS

A. Stainless Steel Sprinkler Fittings

1. Manufacturer: Victaulic AquaFlex®

2. In lieu of rigid pipe offsets for concealed locations only, or return bends for sprinkler drops, the Victaulic AquaFlex® stainless steel, multiple-use, sprinkler fitting system may be used to locate sprinklers as required by final finished ceiling tiles and walls. The drop system shall consist of a braided or unbraided (corrugated) type 304 stainless steel flexible tube, a zinc-plated steel 1" NPT male threaded nipple for connection to branch-line piping, and a zinc-plated steel reducer with ½" or ¾" NPT female thread for connection to the sprinkler head. Union joints shall be provided for ease of installation. The flexible drop shall attach to the ceiling grid using a one-piece open gate bracket. The braided drop system is FM approved for sprinkler services to 200 psi and can be installed without the use of tools, and the unbraided system is UL listed for sprinkler services to 175 psi.

2.4. SIGNS

A. Provide 9 inch x 7 inch signs suspended from control valves which indicate the purpose of the valve and its normal position, Central Type A or approved equal.

B. All control, drain, and test connection valves shall be provided with signs indicating purpose.

C. Signs shall be fabricated of an approved material, painted red with white lettering.

D. Signs shall have typed labels. Handwritten labels shall not be acceptable.

2.5. DRAINS

A. The sprinkler systems shall be arranged to be completely drainable. Means of drainage shall be provided with adequate protection from freezing.

B. Drain valve may be combined with sprinkler alarm test valve and sight glass, G/J Innovations Sure-Test or approved equal. Valve shall be UL listed with positive off handle for off, test or drain, integral sight glass, orifice size equal to smallest sprinkler orifice and full 1 inch drain.

2.6. ALARM DEVICES

A. Approved water flow switches shall be installed to activate the fire alarm, and annunciate sprinkler flow at a minimum on each floor, each system riser, where indicated on the contract documents and where required by N.F.P.A. or the authority having jurisdiction. Conductors shall be provided under the electric division to provide fire alarm, and annunciation. Activation of the sprinkler system by one sprinkler or equivalent test shall cause the fire alarm system to activate, and the appropriate lamp(s) to activate on the

annunciator. An approved test shall be provided for each water flow switch.

B. All valves controlling water supply for sprinklers shall be electrically supervised in accordance with requirements of NFPA 13 and 72A, and provided under this Division. Provide separate valve chart for all fire protection valve indicating valve type, normal position, size, location and type of supervision insert in O&M manual and mount additional copies in fire pump room and mechanical rooms.

C. Valve tamper switches shall be Model OSY2 as manufactured by System Sensor or Model OSYSU-A2 as manufactured by Potter Electric Signal Company or approved equal. The valve tamper switches shall monitor the open position of all OS&Y gate valves. Each tamper switches shall contain two sets of single pole double throw, Form C contacts. All valve tamper switches shall have tamper resistant covers that upon removal of the cover will cause the switches to operate. Tamper switches shall be suitable for 125/250 VAC @ 15 AMPS. All tamper switches shall be U.L. listed and F.M. approved.

D. Pressure type flow switches shall be Model EPS10 as manufactured by System Sensor or Model PS10-2 as manufactured by Potter Electric Signal Company or approved equal. Each pressure type flow switch shall contain two sets of single pole double throw switch contacts. All pressure type flow switches shall have tamper resistant covers that upon removal of the cover will cause the switches to operate. Pressure type flow switches shall be suitable for 125/250 VAC @ 10 AMPS. All pressure type flow switches shall be U.L. listed and F.M. approved.

E. Vane Type waterflow switch with retard shall be WFD Series as manufactured by System Sensor or Model VSR-F as manufactured by Potter Electric Signal Company or approved equal. The VAC type waterflow switches shall contain two single pole, double throw form C, and snap return switches. All Vane type waterflow switches shall have tamper resistant covers that upon removal of the cover will cause the switches to operate. Vane type waterflow switches shall be suitable for 125/250 VAC @ 10 AMPS. All vane type waterflow switches shall be U.L. listed and F.M. approved.

2.7. GAUGES

A. A listed 3 ½ inch dial spring pressure gauge shall be connected to the top of each standpipe. Gauges shall be located in a suitable place to prevent freezing. Each gauge shall be controlled by a valve having arrangement for draining.

B. Listed pressure gauges with connections not smaller than ¼ inch shall be installed at the system main drain, at each main drain associated with a floor control valve, and above and below each alarm check-valve.

C. All pressure gauges shall be listed and shall have a maximum limit not less than twice the normal working pressure at the point where installed. They shall be installed to permit removal and shall be located where they will not be subject to freezing.

2.8. VALVES

A. Provide and install control valves as indicated on contract drawings and as required by N.F.P.A.-13. Gate valves shall be listed O.S. & Y. type. All control valves shall be supervised open. Supervision shall be as required by N.F.P.A.-13. Victaulic Series 705

and 765 grooved end butterfly valves shall be supervised in the open position and Victaulic Series 707 and 766 shall be supervised closed.

PART 3. EXECUTION

3.1. GENERAL INSTALLATION REQUIREMENTS

A. Install equipment in accordance with manufacturer's instructions.

B. Place pipe runs to minimize obstruction to other work.

C. Place piping in concealed spaces above finished ceilings.

D. Center sprinklers in two directions in ceiling tile and provided piping offsets as required.

E. Apply masking tape or paper cover to ensure concealed sprinklers, cover plates, and sprinkler escutcheons do not receive field paint finish. Remove after painting. Replace painted sprinklers.

F. Flush entire piping system of foreign matter.

G. Install guards on sprinklers where subject to abuse and where specified.

H. Hydrostatically test entire system.

I. Test must be witnessed by Fire Marshal/authority having jurisdiction/ Owner's insurance underwriter/ Architect/Engineer.

J. Locate inspectors test stations for sprinkler zones per NFPA-13. Provide and install drain piping from all approved terminations. Provide splash blocks for terminations outside. Splash block locations shall be approved by the Architects.

K. The fire protection contractor shall hydraulically prove the most remote area per NFPA-13.

L. Coordinate locations of sprinkler heads with lights, diffusers, ceiling types, etc.

M. Hydrostatically test system at 200 PSI for 4 hours, per NFPA-13.

N. The sprinkler bulb protector must remain in place until the sprinkler is completely installed and before the system is placed in service. Remove bulb protectors carefully by hand after installation. Do not use any tools to remove bulb protectors.

O. Refer to Architectural Drawings for exact location and extent of all fire rated walls and smoke barriers.

P. Grooved joint piping systems shall be installed in accordance with the manufacturer's (Victaulic) guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by Victaulic. Grooved end shall be clean and free

from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing.

3.2. INTERFACE WITH OTHER PRODUCTS

A. Ensure required devices are installed and connected as required to fire alarm system.

3.3. LAYOUT

A. Coordinate layout and installation of fire protection system with all other buildings structural, mechanical and electrical work. Locate sprinkler heads symmetrically with respect to ceiling tiles, lighting fixtures, registers, grilles, diffusers, etc. Provide piping offsets as required to maintain symmetry. Note that a preliminary sprinkler layout is to be submitted for review. Contractor is cautioned that sprinkler mains must be located to prevent conflict with other work and in any case, sprinkler contractor shall be responsible for coordination of his work with work of other trades.

B. Unless otherwise indicated, the entire building shall be protected throughout with a wet pipe sprinkler system.

3.4. WET PIPE SPRINKLER SYSTEM

A. System components shall include, but not be limited to flow control valves, electrical connections to central fire alarm system, check valves, main piping, branch piping, inspector's test, drains, sprinkler heads, signs, etc. and all other incidental appurtenances as required.

3.5. VALVE INSTALLATION

A. Gate Valves: Install fire-protection-service valves supervised-open, located to control sources of water supply except from fire department connections. Provide permanent identification signs indicating portion of system controlled by each valve.

3.6. CONNECTIONS

A. Connect water supplies to sprinklers.

B. Connect piping to specialty valves, specialties, and accessories.

C. Connect alarm devices to fire alarm.

3.7. COMMISSIONING

A. Verify that specialty valves, trim, fittings, controls, and accessories are installed and operate correctly.

B. Verify that specified tests of piping are complete.

C. Verify that damaged sprinklers and sprinklers with paint or coating not specified are replaced with new, correct type.

D. Verify that sprinklers are correct types, have correct finishes and temperature ratings, and

have guards as required for each application.

E. Fill wet-pipe sprinkler piping with water.

F. Energize circuits to electrical equipment and devices.

G. Adjust operating controls and pressure settings.

H. Coordinate with fire alarm tests. Operate as required.

3.8. DRAINS

A. The sprinkler system shall be arranged to be completely drainable. Means of drainage shall be provided with adequate protection from freezing.

3.9. TESTS

A. The sprinkler systems installation shall be hydrostatically tested, inspected, and approved, in accordance with NFPA Standard No. 13, and NFPA Standard No. 25. Test certificate shall be forwarded to the Office of the State Fire Marshal and the Architect as proof of compliance.

B. Tests shall be performed in accordance with the requirements of the Office of the State Fire Marshal and shall prove the systems to be adequate and satisfactory in every respect. All tests shall be performed in the presence of the State Fire Marshal or his representative.

C. Any deficiencies revealed by these tests shall be corrected and the systems shall be retested until acceptable results are obtained.

3.10. AS-BUILT DRAWINGS & PROJECT CLOSEOUT

A. Provide separate as-built drawings of all fire protection systems meeting requirements of General Mechanical Requirements hereinbefore specified.

B. At the completion of the work, provide a sealed plan of the building indicating the locations of all control valves, low point drains, flow switches, and Inspectors Test Stations. The plan shall be neatly drawn and color coded to indicate the portion of the building protected by each system, framed under glass and permanently mounted on the wall adjacent to the system header.

C. Include manufacturer’s literature, cleaning procedures, replacement parts, lists, and repair data for equipment.

D. Include manufacturers’ instructions, start-up data, troubleshooting, and check lists for all equipment.

3.11. WARRANTY

A. The Contractor's attention is directed to the warranty obligations contained in the Article of the General Conditions of the specifications entitled "warranty".

3.12. OWNER TRAINING

A. Upon completion of the project, furnish a complete copy of NFPA-25 to Owner. Provide correspondence indicating that the pamphlet has been turned over to the Owner.

1. Contractor shall provide at least four (4) hours of training to the Owner on the proper inspection, testing, and maintenance of the installed fire protection system.

2. Schedule training with the Owner through the Architect and/or Engineer with at least seven (7) days prior notice.

3. A Victaulic factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

END OF SECTION

DIVISION 22 SECTION 220500
COMMON WORK RESULTS FOR PLUMBING
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SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

PART 1. GENERAL

1.1. SUMMARY

A. All work under Division 22 is subject to the Division 01, General Requirements, the General Conditions and Supplementary Conditions.

B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all plumbing work.

C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.

D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with Submittals specified below. The right is reserved to make reasonable changes in location of equipment, piping, up to the time of rough-in or fabrication.

E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.

F. Coordinate the work under Division 22 with the work of all other construction trades.

G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.

1.2. PERMITS AND FEES

A. Obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.

B. Permits and fees shall comply with the Division 01, General Requirements of the specification.

1.3. EXAMINATION OF SITE

A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner will be permitted for contractors failure to do so.

B. Examine and verify specific conditions described in individual specifications sections.

C. Verify that utility services are available, of the correct characteristics, and in the correct

locations.

1.4. MATERIALS AND EQUIPMENT

A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality.

B. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or its equal, subject to approval by Engineer. Substituted items shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of substituted items, for approval.

C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Substituted items, including items other than first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application. Contractor, by providing other than the first named manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation. Adjustments and modifications shall include but not be limited to electrical, structural, support, and architectural work.

D. Substitution will not be permitted for specified items of material or equipment where noted.

E. All items of equipment furnished shall have a service record of at least five (5) years.

1.5. FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA and ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.6. REFERENCED STANDARDS, CODES AND SPECIFICATIONS

A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.

B. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers

C. ASME - American Society of Mechanical Engineers

D. ASPE - American Society of Plumbing Engineers

E. ASTM - American Society for Testing and Materials

F. CS - Commercial Standard

G. CSD Control and Safety Devices

H. DNREC - Delaware Department of Natural Resources and

			Environmental Control
I.	EPA	-	Environmental Protection Agency
J.	FDA	-	Food and Drug Administration
K.	FM	-	Factory Mutual
L.	IBC	-	International Building Code
M.	IEEE	-	Institute of Electrical and Electronics Engineers
N.	MSSP Industry	-	Manufacturers Standards Society of the Valve and Fittings
O.	NEC	-	National Electrical Code
P.	NEMA	-	National Electrical Manufacturers Association
Q.	NSF	-	National Sanitation Foundation
R.	UL	-	Underwriters' Laboratories

S. All plumbing equipment and materials shall comply with the codes and standards listed in the latest edition of ASHRAE HVAC Applications Handbook, Chapter entitled Codes and Standards.

1.7. SUBMITTALS, REVIEW AND ACCEPTANCE

A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Architect to be in best interest of Owner.

B. After acceptance of Material and Equipment List, submit six (6) copies or more as required under General Conditions of complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.

C. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.

D. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.

E. Identify submittals, indicating intended application, location and service of submitted items. Refer to specification sections or paragraphs and drawings where applicable.

Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For substituted items, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The contractor shall be responsible for corrective action and maintaining the specification requirements if differences have not been clearly indicated in the submittal.

F. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Call attention, in writing, to deviation from contract requirements.

G. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted. Use only final or corrected submittals and data prior to fabrication and/or installation.

H. For any submittal requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

I. For resubmissions, the Contractor must address in writing all of the Engineer's comments on the original submission to verify compliance.

1.8. SHOP DRAWINGS

A. Prepare and submit shop drawings for all plumbing equipment, specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.

B. Submit data and shop drawings including but not limited to the list below, in addition to provisions of the paragraph above. Identify all shop drawings by the name of the item and system and the applicable specification paragraph number and drawing number.

C. Every submittal including, but not limited to the list below, shall be forwarded with its own transmittal as a separate, distinct shop drawing. Grouping of items/systems that are not related shall be unacceptable.

D. Items and Systems

1. Access Doors/Panels including layout and location

2. Backflow Preventers

3. Backwater Valves

4. Coordinated Drawings

5. Condensate Neutralizers

6. Drain Valves

7. Fire Stopping - Methods and Materials

8. Identification System

9. Material and Equipment List

10. Operations and Maintenance Manuals

11. Pipe Materials Including Itemized Schedule

12. Preliminary Testing and Balancing Report

13. Pressure Reducing Valves

14. Test Certificates

15. Thermal Insulation Materials Include Table Summary

16. Thermometers and Gauges

17. Vacuum Breakers

18. Valves

19. Vibration Isolation Materials

20. Weatherproof Assembly Components

21. Wiring Diagrams, Flow Diagrams and Operating Instructions

E. Contractor, additionally, shall submit for review any other shop drawings as required by the Architect. No item shall be delivered to the site, or installed, until the Contractor has received a submittal from the Engineer marked Reviewed or Comments Noted. After the proposed materials have been reviewed, no substitution will be permitted except where approved by the Architect.

1.9. SUPERVISION AND COORDINATION

A. Provide complete supervision, direction, scheduling, and coordination of all work under the Contract, including that of subcontractors.

B. Coordinate rough-in of all work and installation of sleeves, anchors, and supports for piping, equipment, and other work performed under Division 22.

C. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.

D. Coordinate electrical work required under Division 22 with that under Division 26. Coordinate all work under Division 22 with work under all other Divisions.

E. Supply services of an experienced (10 years minimum) and competent Project Manager to be in constant charge of work at site.

F. Where a discrepancy exists within the specifications or drawings or between the specifications and drawings, the more stringent (or costly) requirement shall apply until clarification can be obtained from the Engineer. Failure to clarify such discrepancies with the Engineer will not relieve the Contractor of the responsibility of conforming to the requirements of the Contract.

G. Failure of contractor to obtain a full and complete set of contract documents (either before or after bidding) will not relieve the contractor of the responsibility of complying with the intent of the contract documents.

1.10. CUTTING AND PATCHING

A. Accomplish all cutting and patching necessary for the installation of work under Division 22. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, perform work in neat and workmanlike manner. Restore disturbed work to match and blend with existing construction and finish, using materials compatible with the original. Use mechanics skilled in the particular trades required.

B. Do not cut structural members without approval from the Architect or Engineer.

1.11. CONNECTIONS AND ALTERATIONS TO EXISTING WORK

A. Unless otherwise noted on the drawings, where existing plumbing work is removed all pipes, valves, etc., shall be removed, including hangers, to a point below finished floors or behind finished walls and capped. Such point shall be far enough behind finished surfaces to allow for installation of normal thickness of required finish material.

B. Where work specified in Division 22 connects to existing equipment, piping, etc., Contractor shall perform all necessary alterations, cuttings, fittings, etc., of existing work as may be necessary to make satisfactory connections between new and existing work, and to leave completed work in a finished and workmanlike condition.

C. Where the work specified under Division 22, or under other Divisions, requires relocation of existing equipment, piping, etc., Contractor shall perform all work and make necessary changes to existing work as may be required to leave completed work in a finished and workmanlike condition. Where existing insulation is disturbed, replace insulation where removed or damaged equal to existing, in type, thickness, density, finish and thermal resistance (R-value) value.

D. Where the relocation of existing equipment is required for access or the installation of new equipment, the contractor shall temporarily remove and/or relocate and re-install as required to leave the existing and new work in a finished and workman like condition.

1.12. DEMOLITION

A. Unless otherwise noted all existing equipment, piping, etc., shall remain.

B. Where existing equipment is indicated to be removed, all associated piping, conduit, power, controls, insulation, hangers, supports and housekeeping pads, etc., patch, paint and repair walls/roof/floor to match existing and/or new finishes.

C. Provide necessary piping, valves, traps, temporary feeds, etc., as required. Drain and refill piping systems as often as necessary to accommodate phasing and to minimize time lengths of outages.

D. The Contractor shall be responsible for visiting the site and determining the existing conditions in which the work is to be performed.

E. Refer to phasing plans for additional requirements.

F. Where any abandoned pipes in existing floors, walls, pipe tunnels, ceilings, etc., conflict with new work, remove abandoned pipes as necessary to accommodate new work.

G. The location of all existing equipment, piping, etc., indicated is approximate only and shall be checked and verified. Install all new plumbing work to connect to or clear existing work as applicable.

H. Maintain egress at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and the authorities having jurisdiction.

I. When applicable, make provisions and include in bid all costs associated with confined entry/space requirements in crawl spaces, tunnels and all other applicable OSHA regulations.

J. Where required to maintain the existing systems in operation, temporarily backfeed existing systems from new equipment. Contractor shall temporarily extend existing piping systems to new piping systems with the appropriate shut-off valves.

K. At completion of project all temporary piping, valves, controls, etc., shall be removed in their entirely.

L. Existing piping, equipment, materials, etc., not required for re-use or re-installation in this project, shall be removed from the project site.

M. Deliver to the Owner, on the premises where directed, existing equipment and materials which are removed and which are desired by the Owner or are indicated to remain the property of the Owner.

N. All other materials and equipment which are removed shall become property of the Contractor and shall be promptly removed, from the premises, and disposed of by the Contractor, in an approved manner. Contractor shall be responsible for proper disposal of all removed equipment containing refrigerants. Contractor shall include in his bid all cost associated with the evacuation, removal and disposal of all existing equipment containing refrigerants in accordance with EPA and Health Department requirements.

O. Where piping is removed, remove all pipe hangers which were supporting the removed piping. Patch the remaining penetration voids with like materials and paint to match existing construction.

P. Where required, provide and coordinate removal and re-installation of existing equipment. Take care to protect materials and equipment indicated for reuse. Contractor shall repair or replace items which are damaged. Contractor shall have Owner's

representative present to confirm condition of equipment prior to demolition.

Q. Before demolition begins, and in the presence of the Owners representative, test and note all deficiencies in all existing systems affected by demolition but not completely removed by demolition. Provide a copy of the list of system deficiencies to the Owner and the Engineer. Videotape existing conditions in each space prior to beginning demolition work.

R. The Owner shall have the first right of refusal for all plumbing devices and equipment removed by the Contractor.

S. All plumbing fixtures, devices and equipment designated by the Owner to remain the property of the Owner shall be moved and stored by the Contractor at a location on site as designated by the Owner. It shall be the Contractor's responsibility to store all plumbing fixtures, devices and equipment in a safe manner to prevent damage while stored.

T. All existing equipment refused by the Owner shall become the property of the Contractor and shall be removed from the site by the Contractor in a timely manner and disposed of in a legal manner.

U. Work Abandoned in Place: cut and remove underground pipe a minimum of 2 inches beyond face of adjacent construction. Cap and patch surface to match existing finish.

V. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.

W. Terminate services and utilities in accordance with local laws, ordinances, rules and regulations.

1.13. FASTENERS

A. All fasteners located in public spaces including classrooms, corridors, lobbies, etc., shall be provided with tamper proof fasteners. Provide Pin Phillips hardware as manufactured by Challenge Industries or approved equal.

1.14. DEFINITIONS

A. Approve - to permit use of material, equipment or methods conditional upon compliance with contract documents requirements.

B. Furnish and install or provide means to supply, erect, install, and connect to complete for readiness for regular operation, the particular work referred to.

C. Contractor means the mechanical contractor and any of his subcontractors, vendors, suppliers, or fabricators.

D. Piping includes pipe, all fittings, valves, hangers, insulation, identification, and other accessories relative to such piping.

E. Concealed means hidden from sight in chases, formed spaces, shafts, hung ceilings, embedded in construction.

F. Exposed means not installed underground or concealed as defined above.

G. Invert Elevation means the elevation of the inside bottom of pipe.

H. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceiling, and unexcavated spaces.

I. Review - limited observation or checking to ascertain general conformance with design concept of the work and with information given in contract documents. Such action does not constitute a waiver or alteration of the contract requirements.

J. Building Line: Exterior wall of building.

1.15. MINIMUM EFFICIENCY REQUIREMENTS

A. All plumbing equipment shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

B. All piping and equipment insulation shall comply with ASHRAE Standard 90.1, latest edition.

C. All plumbing devices, controls, accessories, and components shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

1.16. LEAD FREE REQUIREMENTS

A. All plumbing fixtures, equipment, and devices that contact potable water must be lead free per the State requirements. Potable water systems shall also comply with NSF 61 – Annex G and NSF-372.

PART 2. ELECTRICAL REQUIREMENTS

2.1. GENERAL MOTOR AND ELECTRICAL REQUIREMENTS

A. Furnish and install control and interlock wiring for the equipment furnished. In general, power wiring and motor starting equipment will be provided under Division 26. Carefully review the contract documents to coordinate the electrical work under Division 22 with the work under Division 26. Where the electrical requirements of the equipment furnished differ from the provisions made under Division 26, make the necessary allowances under Division 22. Where no electrical provisions are made under Division 26, include all necessary electrical work under Division 22.

B. All electrical work performed under Division 22 shall conform to the applicable requirements of Division 26 and conforming to the National Electrical Code. All wiring, conduit, etc., installed in ceiling plenums must be plenum rated per NFPA & International Building Code.

C. Provide wiring diagrams with electrical characteristics and connection requirements.

D. Test Reports: Indicate test results verifying nominal efficiency and power factor for three

phase motors larger than five (5) horsepower.

E. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering. For extended outdoor storage, remove motors from equipment and store separately.

F. All motors shall be furnished with visible nameplate indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor and efficiency.

G. Motors located in exterior locations, wet air streams and outdoors shall be totally enclosed weatherproof epoxy-treated type.

H. Nominal efficiency and power factor shall be as scheduled at full load and rated voltage when tested in accordance with IEEE 112.

I. Brake horsepower load requirement at specified duty shall not exceed 85 percent of nameplate horsepower times NEMA service factor for motors with 1.0 and 1.15 service factors.

J. All single phase motors shall be provided with thermal protection: Internal protection shall automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature ratings of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range, unless otherwise indicated.

PART 3. EXECUTION

3.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.

B. Install equipment according to approved submittal data. Portions of the work are shown only in diagrammatic form. Refer conflicts to the Architect.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

E. Install equipment giving right of way to piping installed at required slope.

F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

G. Do not install equipment or piping over electrical gear, electrical panels, motor controllers, and similar electrical equipment. Install equipment and piping to maintain clear space above and in front of all electrical components per the National Electric Code.

3.2. SUPPORTS, HANGERS AND FOUNDATIONS

A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workmanlike manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.

B. Supports, hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For un-insulated copper piping provide copper hanger to prevent contact of dissimilar metals. All exterior hangers shall be constructed of stainless steel utilizing stainless steel rods, nuts, washers, bolts, etc.

3.3. DEMONSTRATION AND TRAINING VIDEO RECORDINGS

A. General: Record demonstration and training video recordings. Record each training module separately.

1. At beginning of each training module, record each chart containing learning objective and lesson outline.

B. Video Recording Format: Provide high-quality color video recordings with menu navigation in format acceptable to Engineer

C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.

D. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.

E. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

3.4. PROVISIONS FOR ACCESS

A. The contractor shall provide access panels and doors for all concealed equipment, valves, strainers, dampers, filters, cleanouts, and other devices requiring maintenance, service, adjustment, balancing or manual operation.

B. Where access doors are necessary, furnish and install manufactured painted steel door assemblies consisting of hinged door, key locks, and frame designed for the particular wall or ceiling construction. Properly locate each door. Door sizes shall be a 12 inches x 12 inches for hand access, 18 inches x 18 inches for shoulder access and 24 inches x 24 inches for full body access where required. Review locations and sizes with Architect prior to fabrication. Provide U.L. approved and labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, Mifab, or approved equal.

1. Acoustical or Cement Plaster: Style B

2. Hard Finish Plaster: Style K or L

3. Masonry or Dry Wall: Style M

C. Where access is by means of liftout ceiling tiles or panels, mark each ceiling grid using small color-coded and numbered tabs. Provide a chart or index for identification. Place markers within ceiling grid not on ceiling tiles.

D. Access panels, doors, etc. described herein shall be furnished under the section of specifications providing the particular service and to be turned over to the pertinent trade for installation. Coordinate installation with installing contractor. All access doors shall be painted in baked enamel finish to match ceiling or wall finish.

E. Submit shop drawings indicating the proposed location of all access panels/doors. Access doors in finished spaces shall be coordinated with air devices, lighting and sprinklers to provide a neat and symmetrical appearance.

F. Where access doors are installed in wet locations (i.e. shower rooms, toilet rooms, kitchen rooms, kitchens, dishwasher rooms, can wash rooms, and similar spaces, etc.) provide aluminum access doors/frame.

3.5. PAINTING AND FINISHES

A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc. shall be stainless steel.

B. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.

C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.

D. Protect all finishes and restore any finishes damaged as a result of work under Division 22 to their original condition.

E. The preceding requirements apply to all work, whether exposed or concealed.

F. Remove all construction marking and writing from exposed equipment, piping and building surfaces. Do not paint manufacturer's labels or tags.

G. All exposed piping, equipment, etc. shall be painted. Colors shall be as stated in this division or as selected by the Architect and conform to ANSI Standards.

H. All exterior roof mounted equipment, piping and vents shall be painted to match roof in color as selected by Architect.

I. All exposed piping, equipment, etc. in finished spaces shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.

J. All exposed piping, equipment, etc., in Mechanical Rooms, Penthouses, Fire Pump Rooms, Mezzanines, Crawlspaces, and Storage where PVC jacketed shall not require

painting. Label and identify and color code as specified.

3.6. CLEANING OF SYSTEMS

A. Thoroughly clean systems after satisfactory completion of pressure tests and before permanently connecting fixtures, equipment, traps, strainers, and other accessory items. Blow out and flush piping until interior surfaces are free of foreign matter.

B. Flush piping in re-circulating water systems to remove cutting oil, excess pipe joint compound, solder slag and other foreign materials. Do not use system pumps until after cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling, the residual alkalinity shall not exceed 300 parts per million. Submit a certificate of completion to Engineer stating name of Service Company used.

C. Maintain strainers and dirt pockets in clean condition.

D. Pay for labor and materials required to locate and remove obstructions from systems that are clogged with construction refuse after acceptance. Replace and repair work disturbed during removal of obstructions.

E. Leave systems clean, and in complete running order.

3.7. COLOR SELECTION

A. Color of finishes shall be as selected by the Architect.

B. Submit color of factory-finished equipment for acceptance prior to ordering.

3.8. PROTECTION OF WORK

A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

B. Cover temporary openings in piping and equipment to prevent the entrance of water, dirt, debris, or other foreign matter. Deliver pipes and tubes with factory applied end caps.

C. Cover or otherwise protect all finishes.

D. Replace damaged materials, devices, finishes and equipment.

E. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, where stored inside.

3.9. OPERATION OF EQUIPMENT

A. Clean all systems and equipment prior to initial operation for testing, balancing, or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.

B. Where specified, or otherwise required, provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment. Where factory start-up of equipment is not specified, provide field start-up by qualified technician.

C. Submit factory start-up sheets or field start-ups sheets for all equipment prior to the commencement of testing and balancing work. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

D. Do not use plumbing systems for temporary services or temporary conditioning during construction. Refer to Division 01 section "Temporary Facilities and Controls" for temporary plumbing during construction.

E. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items such as filters.

3.10. IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS

A. Contractor shall submit for approval schematic piping diagrams of each piping system installed in the building. Diagrams shall indicate the location and the identification number of each valve in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under safety glass and hung in each Mechanical Room where directed. Contractor shall deliver the tracing or sepia from which the diagrams were reproduced to the Owner.

B. All valves shall be plainly tagged. For any bypass valves, install sign indicating valve position as “Normally Open” or “Normally Closed” as required.

C. All items of equipment, including motor starters and disconnects shall be furnished with white on black plastic permanent identification cards. Lettering shall be a minimum of ¼ inch high. Identification plates shall be secured, affixed to each piece of equipment, starters, disconnects, panels by screw or adhesive (tuff bond #TB2 or as approved equal). Equipment identification and room name or area served shall be on each panel.

D. Provide six (6) copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the Operations and Maintenance Manuals as hereinafter specified.

E. All piping installed under this contract shall be stenciled with direction of flow arrows and with stenciled letters naming each pipe and service. Refer to Division 22 Section, Plumbing Piping, Fittings, Valves, Etc. Color code all direction of flow arrows and labels. In finished spaces omit labeling and direction of flow arrows. Paint in color as selected by Architect.

F. Submit list of wording, symbols, letter size, and color coding for plumbing identification. Submit samples of equipment identification cards, piping labels, labels, and valve tags to Engineer for review prior to installation.

G. Provide at least 4 hours of straight time instruction to the operating personnel. Time of instruction shall be designated by the Owner. Additional instruction time for the

automatic temperature control (ATC) system is specified in Division 23 Section, Instrumentation and Controls of HVAC and Plumbing Systems.

H. Contractor shall demonstrate Sequences of Operation of all plumbing equipment in presence of Owner's representative, Engineer, and ATC subcontractor.

3.11. WALL AND FLOOR PENETRATION

A. All penetrations of partitions, ceilings, roofs and floors by piping or conduit under Division 22 shall be sleeved, sealed, and caulked airtight for sound and air transfer control. Penetrations of mechanical room partitions, ceilings, and floors shall be as specified in Division 07 Section, "Fire Protection, HVAC and Plumbing Penetration Firestopping".

B. All penetration of fire rated assemblies shall be sleeved, sealed, caulked and protected to maintain the rating of the wall, roof, or floor. Fire Marshal approved U.L. assemblies shall be utilized. See Division 07 Section, "Fire Protection, HVAC and Plumbing Penetration Firestopping".

C. Where piping extends through exterior walls or below grade, provide waterproof pipe penetration seals, as specified in another division of these specifications.

D. Provide pipe escutcheons and duct flanges for sleeved pipes and ducts in finished areas.

E. Piping sleeves:

1. Galvanized steel pipe, standard weight where pipes are exposed and roofs and concrete and masonry walls. On exterior walls provide anchor flange welded to perimeter.

2. Twenty-two (22) gauge galvanized steel elsewhere.

F. Extend all floor sleeves through floor at least 2-inches above finished floor, caulk sleeve the entire depth and furnish and install floor plate.

3.12. RECORD DRAWINGS

A. Upon completion of the mechanical installations, the Contractor shall deliver to the Architect one complete set of prints of the mechanical contract drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings.

B. Contractor shall incorporate all sketches, addendums, value engineering, change orders, etc., into record drawings prior to delivering to Architect.

3.13. WARRANTY

A. Contractor's attention is directed to warranty obligations contained in the General Conditions and Supplementary Conditions.

B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or

warranty. Certificates of equipment manufacturer's warranties shall be included in the operations and maintenance manuals.

C. The contractor guarantees for a two year period from the time of final acceptance by the Owner.

1. That the work contains no faulty or imperfect material or equipment or any imperfect, careless, or unskilled workmanship.

2. That all work, equipment, machines, devices, etc. shall be adequate for the use to which they are intended, and shall operate with ordinary care and attention in a satisfactory and efficient manner.

3. That the contractor will re-execute, correct, repair, or remove and replace with proper work, without cost to the Owner, any work found to be deficient. The contractor shall also make good all damages caused to their work or materials in the process of complying with this section.

4. That the entire work shall be water-tight and leak-proof.

3.14. LUBRICATION

A. All bearings, motors, and all equipment requiring lubrication shall be provided with accessible fittings for same. Before turning over the equipment to the Owner, the Contractor shall fully lubricate each item of equipment, shall provide one year's supply of lubricant for each, and shall provide Owner with complete written lubricating instructions, together with diagram locating the points requiring lubrication. Include this information in the Operations and Maintenance Manuals.

B. In general, all motors and equipment shall be provided with grease lubricated roller or ball bearings with Alemite or equal accessible or extended grease fittings and drain plugs.

3.15. OPERATIONS AND MAINTENANCE MANUALS

A. The Contractor shall have prepared six (6) hardcopies and one (1) electronic copy of the Operations and Maintenance Manuals and deliver these copies of the manuals to the Owner. The manuals shall be as specified herein. The manuals must be approved and will not be accepted as final until so stamped.

B. The manuals shall be bound in a three ring loose-leaf binder similar to National No. 3881 with the following title lettered on the front: Operations and Maintenance Manual DTCC Arts & Science Building HVAC Renovation – Plumbing Systems. No sheets larger than 8-1/2 inches x 11 inches shall be used, except sheets that are neatly folded to 8-1/2 inches x 11 inches and used as a pull-out. Provide divider tabs and table of contents for organizing and separating information.

C. Provide the following data in the booklet:

1. As first entry, an approved letter indicating the starting/ending time of Contractor's warranty period.

2. Catalog data on each piece of plumbing equipment furnished.

3. Maintenance operation and lubrication instructions on each piece of plumbing equipment furnished.

4. Complete catalog data on each piece of plumbing equipment furnished including approved shop drawing.

5. Manufacturer's extended limited warranties on equipment including but not limited to water heaters, and storage tanks.

6. Chart form indicating frequency and type of routine maintenance for all plumbing equipment. The chart shall also indicate model number of equipment, location and service.

7. Provide sales and authorized service representatives names, address, and phone numbers of all equipment and subcontractors.

8. Provide supplier and subcontractor's names, address, and phone number.

9. Catalog data of all equipment, valves, etc. shall include wiring diagrams, parts list and assembly drawing.

10. Provide and install in locations as directed by the Owner, valve charts including valve tag number, valve type, valve model number, valve manufacturer, style, service and location. Each valve chart shall be enclosed in a durable polymer based frame with a cover safety glass. .

11. Copy of the approved balancing report for plumbing equipment/system.

12. Access panel charts with index illustrating the location and purpose of access panels.

13. Approved Health and Plumbing and Electrical Certificates.

14. Start-up reports for equipment.

15. Insert color graphic with embedded parameters for ATC system into Record and Information Booklet.

D. Submit Operations and Maintenance Manuals prior to the anticipated date of substantial completion for Engineer review and approval. Substantial completion requires that Operations and Maintenance Manuals reviewed and approved.

3.16. PIPING SYSTEMS TESTING

A. The entire new plumbing piping systems shall be tested hydrostatically before insulation covering is applied and proven tight under the following gauge pressures for a duration of four (4) hours. Testing to be witnessed by Owner's representative and documented in writing.

SYSTEM	TEST PRESSURE
Domestic Water & Coil Drain Piping	100 psi
Sanitary & Storm Water Piping	As specified below

B. All storm, waste, vent and water piping shall be tested by the Contractor and approved by the Engineer before acceptance. The costs of all equipment required for tests are to be included in the contract price.

C. The entire new drainage system and venting system shall have all necessary openings plugged and filled with water to the level of the highest stack above or at the roof. The system shall hold this water for thirty (30) minutes without showing a drop greater than 1inch. Where a portion of the system is to be tested, the test shall be conducted in the same manner as described for the entire system, except a vertical stack 10 feet above the highest horizontal line to be tested may be installed and filled with water to maintain sufficient pressure, or a pump may be used to supply the required pressure. The pressure shall be maintained for thirty (30) minutes. All testing shall be in accordance with the local Plumbing Code and witnessed by the Plumbing Inspector or authority having jurisdiction.

D. Upon completion of roughing-in and before setting equipment and fixtures, the entire new water piping system shall be tested at a hydrostatic pressure of not less than one hundred (100) pounds per square inch gauge and proven tight at this pressure. Where a portion of the water piping system is to be concealed before completion, this portion shall be tested separately in a manner described for the entire system.

E. Testing and acceptance thereof shall be in accordance with local requirements and shall meet approval of authority having jurisdiction. Submit certificates and approved permits and insert one (1) copy in the Operations and Maintenance Manuals.

3.17. EQUIPMENT BY OTHERS

A. This Contractor shall make all system connections required to equipment furnished and installed under other divisions or furnished by the Owner. Connections shall be complete in all respects to render this equipment functional to its fullest intent.

B. It shall be the responsibility of the supplier of this equipment to furnish complete instructions for connections. Failure to do so will not relieve this contractor of any responsibility for improper equipment operation.

3.18. PHASING

A. Refer to Architectural Specifications and contract drawings for any required phasing.

B. Maintain building egress and traffic ways at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and Authorities having jurisdiction.

C. Provide dust barriers/partitions, penetration closures, etc., to ensure safety of building occupants and protection of existing surroundings.

D. The Building shall remain watertight at all times.

E. Refer to phasing plans for additional requirements.

F. Provide necessary piping, valves, etc. as required. Drain and refill piping systems as often as necessary to accommodate phasing and to minimize time length of outages. Provide valves, to maintain existing systems in operation until all equipment is connected. Temporarily feed new systems with existing system where required or shown on contract drawings.

G. Within thirty days of Award of Contract, the Contractor shall submit a minimum of six (6) copies of the proposed Phasing Plan (Drawings and detailed written description) to the Architect for review and approval based on the general and specific requirements indicated on the Drawings and Specifications. The phasing plan shall reflect the work of all trades. The phasing plan shall be updated as often as needed (i.e. major deviations and/or modified sequence of events) and reviewed during each progress meeting so the facility and Architect can be aware of the areas of construction and progress as it relates to the approved schedule.

H. Due to phased construction, some systems must be operated at part load conditions until later phases are completed.

I. While work is in progress, except for designated short intervals during which connections are made, continuity of service shall be maintained to all existing systems. Interruptions shall be coordinated with the Owner as to time and duration. The contractor shall be responsible for any interruptions to service and shall repair any damages to existing systems caused by his operations.

3.19. OUTAGES

A. Provide a minimum of fourteen (14) days' notice to schedule outages. The Contractor shall include in their bid outages and/or work in occupied areas to occur on weekends, holidays, or at night. Coordinate and get approval of all outages with the Owner.

B. Submit Outage Request form, attached at end of this Section, to Owner for approval.

END OF SECTION

OUTAGE REQUEST

DATE APPLIED: _____BY: _____

DATE FOR OUTAGE: _____ FIRM: _____

START OUTAGE-TIME: _____ DATE:_____

END OUTAGE -- TIME: _____ DATE:_____

AREAS AND ROOMS: _____

FLOOR(S): _____

AREA(S): _____

ROOM(S): _____

WORK TO BE PERFORMED: _____

SYSTEM(S): _____

REQUEST APPROVED BY: _____

(FOREMAN OR OTHER PERSON IN CHARGE)

(FOR OWNER'S USE ONLY):

APPROVED: _____

YES _____ NO ____ BY: _____DATE: _____

DATE/TIME-AS REQUESTED: _____ OTHER : _____

OWNER'S PRESENCE REQUIRED: _____

YES: ____ NO: ____ NAME: _____

DIVISION 22 SECTION 220505
PLUMBING PIPING, FITTINGS & VALVES
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SECTION 220505 - PLUMBING PIPING, FITTINGS AND VALVES

PART 1. GENERAL

1.1. SUMMARY

A. The conditions of the contract and other general requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 22 Section, Common Work Results for Plumbing and Division 01, General Requirements.

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

1.2. SYSTEM DESCRIPTION CONDITIONS

A. Provide all labor and materials necessary to furnish and install all piping systems on this project as herein specified and/or shown on the drawings. Final connections to equipment furnished in other sections of the specifications shall be included under this section.

B. All piping and insulation installed in ceiling plenums must be plenum rated and comply with NFPA and International Building Code (IBC).

C. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

D. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

E. Use non-conducting dielectric connections whenever jointing dissimilar metals in open systems.

F. Provide pipe hangers and supports in accordance with ASTM B31.9 and MSS SP69 unless indicated otherwise.

G. Use 3/4 inch (20 mm) ball valves with cap and chain for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

H. At all runout piping serving equipment, use swing joints with elbows to prevent excessive movement of piping due to expansion.

1.3. QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulation. Provide certificate of compliance from authority having jurisdiction indicating approval of welders.

C. Welders Certification: In accordance with ASME Section 9.

D. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

E. All castings used for coupling housings, fittings, and valve bodies shall be date stamped for quality assurance and traceability.

F. Maintain one copy of each document on site.

1.4. DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to site under as hereinbefore specified.

B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

C. Provide temporary protective coating on cast iron and steel valves.

D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed systems.

1.5. EXTRA MATERIALS

A. Provide one (1) repacking kit for each size valve.

1.6. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

1.7. LEAD FREE REQUIREMENTS

A. All plumbing fixtures, equipment, and devices that contact potable water must be lead free per the State requirements.

PART 2. PRODUCTS

2.1. PIPE MATERIALS

A. All materials, unless otherwise specified, shall be new and of the best quality of their respective kinds, and shall conform to the requirements and ordinances of local, state and insurance authorities having jurisdiction.

1. Sanitary and Vents Above Floor Inside Building:

a. PVC Pipe: Schedule 40 DWV or cellular core. Fittings: Schedule 40 PVC, ASTM D 2665 or ASTM F891 socket fittings. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement.

2. Storm Water Above Floor Inside Building:

   a. Pipe & Fittings: Cast iron no-hub, pipe and fittings, CISPI 301. Installation and support shall be in accordance with Cast Iron Soil Pipe Institute recommendations. Joints shall be made with neoprene gaskets and 304 stainless steel clamp and shield assemblies listed by.
   b. Hubless Cast Iron Soil Pipe and Fittings
      i. Hubless pipe and fittings must be marked with the Cast Iron Soil Pipe Institute and listed by NSF International as compliant with CISPI 301.
      ii. Manufacturers:
         1) AB&I
         2) Charlotte
         3) Tyler
   c. Heavy Duty Shielding Coupling, ASTM C 1540, Type 304 Stainless Steel corrugated shield and bands, and polychloroprene (neoprene) based rubber sleeve conforming to ASTM C564.
      i. Approved manufacturers:
         1) Clamp-All 125
         2) MG
         3) Husky SD 4000
         4) Mission Rubber Company

3. Domestic Hot, Cold, and Recirc., Water Piping Inside Buildings, Above Grade:

   a. Pipe or Tubing: 2 inches & smaller, all water lines soft temper Type K copper tubing below ground, hard temper Type L copper tubing above ground, ASTM B88, or Type 304/304L, Schedule 10S, stainless steel to ASTM A312.
      2-1/2 inches & larger, hot dipped galvanized steel A120, ASTM A53, Grade B, Schedule 40 steel, or hard copper tube, Type L with copper-tube dimensioned grooved ends; copper ground - end fittings; copper tubing, keyed couplings; and grooved joints. (Flaring of tube or fitting ends to accommodate alternate sized couplings is not permitted.)
      Provide dielectric fittings between steel and copper. Victaulic Style 47 or approved equal.
   b. Fittings & Joints: Copper tubing fittings and joints shall be solder type wrought copper - 95-5 silver solder or braze (lead and antimony based solders are prohibited). Galvanized steel pipe fittings and joints shall be ANSI B16.12 hot dipped galvanized threaded ends and 125 lb. galvanized cast iron fittings or 150 lb. galvanized malleable iron.
      i. Stainless steel fittings shall be Vic-Press or approved equal for Schedule 10S pipe. Fittings shall be precision, cold drawn, stainless steel with EPDM O-ring seals. (Seals shall be UL classified in accordance with ANSI/NSF61 for Potable Water service.) Fittings rated for working pressures to 500-psi.
      ii. Grooved joint couplings shall consist of two ductile iron housing segments cast with offsetting angle pattern bolt pads, FlushSeal elastomer gasket, and ASTM A449 electroplated steel bolts and nuts. (Gasket shall be UL classified in accordance with ASNI/NSF61 for Potable Water service, and shall meet the lead

content requirements of NSF-372.) Installation-Ready, for direct stab installation without field disassembly. Victaulic Style 607H or approved equal.

iii. Installation-ReadyTM fittings for grooved end copper tubing shall be manufactured to copper-tube dimensions. Fittings shall be ductile iron conforming to ASTM A-536, Grade 65-45-12, with Installation-ReadyTM ends, complete with PVDF (Poly Vinylidene Fluoride) and Grade "EHP" EPDM-HP (Grade 'T' Nitrile) gasket; and ASTM A449 electroplated steel bolts and nuts. System shall be rated to 300 psi (2065 kPa) with Type K or L Copper Tubing.

1) UL classified in accordance with NSF-61 for potable water service. The system shall meet the low-lead requirements of NSF-372.

c. Gate Valves: 2-1/2 inches & larger - OS&Y, IBBM flanged, 125 lb. standard solid wedge.

i. 2 inches & smaller - bronze solder end, bronze body, solid wedge, rising stem, 200 lb. w.o.g. non-shock. However, use brass valves only on all copper pipe.

d. Butterfly Valves: Cast brass body to UNS C87850, elastomer pressure responsive seat, aluminum-bronze disc with stainless steel stem. Stem shall be offset from the disc centerline to provide complete 360-degree circumferential seating. Copper-tube dimensioned grooved ends, suitable for working pressures to 300-psig CWP Victaulic Style 608N or approved equal.

e. Ball Valves: Shut-off valves 2-inches and smaller shall be ball valves. Ball valves shall be 150 lbs, brass or bronze body, standard port, 2 piece body, TFE seats with bronze trim. Ball valves shall be threaded end or solder end, or Vic-Press end as required to accommodate piping. Ball valves shall be as manufactured by Victaulic, Conbraco, Crane, Apollo, Nibco, Watts or engineer approved equal.

f. Unions: 2-1/2 inches & larger - 150 lb. brass companion flanges.

i. 2 inches & smaller - wrought copper, ground joint solder ends; threaded hexagonal stainless steel union with Vic-Press ends, Victaulic P589 or approved equal.

g. Check Valves: 2-1/2 inches & larger - IBBM, 125 lb. std. flanged bronze swing check, with metal disc; 2-inches and smaller - 125 lb. std. screwed or solder ends.

h. Globe Valves: 2 inches and smaller, bronze body, bronze trim, rising stem, hand wheel, inside screw, renewable composition disc, solder ends, 150 lb, with back seating capacity.

i. 2 inches & larger: IBBM, 150 lb, bronze trim, rising stem, handwheel OS&Y, plug type disc, flanged ends, renewable seat and disc.

ii. Globe valves shall be Conbraco, Crane, Nibco, Milwaukee, Watts or approved equal.

i. Combination Shut-off/Balancing Valves:

i. Victaulic/TA Hydronics, Taco Circuit Setter, Bell & Gossett Circuit Setter Plus, Flowset Accuset, Gerand, or engineer

approved equal, ½ inch-3 inches 300 psi rated globe type or ball valve with DZR brass Ametal (copper-alloy) or bronze body/brass ball construction with glass and carbon filled TFE seats, in-line flow meter and balancing and shut-off valve with built in ball valve for flow adjustment. Valve shall have memory stop, calibrated nameplate, Schrader valve connections and preformed molded insulation. Valves shall be leaktight at full rated working pressure. Balance valve size shall be selected based on manufacturer's acceptable flow range and design flow rate. Pressure drop through combination shut off balance valves shall not exceed 5 feet of head at design flow rate.

j. Extended Valve Stems: Provide and install round collar type extended valve stems on all valves installed in insulated piping. Valve stem and collar shall be selected to suit insulation thickness and maintain valve handles outside of insulation.

k. (Alternate): At contractor's option, Viega ProPress pressure seal mechanical fittings may be utilized.

i. Viega, ProPress Pressure Seal Fittings: Bronze, or copper shall conform to ASME B16.51, ICC LC 1002, IAPMO PS 117, NSF 61, and NSF 61-G or NSF 372. ProPress fittings ½-inch thru 4-inch for use with ASTM B88 copper tube type L and ½-inch up to 1-1/4-inch annealed copper tube. ProPress fittings shall have an EPDM sealing element grip ring, PBT separator ring, EPDM sealing element and Smart Connect (SC) feature.

B. Steel pipe shall be similar and equal to National Tube Company, Grinnell, Republic, or Bethlehem black or zinc-coated (galvanized) as hereinafter specified. Pipe shall be free from all defects which may affect the durability for the intended use. Each length of pipe shall be stamped with the manufacturer's name.

C. Copper pipe shall be Revere, Anaconda or Chase with approved solder fittings.

D. Welding fittings for steel pipe shall meet the requirements of ASTM Standard A-23 and shall be standard catalog products. Fittings fabricated by metering and notching pipe will not be accepted.

2.2. PIPE HANGERS, ROLLER SUPPORTS, ANCHORS, GUIDES, AND SADDLES

A. All hangers for metallic piping shall be adjustable, wrought clevis type, or adjustable malleable split ring swivel type, having rods with machine threads. Hangers shall be Grinnell Company's Figure 260, Carpenter and Patterson, or approved equal for pipe ¾-inch and larger, and Figure 65 for pipe 2-inches and smaller, or approved equal. Adjustable pipe stanchion with U-bolt shall be Grinnell Company's Figure 191. Pipe roller supports shall be Grinnell's Figure 181 or Figure 271. Exterior pipe hangers shall be galvanized or stainless steel construction. For copper piping in direct contact with the hanger, hanger construction shall be copper coated to prevent contact of dissimilar metals similar to Grinnell's Figure CT-65. Hanger spacing and rod sizes for steel and copper pipe shall not be less than the following:

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
3/4 & 1	6	5	3/8
1 - ½	6	8	3/8
2	8	8	3/8
2 – ½	10	9	½
3	12	10	½
4	14	12	5/8
5	14	12	5/8
6	16	14	3/4

B. Install hangers for cast-iron and storm water soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.

2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.

3. PS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.

4. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.

5. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).

C. Anchors, guides, and roller supports shall be installed in accordance with the contract drawings and manufacturer's recommendations to provide pipe support and control pipe movement for all piping systems. Anchors and guides shall be securely attached to the pipe support structure. Submit shop drawing for proposed pipe support structure for guides and anchors for approval of the Structural Engineer. Pipe alignment guides shall be Fig. 255 Grinnell, or as approved equal. Guides shall be sized to accommodate the pipe with insulation. Guides shall be steel factory, fabricated, with bolted two section outer cylinder and base for alignment of piping and two section guiding spider for bolting to pipe.

D. Hangers for pipe sizes ½ to 1 ½ inch (13 to 38 mm): Carbon steel, adjustable swivel, split ring.

E. Hangers for cold pipe sizes 2 inches (50 mm) and over: Carbon steel, adjustable, clevis.

F. Hangers for cold pipe sizes 2 to 4 inches (50 to 100 mm): Carbon steel, adjustable, clevis.

G. Multiple or Trapeze hangers: Steel channels with welded spacers and hanger rods.

H. Multiple or Trapeze hangers for hot pipe sizes 6 inches (150 mm) and over: Steel channels with welded spacers and hanger rod, cast iron roll.

I. Wall support for pipe sizes to 3 inches (76 mm): cast iron hook

J. Wall support for pipe sizes 4 inches (100 mm) and over: Welded steel bracket and wrought steel clamp.

K. Vertical Support: Steel riser clamp.

L. Floor support for cold pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

M. Floor support for hot pipe sizes to 4 inches (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

N. Copper pipe support: Carbon steel ring, adjustable, copper plated.

O. Hanger rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

P. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.3. VALVES

A. Provide parts list and assembly drawings (exploded view) for all valves in shop drawing submittals. Provide valves of the same type by the same manufacturer.

2.4. STRAINERS

A. Strainers shall be of the basket or "Y" type and shall be heavy and durable, constructed of best grade gray iron with the bottoms drilled and plugged. Bodies shall have arrows clearly cast on the sides to show flow direction. Strainers shall be equipped with easily removable covers and brass sediment baskets made of brass not less than #22 gauge in thickness. Total area of basket perforations shall be not less than four times the cross section of the entering pipe. Flow shall be into basket, and then out through the perforations. Strainers shall be suitable for water or the intended fluid. Strainers 2 inches and smaller shall have threaded or solder ends, 2 inches and larger shall have flanged ends.

B. Strainer screens shall be stainless steel with perforations and shall be 1/16-inch for pipe sizes 5 inches and less, 1/8-inch (40 percent open area) perforations for pipe sizes 6-inch and greater.

C. Provide valved and capped (with chain) blowdowns in each strainer. Blowdown valves shall be Appolo 78-100/200 series or as approved equal.

D. Strainers shall be manufactured by Watts, Mueller, Armstrong, Yarway, Spirax/Sarco or as approved equal.

2.5. UNIONS, FLANGES, AND COUPLINGS

A. Unions in steel pipe 2-inches and smaller shall be malleable iron with brass inserted seats designed for a working pressure of 150 psig.

B. Unions in copper pipe 2-inches and smaller shall be sweat fittings with bronze seats designed for a working pressure of 125 psig.

C. Flanges for steel pipe over 2 inches shall be 150 psig, forged steel, slip on. Gaskets shall be 1/16 inch thick pre-formed neoprene.

D. Flanges for copper pipe over 2 inches shall be bronze. Gaskets shall be 1/16 inch thick preformed neoprene.

2.6. MANUAL AIR VENTS

A. Manual air vents shall be similar to the hereinafter specified gauge valves. Provide 1/4-inch size on ¾-inch pipe and smaller, ½ -inch size on 1-inch pipe and larger. Install at all high points of piping. Valves shall be Crane No. 88, or as approved equal, with threaded ends, bronze body, bronze or brass bonnet and bronze stem.

2.7. THERMOMETERS

A. Unless otherwise indicated, thermometers shall be ASTM E1, in a glass type, organic filled, 9-inch scale size, corrosion-resistant metal case, with "any-angle" mounting with positive locking device. Trerice Industrial Thermometers, Weksler Instruments, Ernst Gage Co., Miljoco, or approved equal. Insertion stem length shall suite the pipe size and configuration. Thermometer wells shall be brass with brass union hubs in copper and in ferrous piping. Where piping is insulated or otherwise covered, use wells with lagging extension. Where wells are installed in pipe tees at turns, increase pipe size so that well does not restrict flow. Accuracy shall be 2 percent.

B. Unless otherwise indicated, thermometer ranges shall be as follows:

1. Domestic cold water: 0 degrees F to 100 degrees F, 1 degrees F Division.

2. Domestic hot and hot water recirculating: 30 degrees F to 180 degrees F, 2 degrees F Division.

C. Provide heat conducting compound in wells.

2.8. PRESSURE GAUGES

A. Unless otherwise indicated, pressure gauges shall be the bronze bourdon tube type, 4-1/2-inch dial, stem mounting, cast aluminum adjustable pointer, 1 percent accuracy over middle half of scale range, 1-1/2 percent over balance: Trerice Model 600C; Weksler Instruments,

Ernst Gage Co., Miljoco, or as approved equal.

B. Gauges shall have pressure, vacuum, compound, or retard ranges as required, select ranges so that the normal readings are at the approximate midpoint and maximum system pressures do not exceed full scale.

C. Furnish and install a gauge valve at each pressure gauge. Gauge valves shall be Crane Model No. 88, Needle Valve, Ernst Gage Co. FLG 200, Wexler Instrument Corp. Type BBV4, or approved equal, rated for pressure intended.

D. Gauge connections for pressure gauges, thermometers, or control instruments shall be made using tee fittings, except that gauge connections up to 1-inch size in steel may be using threaded extra heavy pipe couplings welded directly to the main, provided that the main is at least 2-inch size for 2-inch connections, 3-inch size for 3/4-inch connections, and 4-inch size for 1-inch connections. Minimum gauge connection shall be 2-inch ips.

E. Provide snubbers on all gauges. Snubbers shall be No. 872 by Trerice, RS1/RS6 by Wexler Instruments, Miljoco or as approved equal.

2.9. PIPING SPECIALTIES

A. Furnish and install flexible pipe connections, as specified and/or shown on the drawings, at suction and discharge connections of all in-line pumps, all vibrating equipment and elsewhere as shown. Refer to Division 23 Section, Vibration Control for HVAC, Plumbing and Fire Protection Equipment for specifications.

B. Pressure relief valves shall be provided in the number and sizes required to relieve 110 percent of the full input to the systems. Valves shall be rated; and installed in accordance with ASME, and CSD-1 including all amendments. Pipe discharge full size to floor drain, (with union) and support discharge pipe to prevent exerting any strain on relief valve body, piping to be Type-L copper. Water safety relief valves shall be Watts Series 740, Conbraco, Series 154A, Bell and Gossett, or approved equal. Provide pressure gauge adjacent to all safety relief valves.

2.10. ESCUTCHEONS

A. Provide chromium plated escutcheons properly fitted and secured with set screws on all exposed piping which passes through walls, floors or ceilings of finished spaces.

B. All escutcheon plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface. Plastic escutcheon plates will not be accepted.

2.11. DIELECTRIC CONNECTIONS:

A. Furnish and install electrically insulated dielectric unions, waterway fittings, or flanges, as manufactured by Victaulic Company, EPCO Sales, Inc., at the following locations:

1. Where steel piping systems join copper piping.

2. Where copper tube connects to domestic water storage tanks, water heaters, heat exchangers, expansion tanks, and other steel vessels.

3. Avoid the installation of steel nipples, cast iron or steel valves and specialties, or other ferrous components in predominately copper piping systems. Where such installation is necessary, isolate the component with dielectric connections. Do not mix steel pipe and copper tube in the same run of pipe or in the same section of a piping system.

4. Dielectric Waterway: Copper silicon casting conforming to UNS C87850 with grooved and/or threaded ends. UL classified in accordance with NSF-61 for potable water service, and shall meet the low lead requirements of NSF-372. Basis of Design: Victaulic Series 647.

2.12. SLEEVES

A. Sleeves shall be provided around all pipes through walls, floors, ceilings, partitions, roof structure members or other building parts. Sleeves shall be standard weight galvanized iron pipe two sizes larger than the pipe or insulation so that pipe or insulation shall pass through masonry or concrete walls or floors. Provide 20 gauge galvanized steel sheet or galvanized pipe sleeves for all piping passing through frame walls.

B. Sleeves through floors shall be flush with the floor except for sleeves passing through Equipment Rooms which shall extend ¾-inch above the floor. Refer to Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for mechanical equipment room penetrations additional requirements. Space between the pipe and sleeve shall be caulked. Escutcheon plates shall be constructed to conceal the ends of sleeves. Each trade shall be responsible for drilling existing floors and walls for necessary sleeve holes. Drilling methods and tools shall be as hereinbefore specified.

C. Sleeves through walls and floors shall be sealed with a waterproof caulking compound.

D. Firestop at sleeves that penetrate smoke barriers smoke partitions and/or rated walls/floors.

2.13. PRESSURE REDUCING VALVES

A. Provide pressure reducing valves as indicated, of size and capacity selected by the installer to maintain operating pressure on the system. Body shall be cast-iron or bronze construction, renewable stainless steel seat, non-corrosive disc, water tight cage assembly, adjustable pressure ranges and inlet strainer Watts Regulator Model 223-S, Armstrong, Bell and Gossett or as approved equal.

B. Provide pressure gauge adjacent to all pressure reducing valves to verify proper set point.

2.14. TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.

2. Pressure rating at least equal to pipes to be joined.

3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Plastic-to-Metal Transition Fittings:

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

a. Charlotte Pipe and Foundry Company.
b. Harvel Plastics, Inc.
c. Spears Manufacturing Company.

2. Description: PVC or CPVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket end.

D. Plastic-to-Metal Transition Unions:

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

a. Colonial Engineering, Inc.
b. NIBCO INC.
c. Spears Manufacturing Company.

2. Description: PVC or CPVC four-part union. Include brass threaded end, solvent-cement-joint plastic end, rubber O-ring, and union nut.

PART 3. EXECUTION

3.1. GENERAL PIPING INSTALLATION REQUIREMENTS

A. All pipes shall be cut accurately to measurements established at the building, and shall be worked into place without springing or forcing, properly clearing all windows, doors and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installation will not be permitted. All pipes shall be so installed as to permit free expansion and contraction without causing damage. All open ends of pipe lines, equipment, etc., shall be properly capped or plugged during installation to keep dirt or other foreign material out of the system. All pipes shall be run parallel with the lines of the building and as close to walls, columns and ceilings as may be practical, with proper pitch. All piping shall be arranged so as not to interfere with removal of other equipment on devices not to block access to doors, windows, manholes, or other access openings. Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment, coils, etc., and installed so that there will be no interference with the installation of the equipment, ducts, etc. All valves and specialties shall be placed to permit easy operation and access and all valves shall be regulated, packed and glands adjusted at the completion of the work before final acceptance. All piping shall be installed so as to avoid air or liquid pockets throughout the work. Ends of pipe shall be reamed so as to remove all burrs.

B. All piping shall be graded to convey entrained air to high points where automatic air vents

shall be provided. The size of supply and return pipes for each piece of equipment shall in no case be smaller than the outlets in the equipment.

C. All piping shall be run to provide a minimum clearance of 2-inches between finished covering on such piping and all adjacent work. Group piping wherever practical at common elevations.

D. All valves, strainers, caps, and other fittings shall be readily accessible.

E. Rough-in and final connections are required to all equipment and fixtures provided under this Contract.

F. Drain valves with hose connections shall be provided at low points for drainage of piping systems. Blow down valves shall be provided at the ends of all mains and branches so as to properly clean by blowing down the lines throughout in the direction of normal flow.

G. Discharge lines from all relief valves shall be piped to within 4-inches of floor and extend to floor drains wherever floors are not pitched to drains. Pitch the relief valve piping away from the relief valve to issue that no fluid can be trapped in valve discharge. Support all relief valve piping to prevent exerting strain on the relief valve body. The end of the relief valve discharge piping shall not be threaded to prevent capping or plugging.

H. All branches from water mains shall be taken from the top of the supply mains at an angle of forty-five (45) degrees above the horizontal, unless otherwise directed. Branches feeding down shall be taken from the side or bottom of the main on water mains only. All connections shall be carefully made to insure unrestricted circulation, eliminate air pockets or trapped condensate, and permit the complete drainage of the system.

I. Cutoff valves shall be provided on each branch line from the mains on all plumbing lines.

J. Shut-off valves shall be installed at the inlet and outlet of each piece of equipment to permit isolation for maintenance and repair.

K. Balancing valves shall be installed in all domestic re-circulating systems and at all pumps, and where indicated on the drawings.

L. Unions shall be installed on all bypasses, at all connections to equipment, where shown on drawings or where required to facilitate removal of equipment whether shown or not.

M. Spring clamp plates (escutcheons) shall be provided where pipes are exposed in the building and run through walls, floors, or ceilings. Plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface.

N. If the size of any piping is not clearly evident in the drawings, the Contractor shall request instructions for the Engineer as to the proper sizing. Any changes resulting from the Contractor's failure to request clarification shall be at his expense. Where pipe size discrepancies or conflicts exist in the drawings, the larger pipe size shall govern.

O. Install all valves with stem upright or horizontal, not inverted.

P. Where pipe support members are welded to structural building framing, scrape, brush

clean, weld and apply one coat of zinc rich primer.

Q. Provide clearance for installation of insulation and access to valves and fittings.

R. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

S. All water containing pipes shall be routed clear of combustion air dampers and louvers to prevent freezing condition when dampers are open.

T. Provide manual air vents at top of piping systems.

U. Where access doors are required, install piping so that valves can be grouped together to minimize the quantity of access doors.

V. Install manufactured U.L. listed firestop collars at all floor/wall penetrations for all PVC and CPVC pipe penetrations.

3.2. THERMOMETER AND PRESSURE GAGE INSTALLATION REQUIREMENTS.

A. Install thermometers and adjust vertical and tilted positions.

B. Install separable sockets in vertical position in piping tees where fixed thermometers are indicated.

1. Install with socket extending to one-third diameter of pipe.

2. Fill sockets with oil or graphite and secure caps.

C. Install pressure gages in piping tees with pressure-gage valve located on a pipe at most readable location.

D. Adjust faces of thermometer and gages to proper angle for best visibility.

E. Clean windows of thermometer and gauges and clean factory-finished surfaces. Replace cracked and broken window, and repair scratched and marred surfaces with manufacturer's touch up paint.

3.3. VALVE INSTALLATION REQUIREMENTS

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

F. Examine grooved ends for form and cleanliness. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.

G. Do not attempt to repair defective valves; replace with new valves.

H. Install valves as indicated, according to manufacturer's written instructions.

I. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

J. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

K. Locate valves for easy access and provide separate support where necessary.

L. Install valves in horizontal piping with stem at or above the center of the pipe.

M. Install valves in a position to allow full stem movement.

N. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

3.4. WASTE AND VENT PIPING INSTALLATION REQUIREMENTS

A. Each pipe shall be laid true to line and grade and in such manner as to form a close concentric joint with the adjoining pipe and to prevent sudden offsets of the flow line. All pipe when laid shall rest on the full length of the barrel and bell holes shall be dug in trench bottoms to make joints. Pipe shall not be adjusted to grade by use of block or wedges. Where rock or old foundations are encountered, trenches shall be excavated 6-inches below grade and crusher run limestone shall be used as a bedding material to support barrel of pipe.

B. As the work progresses, the interior of the sewer shall be cleared of all dirt and superfluous materials of every description.

C. Trenches shall be kept free from water until the pipe jointing material has set and pipe shall not be laid when the conditions of the trench or the weather is unsuitable for such work. At all times, when work is not in progress, all open ends of pipe and fittings shall be securely closed to the satisfaction of the Engineer, so that no trench water, earth or other substance will enter the pipe or fittings.

D. Slip joints will be permitted only in trap seals or on the inlet side of the trap. Unions on the sewer side of the trap shall be ground faced, and shall not be concealed or enclosed. Install bell and spigot pipe with bell end upstream.

E. Threaded joints shall be American Standard taper screw threads with permacel joint compound applied to the male thread. Connections between threaded pipe and cast iron

pipe shall have a ring or half coupling screwed on to form a spigot end on the threaded pipe.

F. Establish invert elevations, slopes for drainage to 1/8 inch per foot. Maintain gradients.

3.5. PIPE JOINTS INSTALLATION REQUIREMENTS

A. Welded Joints: Joints in piping 2-1/2-inches and larger shall be fusion welded. Welding shall be in accordance with recommendations of the American Welding Society. Welding fittings shall conform in physical and chemical properties to the latest revisions of the American Society for Testing Materials.

B. Qualify welding procedures, welders and operators in accordance with ASME B31.1, or ASME B31.9 as applicable, for shop and project site welding of piping work. Certify welding of piping work using Standard Procedure Specifications by, and welders tested under supervision of, National Certified Pipe Welding Bureau (NCPWB). Submit welders qualifications for approval.

C. Grooved Joints: Grooved joint shall be installed in accordance with the manufacturer's written recommendations. Grooved ends shall be clean and free from indentations, projections, or roll marks. The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service. The coupling manufacturer's factory trained representative shall provide on-site training for the contractor's field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed. (A distributor's representative is not considered qualified to conduct the training.)

D. Screwed Joints: All screwed joints shall be made with tapered threads properly cut. Screwed joints shall be made perfectly tight with a stiff mixture of graphite and oil, applied with a brush to the male threads on the fittings.

E. Soldered Joints and Copper Piping: Joints in copper piping shall conform to the following minimum standards.

1. The pipes shall be cut to a length making certain that the ends are square, using a fins hacksaw blade or tube cutter. The ends of all pipes shall be reamed and all burrs removed.

2. The outside end of the pipe and the cut end of the fitting shall be cleaned with steel wool, sand cloth, or steel wire brush. All dark spots shall be removed.

3. The flux shall be applied evenly and sparingly to the outside end of the pipe and the inside of the outer end of the fitting until all surfaces to be jointed are completely covered. The piping and fitting shall be slipped together and reworked several times to insure an even distribution of the flux.

4. The correct amount of solder per joint for each size pipe shall be used in accordance with the manufacturer's recommendations.

5. Solder joints shall be made by using a direct flame from a torch.

6. On pipe sizes larger than ¼-inch, the fittings and valves in the pipe shall be moved or tapped with a hammer when the solder starts to melt to insure an even distribution of the solder.

7. The excess solder shall be removed while it is still in the plastic state leaving a fillet around the cup of the fitting.

8. Solder joints shall be suitable for working pressure of 100 psig and for working temperature of not less than 250 degrees F. The type of solder and flux used will be submitted for approval. Type 95-5 shall be the minimum standard.

9. Lead and antimony-based solders shall not be used for potable water systems. Brazing and silver solders are acceptable.

F. Where copper piping joins steel piping, approved bronze adapters shall be used.

G. Prohibited Connections: No direct weld, soldered, or brazed connections, without unions or flanges, shall be made to valves, strainers, apparatus, or related equipment. Right and left couplings, long threads, or caulking of pipe threads or gasket joints will not be permitted.

3.6. HANGERS AND SUPPORTS INSTALLATION REQUIREMENTS

A. General: All hangers shall be of an approved type arranged to maintain the required grading and pitching of lines to prevent vibration and to provide for expansion and contraction. Provide protection saddles between hangers and insulation on heating water insulated pipe. Saddles shall be Grinnells Figure 173/273 or approved equal. Provide approved spacers between saddles and pipe where flexible insulation is specified. Provide insulation protection shields for insulated piping without saddles. Shield shall be Grinnell Figure 167 or as approved equal.

B. Spacing: Regardless of spacing, hangers shall be provided at or near all changes in direction, both vertical and horizontal, for all piping. For cast iron soil pipe, one hanger shall be placed at each hub or bell.

C. Vertical Lines: Shall be supported at their bases, using either a suitable hanger placed in a horizontal line near the riser, or a base type fitting set on a pedestal, foundation or support. All vertical lines extending through more than one floor level shall be supported at each floor with a riser clamp. Riser clamp shall be Grinnell Co.'s Figure 261, or approved equal. All vertical drops to pump suction elbows shall be supported by floor posts.

D. Racks and Brackets: All horizontal piping on vertical walls shall be properly supported by suitable racks securely anchored into the wall construction. Where not practical to obtain ceiling anchorage, all piping near walls shall be supported by approved brackets securely anchored into the wall construction. Washer plates (Fib. 60, 60L) and other miscellaneous attachments, fasteners, etc., shall be Grinnell or as approved equal. All exterior hanger and bracket systems in their entirety shall be galvanized.

E. Pipe Hangers and supports shall be attached to the panel point at the top chord of bar joist or at a location approved by the structural engineer.

F. Select hangers and components for loads imposed. Secure rods with double nuts.

G. Support of horizontal piping shall allow for vertical adjustment after installation of piping.

H. Support overhead piping with clevis hangers.

I. Do not support all parallel piping from the same joist. Stagger all supports in accordance with the structural engineer's recommendations.

J. Refer to structural documents for appropriate connection/attachment materials to building.

3.7. AIR VENTING INSTALLATION REQUIREMENTS

A. The top of each plumbing piping system and other points as indicated or where necessary for the removal of air from the system or equipment, shall be vented using an approved type of manual air vent.

B. In addition to manual air vents at high points of system, each item of water heat transfer equipment shall be manually vented using an approved type manual air vent. All air vents shall be accessible.

3.8. EXPANSION LOOPS AND SWING CONNECTION INSTALLATION REQUIREMENTS

A. Install expansion fittings according to manufacturer's written instructions.

B. Install expansion fittings in sizes matching pipe size in which they are installed.

C. Align expansion fittings to avoid end loading and torsional stress.

D. Install pipe bends and loops cold sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

E. Attach pipe bends and loops to anchors.

1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

F. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

G. Connect risers and branch connections to plumbing equipment with at least four pipe fittings, including tee in riser.

H. Connect mains and branch connections to plumbing equipment with at least four pipe fittings, including tee in main.

3.9. PIPING IDENTIFICATION REQUIREMENTS

A. All piping shall be identified with painted background marked with the name of the service

with arrows to indicate flow direction. Color code and system identification shall comply with ANSI Standards and piping identification system shall comply with ASME A13.1-81., scheme for the identification of piping systems and ASHRAE Fundamentals Handbook, latest edition.

B. Markings shall be plain block letters, stenciled on pipes, and shall be located near each branch connection, near each valve, and at least every 10 feet on straight runs of pipe. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such manner as to be easily legible from the floor. Pipe identification schedule shall be as follows:

OUTSIDE DIAMETER OF PIPE OR COVERING (INCHES)	LENGTH OF COLOR FIELD (INCHES)	SIZE OF LETTERS (INCHES)
½ to 1 ¼	8	½
1-½ to 2	8	¾
2 ½ to 6	12	1 ¼
8 to 10	24	2 ½
Over 10	32	3 ½

3.10. VALVE IDENTIFICATION REQUIREMENTS

A. All valves shall be tagged with a numbered tag.

B. The tags shall be made of 1-inch diameter brass tags fastened to the valve by means of brass chains. Numbers shall agree with valve numbers on diagrammatic herein before specified.

C. Provide a minimum of six (6) valve charts with valve numbers indicating valve type, size, manufacturer and service.

D. Additional valve charts shall be mounted behind glazed wooden frames and be hung in each mechanical equipment room including each air handling unit mechanical equipment room. Additional copies shall be provided in each copy of the O&M manuals.

3.11. CLEANING PIPING AND EQUIPMENT

A. All water, plumbing piping, systems shall be cleaned by filling with a solution of one (1) pound of trisodium phosphate to each 50 gallons of water and circulating this solution for a period of six (6) hours during which time the system shall reach operating temperature. The systems shall then be flushed with fresh water and refilled with fresh water purged of all air.

B. All water piping system shall be flushed clean with fresh water. See Division 22 Sections, Plumbing Fixture and Plumbing Equipment for domestic potable water cleaning and sterilization.

3.12. PRESSURE SEAL FITTING INSTALLATION REQUIREMENTS

A. Viega, ProPress Pressure Seal bronze, or copper fittings: Sealing element shall be verified for the intended use. Tube ends shall be cut on a right angle (square) to the tube. Tube ends shall be reamed and chamfered, all grease oil or dirt shall be removed from the tube end with a clean rag. Visually examine the fitting sealing element to ensure there is no damage, and it is properly seated into the fitting. Utilizing a Viega Insertion Depth Inspection Gauge mark the tube wall, with a felt tip pen, at the appropriate location, or insert the tube fully into the fitting and mark the tube wall at the face of the fitting. Always examine the tube to ensure it is fully inserted into the fitting prior to pressing the joint. ProPress fittings shall be installed according to the most current edition of the Viega installation guidelines. Installers shall attend a Viega ProPress installation training class.

B. After ProPress Pressure seal fittings have been installed a “two step test” shall be followed. Pressurize the system with application appropriate test medium, water between 15 and 85 psi, or air/dry nitrogen between .5 and 45 psi. Check the pressure gauge for pressure loss. If the system does not hold pressure, walk the system and check for un-pressed fittings. Should you identify an un-pressed ensure the tube is fully inserted into the fitting and properly marked, prior to pressing the joint. After appropriate repairs have been made, retest the system per local code, or specification requirements, not to exceed 600 psi with water or 200 psi when using air.

END OF SECTION

DIVISION 22 SECTION 220701
PLUMBING INSULATION
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SECTION 220701 - PLUMBING INSULATION

PART 1. GENERAL

1.1. REFERENCE

A. The Conditions of the Contract and other General Requirements apply to the work specified in this Section. All work under this Section shall be subject to the requirements of Division 22 Section, Common Work Results for Plumbing.

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

1.2. DESCRIPTION

A. All piping and equipment installed under this Contract shall be covered as specified.

1.3. SCOPE

A. The work covered by this specification consists of furnishing all labor, equipment, materials and accessories, and performing all operations required, for the correct fabrication and installation of thermal insulation applied to all piping, equipment, and systems, in accordance with applicable project specifications and drawings, subject to the terms and conditions of the contract.

1.4. STANDARDS

A. Thermal insulation materials shall meet the property requirements of one or more of the following specifications as applicable to the specific product or use:

1. American Society for Testing of Materials Specifications:

   a. ASTM C 547, “Standard Specification for Mineral Fiber Preformed Pipe Insulation”.
   b. ASTM C 533, “Standard Specification for Calcium Silicate Pipe & Block Insulation”.
   c. ASTM C 55, “Standard Specification for Mineral Fiber Blanket and Felt Insulation”.
   d. ASTM E 96, “Standard Test Methods for Water Vapor Transmission of Materials”.
   e. ASTM C 585, “Recommended Practice for Inner and Outer Diameters of Rigid Pipe Insulation for Nominal Sizes of Pipe and Tubing (NPS System)”.
   f. ASTM C 612, “Standard Specification for Mineral Fiber Block and Board Thermal Insulation”.
   g. ASTM C 1136, “Standard Specification for Barrier Material, Vapor, “Type 1 or 2 (Jacket only).
   h. ASHRAE 90.1 “Energy efficient design of new buildings except low-rise residential buildings”, latest edition.

B. Insulation materials, including all weather and vapor barrier materials, closures, hangers, supports, fitting covers, and other accessories, shall be furnished and installed in strict accordance with project drawings, plans, and specifications.

1.5. SYSTEM PERFORMANCE

A. Insulation materials furnished and installed hereunder should meet the minimum economic insulation thickness requirements of the North American Insulation Manufacturers' Association (NAIMA) (formerly known as TIMA), to ensure cost-effective energy conservation performance. Alternatively, materials should meet the minimum thickness requirements of National Voluntary Consensus Standard 90.1, (latest edition) and "Energy Efficient Design of New Buildings," of the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), latest edition. However, if other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor. As minimum, all insulation thicknesses shall be as hereinafter specified.

B. Insulation materials furnished and installed hereunder shall meet the fire hazard requirements of any one of the following specifications:

1.	American Society for Testing of Materials	ASTM E 84
2.	Underwriters' Laboratories, Inc.	UL 723
3.	National Fire Protection Association	NFPA 255

C. Calcium silicate products shall include a visual identification system to permit positive field determination of their asbestos-free characteristics.

1.6. QUALITY ASSURANCE

A. Insulation materials and accessories furnished and installed hereunder shall, where required, be accompanied by manufacturers' current submittal or data sheets showing compliance with applicable specifications listed in Section 1.4 above.

B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.

1.7. DELIVERY AND STORAGE OF MATERIALS

A. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.

B. The Contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The Contractor shall also use all means necessary to protect work and materials installed by other trades.

C. If any insulation material has become wet because of transit or job site exposure to

moisture or water, the Contractor shall not install such material, and shall remove it from the job site. An exception may be allowed in cases where the Contractor is able to demonstrate that wet insulation when fully dried out (either before installation, or afterward following exposure to system operating temperatures) will provide installed performance that is equivalent in all respects to new, completely dry insulation. In such cases, consult the insulation manufacturer in writing for technical assistance.

D. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements. Protect all insulation from water, construction traffic, dirt, chemical and mechanical damage.

PART 2. PRODUCTS

2.1. GENERAL

A. All materials to be insulated shall be thoroughly cleaned, after completion of successful tests, and shall be covered as specified below. Fiberglass insulation shall be Owens-Corning, Manville, Armstrong, or P.P.G, or as approved equal.

2.2. PIPE INSULATION MATERIALS

A. Unless otherwise noted, insulation shall be one piece or half sectional molded fibrous glass with "K" rating of .23 at 75 degrees F mean temperature, for service temperatures between -60 degrees F and +450 degrees F with all service poly-encapsulated jacket. Pipe insulation shall be fiberglass ASJmax SSL II with double closure system as manufactured by Owens Corning, Johns Manville, Knauf or approved equal.

B. Unless otherwise noted, pipe insulation jacket shall be factory-applied vinyl coated, embossed and reinforced vapor barrier laminate, with a perm rating of not more than 0.02 perms. All hot and cold, concealed and exposed butt strips shall be of the same material as the jacket. Jacket and butt strips shall be sealed with field-applied Foster 85-20/85-50 or Childers CP-82 (5 gallon cans only) adhesive. Jacket and butt strips shall be off-white color and shall be equivalent to Owens-Corning Fiberglass 25-ASJ.

C. For fittings on all piping, valves, and flanges, apply fiberglass molded or segmented insulation equal in thickness to the adjoining insulation and securely fasten in place using wire. Cold piping: Apply a tack coat of vapor barrier coating and reinforcing mesh. After ½ hour, apply second coat of same vapor barrier coating, UL labeled, Type C, for cold water piping. Hot piping: Apply tack of breather mastic. Wrap fitting with fiberglass reinforcing cloth overlapping adjoining sections of pipe insulation by 2-inches. Apply a second coat of breather mastic over the reinforcing cloth, working it to a smooth finish. As an option to the above hot fittings, a polyvinyl chloride fitting cover may be supplied.

D. All pipe insulation, jackets, or facings, and adhesives used to adhere jacket or facing to the insulation, including fittings and butt strips, shall have non-combustible fire and smoke hazard system rating and label as tested by ASTM E-84, NFPA 225, and UL 73, not exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50. Accessories such as adhesives, mastic cements, tapes and cloth for fittings shall have the same ratings as listed above. All products or their shipping cartons shall bear the Underwriter's label

indicating that flame and smoke ratings do not exceed the above criteria.

E. For piping having a vapor barrier insulation and for all insulated piping requiring supports, hangers and supports shall be installed outside the insulation. Wherever hangers and supports are installed outside the insulation, pipe insulation protecting shields shall be provided. Where insulation is a load bearing material, of sufficient strength to support the weight of the piping, pipe shields one-third the circumference of the insulation and of a length not less than three times the diameter of the insulation (maximum length 24-inches) shall be provided. Insulation of 7-1/4 pound or greater density will be considered as load bearing for pipe sizes up to and including 2-inches. Where insulation is not of sufficient strength to support the weight of the piping, a half section of high density fiberglass or foam inserts, shall be provided. Vapor barrier and finish shall be applied as required to match adjoining insulation. In addition, shields shall be furnished as specified above.

F. All disturbed piping insulation in existing areas shall be re-insulated with insulation type, density, and thickness as specified for new piping. Insulation damaged due to new work and demolition only shall be replaced unless otherwise noted.

G. On cold systems such as domestic cold water, rainleaders, vapor barrier performance is extremely important. All penetrations and seams of the ASJ and exposed ends of insulation must be sealed with vapor barrier coating. The ASJ must be protected with either a vapor barrier coating or a suitable vapor retarding outer jacket. Vapor seals at butt joints shall be applied at every fourth pipe section joint and at each fitting to provide isolation of water incursion. Vapor Barrier Coating: Foster 30-65; Childers CP-34 or Vimasco 749. Permeance shall be 0.03 perms or less at 45 mils dry at test by ASTM E96.

H. Fittings and valves shall be insulated with pre-formed fiberglass fittings, fabricated sections of Fiberglass pipe insulation, Fiberglass pipe and tank insulation, Fiberglass blanket insulation, or insulating cement. Thickness shall be equal to adjacent pipe insulation. Finish shall be with pre-formed PVC fitting covers or as otherwise specified on contract drawings. Where applicable, Victaulic PVC fitting valve and coupling covers shall be utilized. Victaulic PVC covers shall be installed with matching pipe insulation jacketing material, vinyl tape, solvent weld adhesive and appropriate fasteners.

1. Flanges, couplings and valve bonnets shall be covered with an oversized pipe insulation section sized to provide the same insulation thickness as on the main pipe section. An oversized insulation section shall be used to form a collar between the two insulation sections with low density blanket insulation being used to fill gaps. Jacketing shall match that used on straight pipe sections. Rough cut ends shall be coated with a suitable weather or vapor-resistant mastic as dictated by the system location and service. Finish valve installation with a Tyvac jacket with ends that secure to adjacent piping.

2. On hot systems where fittings are to be left exposed, insulation ends should be beveled away from bolts for easy access.

3. On cold systems, particular care must be given to vapor sealing the fitting cover or finish to the pipe insulation vapor barrier. All valve stems must be sealed with

caulking which allows free movement of the stem but provides a seal against moisture incursion. All gauge and thermometer penetrations and extensions shall be correctly sealed and insulated to prevent surface condensation.

I. All piping shall be supported in such a manner that neither the insulation or the vapor/weather barrier is compromised by the hanger or the effects of the hanger. In all cases, hanger spacing must be such that the circumferential joint may be made outside the hanger. On cold systems, vapor barrier must be continuous, including material covered by the hanger saddle.

1. Piping systems 3-inches (7.5cm) in diameter or less, insulated with Fiberglass insulation, may be supported by placing saddles of the proper length and spacing, as designated in Owens-Corning Pub. 1-IN-12534, under the insulation. Hangers saddles shall be minimum 16 gauge with a saddle arc of 120 degrees minimum.

2. For hot or cold piping systems larger than 3-inches (7.5 cm) in diameter, operating at temperatures less than +200 degrees F (93 degrees C) and insulated with fiber glass, high density inserts such as foam with sufficient compressive strength shall be used to support the weight of the piping system. At temperatures exceeding +_200 degrees F (93 degrees C), Owens-Corning Pink or IIG, Calcium Silicate pipe insulation shall be used for high density inserts.

3. Owens-Corning Pink Calcium Silicate pipe insulation may be used to support the entire weight of the piping system provided the hanger saddle is designed so the maximum compressive load does not exceed 100 psi (7kg/cm).

4. Where pipe shoes and roller supports are required, insulation shall be inserted in the pipe shoe to minimize pipe heat loss. Where possible, the pipe shoe shall be sized to be flush with the outer pipe insulation diameter.

5. Thermal expansion and contraction of the piping and insulation system shall generally be taken care of by utilizing double layers of insulation and staggering both longitudinal and circumferential joints. Where long runs are encountered, expansion joints may be required where single layers of insulation are being used and should be so noted on the contract drawings.

6. On vertical runs, insulation support rings shall be used.

2.3. PIPING INSULATION THICKNESSES SCHEDULE

A. All piping shall be insulated with pipe insulation of the thicknesses indicted below:

PIPING INSULATION THICKNESS SCHEDULE SERVICES	THICKNESS
All Horizontal Roof Drain Piping Including Sumps	1-inch thickness
All Drain Piping from Cooling Coils/Evaporators	½-inch thickness

PIPING INSULATION THICKNESS SCHEDULE SERVICES	THICKNESS
All Domestic Cold and Hot Water Piping	1-inch thickness
Existing Floor Drain or Stormwater Piping That Collects A/C Condensate	1-inch thickness

2.4. EQUIPMENT INSULATION MATERIALS AND THICKNESSES

A. The following equipment shall be insulated with Fiberglass Rigid Board Insulation or Foam Plastic Insulation:

1. Backflow Preventer Valve Bodies.

2. Make-up Water Valve Bodies

B. Insulation for cold surfaces shall be 1-1/2-inch thickness, 6 lb. density, 705 FRK with a "K" rating of .23 at 75 degrees F mean temperature. Insulation for hot surfaces except as otherwise noted shall be 1-1/2-inch thickness, 6 lb. density, 705 with a "K" rating of .23 at 75 degrees F mean temperature. Insulation shall be applied with staggered joints firmly butted and joined. The insulation shall be held in place by steel bands. Bands shall be 1-inch by 25 gauge galvanized steel spaced on not over 12-inch centers. All joints and voids shall be filled with Owens-Corning #110 cement, well troweled into openings. For 705 FRK insulation, all joints and voids shall be FRK taped and vapor sealed. There shall be applied over the insulation surface 1-inch galvanized wire netting laced together at all edges and wired to the steel bands with 16 gauge soft annealed wire. Over this shall be applied 2-inch thick layer of Owens-Corning #110 cement applied in two layers. Install metal corner beads at all corners and edges in order to provide a permanent installation. Onto the dry cement surface apply a brush coat of Foster Sealfas 30-36 or Childers CP-50AMV1 lagging adhesive at the rate of 60-70 square feet per gallon. Embed into wet coating a layer of 8 ounce canvas smoothed out to avoid wrinkles and lap all seams a minimum of 2-inches. Apply a second brush coat of Sealfas 30-36 or Childers CP-50 AMV1 lagging adhesive to the entire surface at the rate of 60-70 square feet per gallon. Cleanouts, nameplates, and manholes shall not be insulated, and the insulation on surrounding surfaces shall be neatly beveled off at such openings.

C. Mechanical fasteners shall be utilized to hold insulation to surface with bands as required to hold the curvature of the material.

D. Support rings shall be provided to support the top head insulation where required.

E. Insulation types materials shall be suitable for temperatures encountered by each item of equipment.

2.5. ACCESSORY MATERIALS

A. Accessory materials installed as part of insulation work under this section shall include, but not be limited to:

1. Closure Materials - Butt strips, bands, wires, staples, mastics, adhesives; pressure-sensitive tapes.

2. Field-applied jacketing materials - sheet metal, plastic, canvas, fiber glass cloth, insulating cement; PVC fitting covers, PVC jacketing.

3. Support Materials - Hanger straps, hanger rods, saddles.

4. Fasteners, weld pins/studs, speed clips, insulation washers.

5. Metal mesh or expanded metal lagging.

B. All accessory materials shall be installed in accordance with project drawings and specifications, manufacturer's instructions, and/or in conformance with the current edition of the Midwest Insulation Contractors Association (MICA) "Commercial & Industrial Insulation Standards."

2.6. FIELD-APPLIED JACKET

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Johns Manville; Zeston.
   b. P.I.C. Plastics, Inc.; FG Series.
   c. Proto PVC Corporation; LoSmoke.
   d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer. VOC content not to exceed 250 g/L.

3. Color: High Gloss White

4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

PART 3. EXECUTION

3.1. WORKMANSHIP

A. The Contractor shall take special care to prevent soiling equipment below or adjacent to areas being insulated. He shall be completely responsible for removing insulation cement splashes and smears and all surfaces that he mars or otherwise soils or defaces, and he will be totally responsible for restoring these damaged surfaces to their like-new condition when delivered to the site.

3.2. SITE INSPECTION

A. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.

B. Verify that all materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.

C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all materials and accessories to be installed on the project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.3. PREPARATION

A. Ensure that all pipe and equipment surfaces over which insulation is to be installed are clean and dry.

B. Ensure that insulation is clean, dry, and in good mechanical condition with all factory-applied vapor or weather barriers intact and undamaged. Wet, dirty, or damaged insulation shall not be acceptable for installation.

C. Ensure that pressure testing of piping systems has been completed prior to installing insulation.

3.4. INSTALLATION

A. Piping Systems

1. General:

a. Install all insulation materials and accessories in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
b. Install insulation on piping subsequent to installation of heat tracing, painting, testing, and acceptance tests.
c. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other. Butt insulation joints firmly to ensure complete, tight fit over all piping surfaces.
d. Maintain the integrity of factory-applied vapor barrier jacketing on all pipe insulation, protecting it against puncture, tear or other damage. Seal

all tears, punctures and other penetrations of the pipe insulation vapor barrier coating.

e. On exposed piping, locate insulation and cover seams in least visible location.

2. Fittings: Cover valves, fittings, unions, flanges, strainers, flexible connections, expansion joints, pump bodies, strainers, blowdowns, backflow preventers, autoflow valves and similar items in each piping system using one of the following:

a. Mitered sections of insulation equivalent in thickness and composition to that installed on straight pipe runs.

b. Insulation cement equal in thickness to the adjoining insulation.

c. PVC fitting covers insulated with material equal in thickness and composition to adjoining insulation.

3. Penetrations: Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise specified.

4. Joints:

a. Butt pipe insulation against hanger inserts. For hot pipes, apply 3-inch (7.5cm) wide vapor barrier tape or bank over butt joints. For cold piping, apply wet coat of vapor barrier lap cement on butt joints, and seal joints with 3-inch (7.5cm) wide vapor barrier tape or band.

b. All pipe insulation ends shall be tapered and sealed, regardless of service.

B. Equipment Insulation:

1. General:

a. Install insulation in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.

b. Install insulation on equipment after installation of heat tracing, painting, testing, and acceptance tests.

c. Install insulation materials with smooth, even surfaces. Rework poorly fitted joints. Do not use joint sealer or mastic as filler for joint gaps and excessive voids resulting from poor workmanship. Apply insulation using staggered joint method for both single and double layer installation, applying each layer of insulation separately.

d. Coat insulated surfaces where specified on contract drawings with layer of insulating cement, troweled in a workmanlike manner, leaving a smooth and continuous surface. Fill in seams, broken edges, and depressions. Cover over wire mesh and joints with cement sufficiently thick to remove surface irregularities.

e. Maintain the integrity of factory-applied vapor barrier jacketing on all insulation, protecting it against puncture, tears or other damage. Seal all tears, punctures and other penetrations of equipment insulation facing.

f. Where specification calls for field-applied all-service vapor barrier jacketing, it shall be neatly fitted and tightly secured. Lap seams 2-inches (5cm) (min.). Seal all joints with adhesive. Tape with 3-inches (7.5cm) matching pressure-sensitive tape or 3-inch (7.5cm) glass fabric and vapor barrier coating.

g. On exposed equipment, locate insulation and cover seams in least visible location.

2. Removable Insulation: Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance, such as vessel covers, fasteners, flanges, frames accessories, manholes, handholes, cleanouts ASME stamp, and manufacturer nameplates.

3. Areas Left Uninsulated: Items such as manholes, handholes, clean-outs, ASME stamp, and manufacturers' nameplates should be left uninsulated unless omitting insulation would cause a condensation problem. When such is the case, provide removable insulation and appropriate tagging to identify the presence of these items. Provide neatly beveled edges at interruptions of insulation.

4. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of weather barrier mastic protective finish or jacketing as recommended by the jacketing manufacturer.

3.5. FIELD QUALITY ASSURANCE

A. Upon completion of all insulation work covered by this specification, visually inspect the work and verify that it has been correctly installed. This may be done while work is in progress, to assure compliance with requirements herein to cover and protect insulation materials during installation.

3.6. PROTECTION

A. Replace damaged insulation which cannot be satisfactorily repaired, including insulation with vapor barrier damage and moisture-saturated insulation.

B. The insulation contractor shall advise the general and/or the mechanical contractor as to requirements for protection of the insulation work during the remainder of the construction period, to avoid damage and deterioration of the finished insulation work.

3.7. SAFETY PRECAUTIONS

A. Insulation contractor's employees shall be properly protected during installation of all insulation. Protection shall include proper attire when handling and applying insulation materials, and shall include (but not be limited to) disposable dust respirators, gloves, hard hats, and eye protection.

B. The insulation contractor shall conduct all job site operations in compliance with applicable provisions of the Occupational Safety and Health Act, as well as with all state and/or local safety and health codes and regulations that may apply to the work.

3.8. INSULATION COVERING

A. Unless otherwise noted, all exposed equipment insulation shall have a field applied PVC jacket cover neatly cut and pasted over equipment insulation. PVC shall be high gloss white and shall be 20 mils thick. Exposed areas include, but are not limited to, all mechanical equipment rooms/fan rooms, penthouses, boiler rooms, janitor's closets, and piping and ductwork exposed in an occupied space.

B. Unless otherwise noted, all exposed pipe insulation required to be insulated shall be jacketed with a PVC Jacketing with fitting covers. PVC jacket shall be color fade resistant, white high gloss, U.S.D.A. authorized as manufactured by Proto Corporation or approved equal. PVC jacketing shall be high impact, ultraviolet resistant PVC. Minimum thickness shall be 20 mils, roll stock ready for shop or field cutting and forming.

C. Where PVC jackets are indicated, install with 1 inch overlap at longitudinal seams and end joints, for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

END OF SECTION

DIVISION 22 SECTION 224000
PLUMBING FIXTURES

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SECTION 224000 – PLUMBING FIXTURES

PART 1. GENERAL

1.1. GENERAL

A. For General Mechanical Requirements, see Division 22 Section, Common Work Results for Plumbing & Division 01, General Requirements.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specifications apply to this Section.

C. All exposed bolts, screws, etc., shall be vandal proof.

D. All plumbing materials, equipment and fixtures shall be new and of best grade, free of defects and complete with all required appurtenances and accessories.

E. Piping and insulation are specified under other sections.

F. Use "Sani-Sett" setting compound for fixtures.

G. Provide all materials, equipment and perform all labor required to install plumbing system complete as specified, as drawings indicated and as required by the State of Delaware, National Standard Plumbing Code and International Plumbing Code, Sussex County local code, and all other authorities have jurisdiction. Comply with the current lead free laws per the requirements of the state in which the project is being constructed.

H. Provide stops for all plumbing fixtures and equipment. Stops are to be accessible.

I. Provide P traps on fixtures for which traps have not been included as part of furnished equipment. Trap size to equal size of fixture tailpiece.

J. All exposed metal parts of fixtures shall be chromium plated brass. Piping, fittings, valves, traps and accessories including escutcheons for piping shall be chromium plated where exposed in finished areas.

K. All faucets for residential kitchen sinks, lavatories, shall be listed for drinking-water or commercial applications by the National Sanitation Foundation (NSF) or Underwriters Laboratory (U.L.). All required faucets shall comply with NSF Standard 61 for both lead content and leaching rate. Submit documentation indicating compliance for all required faucets.

L. Ensure products and installation of specified products are in conformance with recommendations and requirements of the following organizations:

1. American Gas Association (AGA).
2. National Sanitation Foundation (NSF).
3. American Society of Mechanical Engineers (ASME).
4. National Electrical Manufacturers' Association (NEMA).
5. Underwriters Laboratories (UL).

1.2. REFERENCES

A. ASME A112.18.1 - Finished and Rough Brass Plumbing Fixture Fittings.

B. ANSI/ASME A112.19.3 - Stainless Steel Plumbing Fixtures (Designed for Residential Use).

C. ANSI/NFPA 70 - National Electrical Code.

D. IBC - International Building Code

1.3. DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Division 01, Section General Requirements.

B. Accept fixtures on site in factory packaging. Inspect for damage.

C. Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

1.4. FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on shop drawings and per the manufacturer.

B. Confirm that millwork is constructed with adequate provisions for the installation of counter top lavatories and sinks.

PART 2. PRODUCTS

2.1. COUNTER SINKS

A. P-1 Counter Sink – Single Bowl (Handicapped)

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

   a. Elkay Manufacturing Co. – Lustertone LRAD Series
   b. Just Manufacturing Co.

2. Fixture:

   a. Type: Single Bowl, Counter Mounted, Self-Rimming.
   b. Overall Dimensions (L x W x D) inches:
      22 x 19-1/2 x 5-1/2
   c. Material: 302 Stainless Steel, 18 gauge, fully coated underside.

3. Faucet:

   a. Standard: ASME A112.18/CSA B125.1
   b. General: Include hot and cold water indicators; coordinate faucet inlets with supplies and fixture hold punchings; coordinate outlet with spout and

sink receptor.

c. Model: Chicago Faucet Model 2300-8ABCP
d. Body Type: Centerset, 8” fixed centers
e. Finish: Chrome Plated
f. Maximum Flow Rate: 2.2 gpm.
g. Handle(s): 3-5/8” Lever, ADA Compliant
h. Mounting Type: Deck, concealed.
i. Spout Type: 10” swing spout
j. Spout Outlet: E3 Aerator

4. Strainer: Jomar Model SS-306 Snap-N-Loc, or Just J-35 basket strainer and brass locknut and tailnut. Deep cup body and basket shall be 300 series stainless steel. Provide 1 ½-inch tailpiece.

5. P-Trap: Cast Brass 1 ½ -inch “P" trap.

6. Stops: Chicago Faucets Model 1005ABCP valve stops with riser supply, 3/8-inch loose key cap and removable tee handle, wall flange, chrome plated finish.

2.2. REFRIGERATORS

A. P-2

1. Refrigerator: Refrigerator provided in another Division of Specifications. Provide rough-in and final connection of ice maker line from adjacent sink. Provide shut-off valve in cold water line. Provide sufficient copper tubing to allow movement of refrigerator for cleaning.

2.3. HANDICAPPED LAVATORY/SINK INSULATION

A. All handicapped lavatories and sinks shall be provided with under counter pipe and trim insulation.

B. Insulation shall be fully molded "P" trap and angle valve insulated Hand-I-Lav Guard, Truebro, and Pro-Extreme Model #101, 102, and 105 to suit.

C. Insulation to meet ADA #4 19.4, ANSI A117.1, ASTM C1822, Type III and International Plumbing Code.

D. Self-extinguishing ASTM D635 burn characteristics, thermal conductivity ASTM C177 K-Value ' 1.17.

E. Insulation thickness to be minimum 2 inch.

F. Where lav. Guards are provided insulation may be omitted.

2.4. FIXTURE STOPS/SUPPLIES

A. For all lavatories/sinks stops and supplies shall be Chicago Faucets No. 1017-CR43829, Angle Stop Fitting with Supply Tube and Loose Key, Chrome plated solid brass construction. 2-1/4” Metal tee handles with tapered square. Slow compression check

cartridge that shall open and close 360º for fine adjustment, valves shall close with water pressure, furnish with square tapered stem. ½" NPT female thread inlet 3/8" O.D. female compression outlet. Slip wall flange. 3/8" O.D. x 12" bullnose flexible supply riser. ECAST construction with less than 0.25% lead content by weighted average. This product shall be tested and certified to industry standards: ASME A112.18.1/CSA B125.1, Certified to NSF/ANSI 61, Section 9 by CSA, California Health and Safety Code 116875 (AB1953-2006), Vermont Bill S. 152, and NSF/ANSI 372 Low Lead Content.

PART 3. EXECUTION

3.1. GENERAL INSTALLATION REQUIREMENTS

A. Install all equipment in accordance with manufacturer's instructions.

B. Protect chromium plated trim from corrosive solutions used to clean tile work.

C. Provide white, silicone caulking where fixtures come in contact with walls and floors. Sealant shall be mildew resistant type in accordance with ANSI A-136.1.

D. Install components plumb and level.

E. Install and secure fixtures in place with wall supports, wall carriers and bolts.

F. Coordinate with plumbing piping and related fuel piping, gas venting and electrical work to achieve a complete operating system.

G. Slopes and invert elevations of all interior piping shall be established before any piping is installed in order that proper slopes will be maintained. All piping shall be located and determined where to be run to avoid conflict with other trades.

H. Unless otherwise noted, all plumbing piping shall be routed as high as possible between bottom of roof joists and above ceiling to allow proper installation of ductwork, fire protection piping, conduits, etc.

I. Coordinate with Architectural Drawings before roughing in plumbing.

J. Make proper HW, CW, re-cir., waste, and vent connections to all fixtures and equipment even though all branch main, elbows and connections are not shown.

K. Unless otherwise noted, sanitary waste piping shown is below floor and all other piping is overhead, above ceiling. Domestic hot, cold and re-circ. water piping shall be installed between ceiling and attic insulation.

L. Unless otherwise noted, horizontal sanitary piping shall be pitched 1 percent.

M. All piping and installation shall comply with all local and national plumbing codes. Test piping as required by plumbing code and authority having jurisdiction.

3.2. PLUMBING SPECIALTY INSTALLATION REQUIREMENTS

A. General: Install plumbing specialty components, connections, and devices according to

manufacturer's written instructions.

B. Secure supplies to supports or substrate.

C. Install individual stop valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve as appropriate is not indicated.

D. Install water-supply stop valves in accessible locations.

E. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.3. TESTING

A. After plumbing fixtures are connected, all piping and fixtures shall be tested for operation and a smoke or peppermint test shall be made on all soil, waste and vent piping.

B. After the building has been occupied and the various equipment is in actual use, the Contractor shall make an operating test of all equipment at a time directed by the Engineer to determine that all contract requirements are met.

3.4. CLEANING AND STERILIZATION

A. After final testing for leaks, all potable water lines shall be thoroughly flushed, by plumbing contractor, to remove foreign material. Before placing the systems in service, sterilize the new water lines in accordance with local health department codes and at a minimum according to the following procedure:

B. Through a 3/4-inch hose connection in each branch main and building main, pump in sufficient sodium hypochlorite to produce a free available chlorine residual of not less than 200 ppm. Plumbing Contractor shall provide plumbing connections and power for pumping chlorine into system.

C. Proceed upstream from the point of chlorine application opening all faucets and taps until chlorine is detected. Close faucets and taps when chlorine is evident.

D. When chlorinated water has been brought to every faucet and tap with a minimum concentration of 200 ppm chlorine, retain this water in the system for at least three (3) hours.

E. CAUTION: Over-concentration of chlorine and more than three (3) hours of retention may result in damage to piping system. It is not necessary to retain chlorine in any system for twenty-four hours to achieve sterilization. AWWA states that 200 ppm chlorine for three hours is sufficient.

F. At the end of the retention period, no less than 100 ppm of chlorine shall be present at the extreme end of the system.

G. Proceed to open all faucets and taps and thoroughly flush all new lines until the chlorine

residual in the water is less than 1.0 ppm.

H. Obtain representative water sample from the system for analysis by an independent and recognized bacteriological laboratory.

I. If the sample tested for coliform organisms is negative, a letter and laboratory report shall be submitted by the service organization to the Contractor, certifying successful completion of the sterilization. Additionally, this report shall be forwarded to the Owner as well as be included in the O&M Manual.

J. If any samples tested indicate the presence of coliform organisms, the entire sterilization procedure shall be repeated.

K. Take precautions to avoid use of plumbing fixtures and domestic water systems during sterilization period. Place signs on all plumbing fixtures and outlets during sterilization period.

3.5. EXAMINATION

A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.

3.6. PREPARATION

A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.7. INTERFACE WITH OTHER PRODUCTS

A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.8. ADJUSTING

A. Adjust stops and valves for intended water flow rate to fixtures without splashing, noise, or overflow.

3.9. CLEANING

A. At completion, clean plumbing fixtures and equipment. Polish all chrome plated faucets, accessories, equipment, and piping.

END OF SECTION

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PLUMBING EQIPMENT
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SECTION 224005 - PLUMBING EQUIPMENT

PART 1. GENERAL

1.1. GENERAL

A. For General Mechanical Requirements, see Division 22 Section, Common Work Results for Plumbing & Division 01, General Requirements.

B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specifications apply to this Section.

C. All exposed bolts, screws, etc., shall be vandal proof.

D. All plumbing materials and equipment shall be new and of best grade, free of defects and complete with all required appurtenances and accessories.

E. Piping and insulation are specified under other sections.

F. Provide all materials, equipment and perform all labor required to install plumbing system complete as specified, as drawings indicated and as required by the State of Delaware, National Standard Plumbing Code , International Plumbing Code, City of Georgetown Code, the local code, and all other authorities have jurisdiction.

G. Provide stops for all plumbing equipment. Stops are to be accessible.

H. Provide pumps with manufacturer's name, model number, and rating/capacity identified.

I. Ensure products and installation of specified products are in conformance with recommendations and requirements of the following organizations:

1. National Sanitation Foundation (NSF).

2. American Society of Mechanical Engineers (ASME).

3. National Board of Boiler and Pressure Vessel Inspectors (NBBPVI).

4. National Electrical Manufacturers' Association (NEMA).

5. Underwriters Laboratories (UL).

J. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitations, are non-overloading in parallel or individual operation, operate within 25 percent of midpoint of published maximum efficiency curve.

1.2. REFERENCES

A. ANSI/ASSE 1011 - Hose Connection Vacuum Breakers.

B. ANSI/ASSE 1013 - Backflow Preventers, Reduced Pressure Principle.

C. ANSI/ASE 1019 - Wall Hydrants, Frost Proof Automatic Draining Anti-Backflow Types.

D. ANSI A112.26.1 - Water Hammer Arrestors.

E. AWWA C506 - Backflow Prevention Devices - Reduced Pressure Principle and Double Check Valve Types.

F. PDI WH-201 Water Hammer Arresters.

G. ANSI/ASHRAE 90A - Energy Conservation in New Building Design.

H. ASME Section VIIID - Pressure Vessels; Boiler and Pressure Vessel Codes.

I. ANSI/NFPA 54 - National Fuel Gas Code.

J. ANSI/NFPA 70 - National Electrical Code.

K. ANSI/NEMA 250 - Enclosure for Electrical Equipment (1000 Volts Maximum).

L. IBC - International Building Code

1.3. DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of General Requirements.

B. Accept equipment on site in factory packaging. Inspect for damage.

C. Protect installed equipment from damage by securing areas and by leaving factory packaging in place to protect equipment and prevent use.

1.4. FIELD MEASUREMENTS

A. Verify that field measurements are as indicated on shop drawings and per the manufacturer.

1.5. ALTERNATES

A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. CLEANOUTS

A. Provide cleanouts in sanitary and storm drainage systems at ends of runs, at changes in direction, near the base of stacks, every 50 feet in horizontal runs, of 4-inch diameter or less, every 100 feet in horizontal runs over 4-inches, and where indicated.

B. Cleanouts shall be full size of pipe up to 4-inches and shall be 4-inches for larger sizes. Where installed in finished floors inserts shall match adjacent floor construction.

C. Materials and Approved Manufacturers: Josam, J.R. Smith, Zurn, Wade or Ancon, Mifab, Watts, equal to Josam numbers given below:

1.	Concealed Piping	C.I. Pipe
2.	Unfinished Areas	
3.	Floors	57000-Z-CI
4.	Walls	58600-PLG
5.	Finished Areas Floors	
6.	Terrazzo	56040-13
7.	Composition Tile	57000-X-12
8.	Ceramic Tile	57000-X
9.	Carpet	56070-14
10.	Carpet insert to match adjacent carpet in type, color and grade.	
11.	Finished Areas Walls	
12.	Plaster/Dry Wall	58640-COT
13.	Tile/CMU	58600-COT

2.2. SHOCK ABSORBERS

A. Provide shock absorbers equal to Josam Shokstops at all fast closing valves, at the top of all cold water risers, at each flush valve or battery of flush valves, and where indicated. Sizes and locations shall be in accordance with PDI Standard WH 201.

B. Shock absorbers shall conform to ANSI A112.26.1, precharged suitable for operation in temperature range -100 to 300 degrees F and maximum 250 psig working pressure.

C. Approved Manufacturers: Josam, Wade, Zurn, J.R. Smith, Sioux Chief, Watts, or approved equal.

2.3. VACUUM BREAKERS

A. Provide vacuum breakers on water connections to fixtures and equipment where minimum air gaps required by Plumbing Code are not possible and on hose bibbs and other outlets to which hoses can be attached.

B. Vacuum breakers not subject to back pressure, Watts No. 288A; vacuum breakers subject to back pressure, Watts Series 9D or for hose threads, Watts Series 8A.

C. Hose connection backflow preventers shall be ASSE 1052, suitable for at least 5 gpm flow and applications with up to 10 foot head back pressure. Include two (2) check valves, intermediate atmospheric vent, and non-removable, ASME B1.20.7 garden-hose thread on outlet.

D. Hose connection vacuum breakers shall be ASSE 1011, nickel plated, with nonremovable and manual drain features, and ASME B1.20.7 garden-hose threads on outlet. Units attached to rough-bronze finish hose connections may be rough bronze.

E. Approved manufacturers: Watts, Beeco, B&K Industries, Zurn, Sparco, Conbraco or approved equal.

2.4. HOSE BIBBS

A. Chicago Faucet No. 952 or approved equal hose and faucet. Bronze or brass with integral mounting flange, replaceable hexagonal disc, hose threaded spout, polished chrome plated where exposed in finished areas, with hand wheel and removable key, integral vacuum breaker in conformance with ANSI/ASSE 1011.

B. Hose bibbs in finished areas shall be polished chrome finish.

C. Approved Manufacturers: Chicago Faucet, American Standard, Crane, T&S Brass, Watts.

2.5. BACKFLOW PREVENTER (REDUCED PRESSURE PRINCIPAL TYPE)

A. Furnish and install reduced pressure principal backflow preventers at all cold water make-up connections to HVAC water systems, and where indicated on contract drawings.

B. Backflow preventers shall be of bronze body construction, inlet and discharge OS&Y gate valves, stainless steel check and relief valve seats, stainless steel relief valve shafts and flange bolts. Ball valve test cocks shall be bronze body.

C. Pressure ratings shall be up to 175 psi and temperature ratings shall be up to 210 degrees F continuous.

D. Install unit per local code requirements and authorities having jurisdiction. Unless otherwise noted, install backflow preventers between 12 inches and 60 inches above finished floor.

E. Units shall be approved by ASSE 1013, UPC, UL, and shall be No. 909 with air gap fitting and inlet/outlet gate valves as manufactured by Watts Regulator, Conbraco, Wilkens, or as approved equal. Pipe discharge to nearest floor drain/floor sink. Provide minimum 18-inch clearance for servicing and testing.

F. Pipe discharge of backflow preventer full size to closest floor drain utilizing type "L" copper.

G. Furnish test kit for field testing units. Watts Model TK-9A Analog Differential Gauge or approved equal.

PART 3. EXECUTION

3.1. GENERAL INSTALLATION REQUIREMENTS

A. Install all equipment in accordance with manufacturer's instructions.

B. Install components plumb and level.

C. Cleanouts in vertical pipes shall be installed in tees near floor. Cleanouts in horizontal pipes shall be installed with wyes on long sweep quarter beds. Cleanouts punching water proofing membranes shall have flashing clamps. Cleanout access covers in dry wall or gypsum board shall be painted to match walls.

D. Unless otherwise noted, drains are to be installed at the low point of floors. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

E. Extend cleanouts to finish floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.

F. All plumbing vents within a 10'-0" radius of exhaust vents shall be extended to a height of 3'-0" above exhaust vent crown.

G. All plumbing vents within a 10'-0" radius of any rooftop unit or intake louver shall be extended to a height of 3'-0" above fresh air intake.

H. Slopes and invert elevations of all interior piping shall be established before any piping is installed in order that proper slopes will be maintained. All piping shall be located and determined where to be run to avoid conflict with other trades.

I. Unless otherwise noted, all plumbing piping shall be routed as high as possible between bottom of roof joists and above ceiling to allow proper installation of ductwork, fire protection piping, conduits, etc.

J. Coordinate with Architectural Drawings and case work drawings before roughing in plumbing.

K. All openings in ceilings and plenum walls for plumbing shall be sealed air tight and protected with fire stop.

L. See site plan for extent of all piping leaving and entering building.

M. See domestic water riser diagrams for location of valves, shock absorbers, etc.

N. Make proper HW, CW, re-circ., waste, and vent connections to all equipment even though all branch main, elbows and connections are not shown.

O. Cleanouts shall be provided near base of each vertical waste or solid stack. Provide 18" minimum clearance for access.

P. Unless otherwise noted, sanitary waste piping shown is below floor and all other piping is overhead, above ceiling. Domestic hot, cold and re-circ. water piping shall be installed between ceiling and roof insulation.

Q. Unless otherwise noted, horizontal sanitary piping pitches shall be 1 percent.

R. Unless otherwise noted, all domestic water piping shall be installed on heated side of ceiling insulation.

S. All piping and installation shall comply with all local and national plumbing codes. Test piping as required by plumbing code and authority having jurisdiction.

T. For sizes of all domestic water piping see plumbing fixture schedule and drawings.

U. For sizes of all sanitary and vent piping see plumbing fixture schedule and drawings.

3.2. PLUMBING SPECIALTY INSTALLATION REQUIREMENTS

A. General: Install plumbing specialty components, connections, and devices according to manufacturer's written instructions.

B. Install backflow preventers of type, size, and capacity indicated, at each water supply connection to mechanical equipment and systems, and to other equipment and water systems as indicated. Comply with authorities having jurisdiction. Locate backflow preventers in same room as connected equipment. Install air gap fitting on units with atmospheric vent connection and pipe relief outlet drain to nearest floor drain. Do not install bypass around backflow preventer. Label all piping downstream of backflow preventers as "non-potable" water.

C. Field test all backflow preventers and submit test reports to Engineer. Furnish test kits as required for field testing.

D. Install pressure regulators with inlet and outlet shutoff valves and balance valve bypass. Install pressure gages on inlet and outlet.

E. Install strainers on supply side of each control valve, pressure regulator, and solenoid valve, and where indicated.

F. Install hose bibbs with integral or field installed vacuum breaker.

G. Install wall hydrants with integral or field installed vacuum breaker.

H. All hose bibs shall be mounted 18" above finished floor, unless otherwise specified.

I. Fasten recessed, wall mounting plumbing specialties to reinforcement built into walls.

J. Secure supplies to supports or substrate.

K. Install individual stop valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve as appropriate is not indicated.

L. Install water supply stop valves in accessible locations.

M. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep pattern escutcheons if required to conceal protruding pipe fittings.

N. Include wood blocking reinforcement for recessed and wall mounting plumbing specialties.

O. Install ball valves at all shock absorbers to allow removal for service/replacement.

3.3. TESTING

A. After plumbing fixtures are connected, all piping and fixtures shall be tested for operation and a smoke or peppermint test shall be made on all soil, waste and vent piping.

B. After the building has been occupied and the various equipment is in actual use, the Contractor shall make an operating test of all equipment at a time directed by the Engineer to determine that all contract requirements are met.

3.4. CLEANING AND STERILIZATION

A. After final testing for leaks, all potable water lines shall be thoroughly flushed, by plumbing contractor, to remove foreign material. Before placing the systems in service, sterilize the new water lines in accordance with local health department codes and at a minimum according to the following procedure:

1. Through a 3/4-inch hose connection in each branch main and building main, pump in sufficient sodium hypochlorite to produce a free available chlorine residual of not less than 200 ppm. Plumbing Contractor shall provide plumbing connections and power for pumping chlorine into system.

2. Proceed upstream from the point of chlorine application opening all faucets and taps until chlorine is detected. Close faucets and taps when chlorine is evident.

3. When chlorinated water has been brought to every faucet and tap with a minimum concentration of 200 ppm chlorine, retain this water in the system for at least three (3) hours.

4. CAUTION: Over-concentration of chlorine and more than three (3) hours of retention may result in damage to piping system. It is not necessary to retain chlorine in any system for twenty-four hours to achieve sterilization. AWWA states that 200 ppm chlorine for three hours is sufficient.

5. At the end of the retention period, no less than 100 ppm of chlorine shall be present at the extreme end of the system.

6. Proceed to open all faucets and taps and thoroughly flush all new lines until the chlorine residual in the water is less than 1.0 ppm.

7. Obtain representative water sample from the system for analysis by an independent and recognized bacteriological laboratory.

8. If the sample tested for coliform organisms is negative, a letter and laboratory report shall be submitted by the service organization to the Contractor, certifying successful completion of the sterilization. Additionally, this report shall be forwarded to the Owner as well as be included in the O&M Manual.

9. If any samples tested indicate the presence of coliform organisms, the entire sterilization procedure shall be repeated.

10. Take precautions to avoid use of plumbing fixtures and domestic water systems

during sterilization period. Place signs on all plumbing fixtures and outlets during sterilization period.

3.5. EXAMINATION

A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.

3.6. PREPARATION

A. Confirm rough-in location and size of fixtures and openings prior to commencing work.

B. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.7. INTERFACE WITH OTHER PRODUCTS

A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.8. CLEANING

A. At completion, clean plumbing equipment.

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SECTION 230500 COMMON WORK RESULTS FOR HVAC

PART 1. GENERAL

1.1. SUMMARY

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

B. Provide all labor, materials, equipment, and services necessary for and incidental to the complete installation and operation of all mechanical work.

C. Unless otherwise specified, all submissions shall be made to, and acceptances and approvals made by the Architect and the Engineer.

D. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange piping, ductwork, equipment, and other work generally as shown on the contract drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawings for approval in accordance with Submittals specified below. The right is reserved to make reasonable changes in location of equipment, piping, and ductwork, up to the time of rough-in or fabrication.

E. Conform to the requirements of all rules, regulations and codes of local, state and federal authorities having jurisdiction.

F. Coordinate the work under Division 23 with the work of all other construction trades.

G. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the contract documents.

1.2. PERMITS AND FEES

A. Obtain all permits and pay taxes, fees and other costs in connection with the work. File necessary plans, prepare documents, give proper notices and obtain necessary approvals. Deliver inspection and approval certificates to Owner prior to final acceptance of the work.

B. Permits and fees shall comply with the Division 01, General Requirements of the specification.

1.3. EXAMINATION OF SITE

A. Examine the site, determine all conditions and circumstances under which the work must be done, and make all necessary allowances for same. No additional cost to the Owner will be permitted for contractors' failure to do so.

B. Examine and verify specific conditions described in individual specifications sections.

C. Verify that utility services are available, of the correct characteristics, and in the correct locations.

1.4. CONTRACTOR QUALIFICATION

A. Any Contractor or Subcontractor performing work under Division 23 shall be fully qualified and acceptable to the Architect/Engineer and Owner. Submit the following evidence when requested:

1. A list of not less than five comparable projects which the Contractor completed.

2. Letter of reference from not less than three registered professional engineers, general contractors or building owners.

3. Local and/or State License, where required.

4. Membership in trade or professional organizations where required.

B. A Contractor is any individual, partnership, or corporation, performing work by contract or subcontract on this project.

C. Acceptance of a Contractor or Subcontractor will not relieve the Contractor or subcontractor of any contractual requirements or his responsibility to supervise and coordinate the work, of various trades.

1.5. MATERIALS AND EQUIPMENT

A. Materials and equipment installed as a permanent part of the project shall be new, unless otherwise indicated or specified, and of the specified type and quality. Existing items of equipment are being relocated under another Division of these specifications. The Contractor shall be responsible for connecting all utilities as shown on the drawings, to equipment identified as existing.

B. Where material or equipment is identified by proprietary name, model number and/or manufacturer, furnish named item, or its equal, subject to approval by Engineer. Substituted items shall be equal or better in quality and performance and must be suitable for available space, required arrangement, and application. Submit all data necessary to determine suitability of substituted items, for approval.

C. The suitability of named item only has been verified. Where more than one item is named, only the first named item has been verified as suitable. Substituted items, including items other than first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement and application. Contractor, by providing other than the first named manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation. Adjustments and modifications shall include but not be limited to electrical, structural, support, and architectural work.

D. Substitution will not be permitted for specified items of material or equipment where noted.

E. All items of equipment furnished shall have a service record of at least five (5) years.

1.6. FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA and ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of 25 and smoke developed of 50.

1.7. REFERENCED STANDARDS, CODES AND SPECIFICATIONS

A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.

B. AABC Associated Air Balance Council

C. ABMA - American Boiler Manufacturers Association

D. ACCA - Air Conditioning Contractors of America

E. ACGIH - American Conference of Governmental Industrial Hygienist

F. AIHA - American Industrial Hygiene Association

G. ASA - Acoustical Society of America

H. ADC Air Diffusion Council

I. AMCA Air Movement and Control Association

J. ANSI - American National Standards Institute

K. API - American Petroleum Institute

L. ARI - Air Conditioning and Refrigeration Institute

M. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers

N. ASME - American Society of Mechanical Engineers

O. ASPE - American Society of Plumbing Engineers

P. ASTM - American Society for Testing and Materials

Q. ASME CSD-1 - American Society of Mechanical Engineers Controls and Safety Devices for Automatically Fired Boilers

R. CS - Commercial Standard

S.	CSD		Control and Safety Devices
T.	DNREC	-	Delaware Department of Natural Resources
U.	FM	-	Factory Mutual
V.	IBC	-	International Building Code
W.	IBR	-	Institute of Boiler and Radiator Manufacturers
X.	IEEE	-	Institute of Electrical and Electronics Engineers
Y.	MSSP Industry	-	Manufacturers Standards Society of the Valve and Fittings
Z.	NEC	-	National Electrical Code
AA.	NEMA	-	National Electrical Manufacturers Association
BB.	NFPA	-	National Fire Protection Association
CC.	NSF	-	National Sanitation Foundation
DD.	SMACNA Association	-	Sheet Metal and Air Conditioning Contractors National
EE.	UL	-	Underwriters' Laboratories

FF. State of Delaware Fire Protection Regulations.

GG. All mechanical equipment and materials shall comply with the codes and standards listed in the latest edition of ASHRAE HVAC Applications Handbook, Chapter entitled Codes and Standards.

1.8. SUBMITTALS, REVIEW AND ACCEPTANCE

A. Equipment, materials, installation, workmanship and arrangement of work are subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Architect to be in best interest of Owner.

B. After acceptance of Material and Equipment List, submit six (6) copies or more as required under General Conditions of complete descriptive data for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, installation instructions, and any other information necessary to indicate complete compliance with Contract Documents. Edit submittal data specifically for application to this project.

C. Thoroughly review and stamp all submittals to indicate compliance with contract requirements prior to submission. Coordinate installation requirements and any electrical

requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.

D. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.

E. Identify submittals, indicating intended application, location and service of submitted items. Refer to specification sections or paragraphs and drawings where applicable. Clearly indicate exact type, model number, style, size and special features of proposed item. Submittals of a general nature will not be acceptable. For substituted items, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The contractor shall be responsible for corrective action and maintaining the specification requirements if differences have not been clearly indicated in the submittal.

F. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Call attention, in writing, to deviation from contract requirements.

G. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted. Use only final or corrected submittals and data prior to fabrication and/or installation.

H. For any submittal requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

I. For resubmissions, the Contractor must address in writing all of the Engineer's comments on the original submission to verify compliance.

1.9. SHOP DRAWINGS

A. Prepare and submit shop drawings for all mechanical equipment, specially fabricated items, modifications to standard items, specially designed systems where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on contract drawings.

B. Submit data and shop drawings including but not limited to the list below, in addition to provisions of the paragraph above. Identify all shop drawings by the name of the item and system and the applicable specification paragraph number and drawing number.

C. Every submittal including, but not limited to the list below, shall be forwarded with its own transmittal as a separate, distinct shop drawing. Grouping of items/systems that are not related shall be unacceptable.

D. Items and Systems

1. Access Doors/Panels including layouts and locations

2. Airflow Monitoring Stations
3. Air Cooled Condensing Units and Heat Pumps
4. Air Distribution Systems
5. Air Separators
6. Automatic Temperature Control Systems and Equipment
7. Backwater Valves
8. Boiler Accessories, Trim, Flow Switches
9. Branch Selector Boxes/Heat Recovery Boxes
10. Carbon Dioxide Sensors
11. Carbon Monoxide Detectors
12. Central Control and Monitoring Systems (CCMS) and Equipment
13. Condensate Pumps
14. Condensing Units
15. Coordinated Drawings
16. Drip Pans
17. Duct Materials
18. Energy Recovery Ventilators
19. Equipment Rails
20. Expansion Tanks and Accessories
21. Exterior Equipment/Duct Piping Supports
22. Exterior Pipe Roller Supports
23. Fans
24. Filters
25. Filter Housings
26. Fire Stopping - Methods and Materials
27. Fire Dampers

28. Flow Measuring Stations
29. Flowmeter and Primary Elements (Flow Fittings)
30. Grilles, Registers, Diffusers
31. Horizontal Hot Water Unit Heaters
32. Identification Systems
33. In-Line Circulators
34. Intake Hoods
35. Louvers
36. Material and Equipment Lists
37. Operations and Maintenance Manuals
38. Pipe Enclosures
39. Pipe Guides and Anchors
40. Pipe Materials Including Itemized Schedules
41. Preliminary Testing and Balancing Reports
42. Pressure Relief Valves
43. Pressure Regulating Valves
44. Pumps
45. Refnets
46. Roof Curbs
47. Relief Hoods
48. Screen shots of ATC System Graphics
49. Single Zone VAV Units
50. Split System Air Conditioning Units Ductless
51. Split System Heat Pumps, Ductless
52. Static Pressure Gauges
53. Strainers

54. Tempering Valves

55. Test Certificates

56. Thermal Insulation Materials Include Table Summaries

57. Thermometers and Gauges

58. Unit Heaters

59. Variable Frequency Drive Motor Bearing Protective Rings

60. Variable Refrigerant Volume Equipment

61. Variable Speed Drives

62. Vertical In-Line Pumps

63. Vertical Cabinet Unit Heaters

64. Vibration Isolation Materials

65. Water Treatment Services

66. Weatherproof Assembly Components

67. Wiring Diagrams, Flow Diagrams and Operating Instructions

E. Contractor, additionally, shall submit for review any other shop drawings as required by the Architect. No item shall be delivered to the site, or installed, until the Contractor has received a submittal from the Engineer marked Reviewed or Comments Noted. After the proposed materials have been reviewed, no substitution will be permitted except where approved by the Architect.

F. For any shop drawing requiring more than two (2) reviews by the Engineer (including those caused by a change in subcontractor or supplier) the Owner will withhold contractor's funds by a change order to the contract to cover the cost of additional reviews. One review is counted for each action including rejection or return of any reason.

1.10. SUPERVISION AND COORDINATION

A. Provide complete supervision, direction, scheduling, and coordination of all work under the Contract, including that of subcontractors.

B. Coordinate rough-in of all work and installation of sleeves, anchors, and supports for piping, ductwork, equipment, and other work performed under Division 23.

C. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.

D. Coordinate electrical work required under Division 23 with that under Division 26. Coordinate all work under Division 23 with work under all other Divisions.

E. Supply services of an experienced (10 year minimum) and competent Project Manager to be in constant charge of work at site.

F. Where a discrepancy exists within the specifications or drawings or between the specifications and drawings, the more stringent (or costly) requirement shall apply until clarification can be obtained from the Engineer. Failure to clarify such discrepancies with the Engineer will not relieve the Contractor of the responsibility of conforming to the requirements of the Contract.

G. Failure of contractor to obtain a full and complete set of contract documents (either before or after bidding) will not relieve the contractor of the responsibility of complying with the intent of the contract documents.

H. Coordinate installation of large equipment requiring positioning before closing in building. Where required arrange for manufacturer to ship equipment in modules.

1.11. CUTTING AND PATCHING

A. Accomplish all cutting and patching necessary for the installation of work under Division 23. Damage resulting from this work to other work already in place, shall be repaired at Contractor's expense. Where cutting is required, perform work in neat and workmanlike manner. Restore disturbed work to match and blend with existing construction and finish, using materials compatible with the original. Use mechanics skilled in the particular trades required.

B. Do not cut structural members without approval from the Architect or Engineer.

1.12. PENETRATION OF WATERPROOF CONSTRUCTION

A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls, and interior waterproof construction. Where such penetrations are necessary, furnish and install all necessary curbs, sleeves, flashings, fittings and caulking to make penetrations absolutely watertight.

B. Where pipes penetrate roofs, flash pipe with Stoneman Stormtite, Pate or approved equal, roof flashing assemblies with skirt and caulked counter flashing sleeve.

C. Furnish and install pitch pockets or weather tight curb assemblies where required.

D. Furnish and install curbs, vent assemblies, and duct sleeves specifically designed for application to the particular roof construction, and install in accordance with the manufacturer's instructions. The Contractor shall be responsible for sleeve sizes and locations. All roof penetrations shall be installed in accordance with manufacturer’s instructions, the National Roofing Contractors Association, SMACNA, and as required by other divisions of these specifications.

E. All work associated with the existing roof shall be performed so as to maintain the

existing roof warranty.

1.13. CONCRETE AND MASONRY WORK

A. Furnish and install concrete and masonry work for equipment foundations, supports, pads, and other items required under Division 23. Perform work in accordance with requirements of other applicable Divisions of these specifications.

B. Concrete shall test not less than 3,000 psi compressive strength after 28 days.

C. Grout shall be non-shrink, high strength mortar, free of iron of chlorides and suitable for use in contact with all metals, without caps or other protective finishes. Apply in accordance with manufacturer's instructions and standard grouting practices.

1.14. CONNECTIONS AND ALTERATIONS TO EXISTING WORK

A. Unless otherwise noted on the drawings, where existing mechanical work is removed, pipes, valves, ductwork, etc., shall be removed, including hangers, to a point below finished floors or behind finished walls and capped. Such point shall be far enough behind finished surfaces to allow for installation of normal thickness of required finish material.

B. Where work specified in Division 23 connects to existing equipment, piping, ductwork, etc., Contractor shall perform all necessary alterations, cuttings, fittings, etc., of existing work as may be necessary to make satisfactory connections between new and existing work, and to leave completed work in a finished and workmanlike condition.

C. Where the work specified under Division 23, or under other Divisions, requires relocation of existing equipment, piping, ductwork, etc., Contractor shall perform all work and make necessary changes to existing work as may be required to leave completed work in a finished and workmanlike condition. Where existing insulation is disturbed, replace insulation where removed or damaged equal to existing, in type, thickness, density, finish and thermal resistance (R-value) value.

D. Where the relocation of existing equipment is required for access or the installation of new equipment, the contractor shall temporarily remove and/or relocate and re-install as required to leave the existing and new work in a finished and workman like condition.

1.15. DEMOLITION

A. Unless otherwise noted all existing equipment, piping, ductwork, etc., shall remain.

B. Where existing equipment is indicated to be removed, all associated piping, conduit, power, controls, insulation, hangers, ductwork, supports and housekeeping pads, etc., patch, paint and repair walls/roof/floor to match existing and/or new finishes.

C. Provide necessary piping, valves, traps, temporary feeds, drips, etc., as required. Drain and refill piping systems as often as necessary to accommodate phasing and to minimize time lengths of outages.

D. The Contractor shall be responsible for visiting the site and determining the existing conditions in which the work is to be performed.

E. Refer to phasing plans for additional requirements.

F. Where any abandoned pipes in existing floors, walls, pipe tunnels, ceilings, etc., conflict with new work, remove abandoned pipes as necessary to accommodate new work.

G. The location of all existing equipment, piping, ductwork, etc., indicated is approximate only and shall be checked and verified. Install all new mechanical/plumbing/fire protection work to connect to or clear existing work as applicable.

H. Maintain egress at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and the authorities having jurisdiction.

I. Make provisions and include in bid all costs associated with confined entry/space requirements in auditorium ceilings and all other applicable OSHA regulations.

J. Where required to maintain the existing systems in operation, temporarily backfeed existing systems from new equipment. Contractor shall temporarily extend existing piping systems to new piping systems with the appropriate shut-off valves.

K. At completion of project all temporary piping, valves, controls, etc., shall be removed in their entirely.

L. Existing piping, equipment, ductwork, materials, etc., not required for re-use or re-installation in this project, shall be removed from the project site.

M. Deliver to the Owner, on the premises where directed, existing equipment and materials which are removed and which are desired by the Owner or are indicated to remain the property of the Owner.

N. All other materials and equipment which are removed shall become property of the Contractor and shall be promptly removed, from the premises, and disposed of by the Contractor, in an approved manner. Contractor shall be responsible for proper disposal of all removed equipment containing refrigerants. Contractor shall include in his bid all cost associated with the evacuation, removal and disposal of all existing equipment containing refrigerants in accordance with EPA and Health Department requirements. Where existing split systems or ductless units are indicated to be relocated, extend refrigeration piping, power, and control wiring to the same.

O. Where piping and/or ductwork is removed, remove all pipe or ductwork hangers which were supporting the removed piping or ductwork. Patch the remaining penetration voids with like materials and paint to match existing construction.

P. Where required, provide and coordinate removal and re-installation of existing equipment. Take care to protect materials and equipment indicated for reuse. Contractor shall repair or replace items which are damaged. Contractor shall have Owner's representative present to confirm condition of equipment prior to demolition.

Q. Before demolition begins, and in the presence of the Owners representative, test and note all deficiencies in all existing systems affected by demolition but not completely removed by demolition. Provide a copy of the list of system deficiencies to the Owner and the Engineer. Videotape existing conditions in each space prior to beginning demolition work.

R. The Owner shall have the first right of refusal for all fixtures, devices and equipment removed by the Contractor.

S. All devices and equipment designated by the Owner to remain the property of the Owner shall be moved and stored by the Contractor at a location on site as designated by the Owner. It shall be the Contractor's responsibility to store all devices and equipment in a safe manner to prevent damage while stored.

T. All existing equipment refused by the Owner shall become the property of the Contractor and shall be removed from the site by the Contractor in a timely manner and disposed of in a legal manner.

U. Work Abandoned in Place: Cut and remove underground pipe a minimum of 2 inches beyond face of adjacent construction. Cap and patch surface to match existing finish.

V. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.

W. Terminate services and utilities in accordance with local laws, ordinances, rules and regulations.

X. Where hydronic system piping and equipment is removed, Contractor shall be responsible for proper disposal of all contained fluids containing glycol (ethylene or propylene), hazardous waste and water treatment chemicals. Contractor shall include in his bid all associated costs with the removal, testing, and disposal of hydronic system fluid in accordance with EPA, Health Department, and the Local Authority Having Jurisdiction.

1.16. DRIVE GUARDS

A. Provide safety guards on all exposed belt drives, motor couplings, and other rotating machinery. Provide fully enclosed guards where machinery is exposed from more than one direction.

B. When available, guards shall be factory fabricated and furnished with the equipment. Otherwise fabricate guards of heavy gauge steel, rigidly braced, removable, and finish to match equipment served. Provide openings for tachometers. Guards shall meet local, State and O.S.H.A. requirements.

1.17. VIBRATION ISOLATION

A. Furnish and install vibration isolators, flexible connections, supports, anchors and/or foundations required to prevent transmission of vibration from equipment, piping or ductwork to building structure. See Division 23 Section, "Vibration Control for HVAC,

Plumbing and Fire Protection Equipment".

1.18. FASTENERS/CAPS

A. All fasteners located in public spaces including classrooms, corridors, lobbies, toilet rooms, etc., shall be provided with tamper proof fasteners. Provide Pin Phillips hardware as manufactured by Challenge Industries or approved equal.

B. For all exterior grade and roof mounted equipment containing refrigerant install lockable caps on service valves to prevent tampering. Lockable caps shall be Model NPR as manufactured by Rector Seal or approved equal. Provide Model NPR Novent screwdriver tool with swiveling tip. Caps shall be suitable and specific for the refrigerant type utilized.

1.19. DEFINITIONS

A. Approve - to permit use of material, equipment or methods conditional upon compliance with contract documents requirements.

B. Furnish and install or provide means to supply, erect, install, and connect to complete for readiness for regular operation, the particular work referred to.

C. Contractor means the mechanical contractor and any of his subcontractors, vendors, suppliers, or fabricators.

D. Piping includes pipe, all fittings, valves, hangers, insulation, identification, and other accessories relative to such piping.

E. Ductwork includes duct material, fittings, hangers, insulation, sealant, identification and other accessories

F. Concealed means hidden from sight in chases, formed spaces, shafts, hung ceilings, or embedded in construction.

G. Exposed means not installed underground or concealed as defined above.

H. Invert Elevation means the elevation of the inside bottom of pipe.

I. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceiling, unexcavated spaces, crawl spaces, and tunnels.

J. Review - limited observation or checking to ascertain general conformance with design concept of the work and with information given in contract documents. Such action does not constitute a waiver or alteration of the contract requirements.

K. ECM: Electronically Commutating Motor.

L. Building Line: Exterior wall of building.

1.20. MINIMUM EFFICIENCY REQUIREMENTS

A. All heating, ventilating, and air conditioning equipment shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

B. All piping, ductwork, and equipment insulation shall comply with ASHRAE Standard 90.1, latest edition.

C. All mechanical devices, controls, accessories, and components shall be manufactured to provide the minimum efficiency requirements as specified in ASHRAE Standard 90.1, latest edition.

1.21. SYSTEM INTEGRATION

A. For all HVAC equipment specified to be provided with packaged controls and interfaced with the automatic temperature control system, provide system integration between the equipment manufacturer and the automatic temperature control subcontractor.

B. HVAC equipment submittals requiring system integration as defined above must identify all required system integration points.

C. HVAC equipment manufacturers must coordinate with ATC subcontractor regarding system integration prior to submitting on the equipment.

D. A system integration meeting must be arranged by the Mechanical Contractor and include, but not be limited to the systems integrator for the HVAC equipment manufacturer and the ATC Subcontractor. This portion of systems integration must occur prior to HVAC equipment being delivered to the project.

E. Once the HVAC equipment is on site, a second systems integration meeting must be arranged by the Mechanical Contractor to coordinate the packaged controls with the ATC system. The HVAC equipment manufacturer's representative familiar with system integration and the ATC subcontractor familiar with programming must be present.

F. A final system integrations meeting shall occur once all equipment is in place and ready for operation. The Mechanical Contractor, the HVAC equipment systems' integrator, and the ATC Subcontractor shall meet on site to jointly program, schedule, verify points, interlock devices, and fully set up all systems integration components.

G. All systems integration coordination, programming, and graphics must be completed prior to requesting commissioning and/or inspections by the Engineer of Record.

PART 2. ELECTRICAL REQUIREMENTS

2.1. GENERAL MOTOR AND ELECTRICAL REQUIREMENTS

A. Furnish and install control and interlock wiring for the equipment furnished. In general, power wiring and motor starting equipment will be provided under Division 26. Carefully review the contract documents to coordinate the electrical work under Division 23 with the work under Division 26. Where the electrical requirements of the equipment furnished differ from the provisions made under Division 26, make the necessary

allowances under Division 23. Where no electrical provisions are made under Division 26, include all necessary electrical work under Division 23.

B. All electrical work performed under Division 23 shall conform to the applicable requirements of Division 26 and conforming to the National Electrical Code. All wiring, conduit, etc., installed in ceiling plenums must be plenum rated per NFPA and the International Building Code.

C. Provide wiring diagrams with electrical characteristics and connection requirements.

D. Test Reports: Indicate test results verifying nominal efficiency and power factor for three phase motors larger than five (5) horsepower.

E. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering. For extended outdoor storage, remove motors from equipment and store separately.

F. All motors shall be furnished with visible nameplate indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor and efficiency.

G. Motors located in exterior locations, wet air streams, air cooled condensers, and outdoors shall be totally enclosed weatherproof epoxy-treated type.

H. Nominal efficiency and power factor shall be as scheduled at full load and rated voltage when tested in accordance with IEEE 112.

I. Brake horsepower load requirement at specified duty shall not exceed 85 percent of nameplate horsepower times NEMA service factor for motors with 1.0 and 1.15 service factors.

J. All single phase motors shall be provided with thermal protection: Internal protection shall automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature ratings of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range, unless otherwise indicated.

2.2. MOTORS AND CONTROLS

A. Motors and controls shall conform to the latest requirements of IEEE, NEMA, NFPA-70 and shall be UL listed. Motor sizes are specified with the driven equipment. Motor starting and control equipment is specified either with the motor which is controlled or in an electrical specification section. The Contractor is advised to consult all specification sections to determine responsibility for motors and controls.

B. Motors shall be designed, built and tested in accordance with the latest revision of NEMA Standard MG l.

C. Motors used with variable-frequency controllers shall have ratings, characteristics, and features coordinated with and approved by the variable frequency controller (drive)

manufacturer. As a minimum the following shall apply to variable frequency controlled motors:

1. Motors shall be manufactured to withstand peak voltages of 1600 volts with .1 microsecond rise time per NEMA MG-1.

2. Critical vibration frequencies of motor shall not be within operating range of variable frequency controller output.

3. Temperature rise: Match rating for Class B insulation.

4. Insulation: Class F.

5. Thermal Protection: Conform to MG1 requirements for thermally protected motors.

D. Motors shall be suitable for use under the conditions and with the equipment to which applied, and designed for operation on the electrical systems specified or indicated.

1. Motor capacities shall be such that the horsepower rating and the rated full-load current will not be exceeded while operating under the specified operating conditions. Under no condition shall the motor current exceed that indicated on the nameplates.

2. Motor sizes noted in the individual equipment specifications are minimum requirements only. It is the responsibility of the equipment manufacturers and of the Contractor to furnish motors, electrical circuits and equipment of ample capacity to operate the equipment without overloading, exceeding the rated full-load current, or overheating at full-load capacity under the most severe operating service of this equipment. Motors shall have sufficient torque to accelerate the total WR2 of the driven equipment to operating speed.

3. Motors shall be continuous duty type and shall operate quietly at all speeds and loads.

4. Motors shall be designed for operation on 60 hertz power service. Unless otherwise specified or shown, motors less than ½ horsepower shall be single phase, and motors ½ horsepower and larger shall be 3 phase unless otherwise noted.

5. Motors shall be mounted so that the motor can be removed without removing the entire driven unit.

E. Single phase motors, smaller than 1/20 horsepower shall be ball or sleeve bearing; drip-proof, totally enclosed or explosion proof, as specified; 120 volts; permanent-split capacitor or shaded pole type. These motors shall not be used for general power purposes, and shall only be provided as built-in components of such mechanical equipment as fans, unit heaters, humidifiers and damper controllers. When approved by the Engineer, deviations from the specifications will be permitted as follows:

1. Open motors may be installed as part of an assembly where enclosure within a cabinet provides protection against moisture.

2. Motors used in conjunction with low voltage control systems may have a voltage rating less than 115 volts.

F. Single phase motors, greater than 1/20 horsepower and less than ½ horsepower shall be ball bearing; drip-proof, totally enclosed or explosion proof, as specified, with Class A or B insulation, as standard with the motor manufacturer; 115 or 120/208/240 volts as required; capacitor start-induction run, permanent split capacitor, or repulsion start-induction run type with minimum efficiency of 70 percent and a minimum full load power of 77 percent.

G. Except as otherwise specified in the various specification sections, 3 phase motors 60 horsepower and smaller shall be NEMA design B squirrel cage induction type meeting the requirements of this paragraph. Motors shall be drip-proof, totally enclosed or explosion proof, as specified or indicated. Insulation shall be Class B or F, at 40 degrees C ambient temperature. Drip-proof motors shall have a 1.15 service factor and totally enclosed and explosion proof motors shall have a service factor of 1.00 or higher. Motors specified for operation at 480, 240, and 208 volts shall be nameplated 460, 230, 200 volts, respectively. Efficiencies and percent power factor at full load for three phase motors shall be not less than the values listed below for premium efficiency motors:

MOTOR NAMEPLATE	MINIMUM PERCENT EFFICIENCY AT NOMINAL SPEED AND RATED LOAD	MINIMUM PERCENT POWER FACTOR
1HP and above to	85.5 percent	84 percent
1-½ HP	86.5 percent	85 percent
2HP	86.5 percent	85 percent
3HP	89.5 percent	86 percent
5HP	89.5 percent	87 percent
7½ HP	91 percent	86 percent
10HP	91.7 percent	85 percent
15HP	93.0 percent	85 percent
20HP	93.0 percent	86 percent
25HP	93.6 percent	85 percent

MOTOR NAMEPLATE	MINIMUM PERCENT EFFICIENCY AT NOMINAL SPEED AND RATED LOAD	MINIMUM PERCENT POWER FACTOR
50HP and above	94.5 percent	88 percent

H. Three phase motors ½ HP or greater shall be the Duty Master XE by Reliance Electric Company, Super-E Premium Efficiency of Baldor Motor and Drives, E-plus Efficient Standard Duty Motor of the Electric Motor Division of Gould, Inc., the MAC II High Efficiency motor of Westinghouse Electric Corp., the equivalent product of General Electric, or approved equal.

I. For motors serving equipment being controlled by a variable speed drive, motor shall be premium efficiency inverter duty rated.

J. Motor frames shall be NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast-iron or aluminum with steel inserts.

K. Control of each motor shall be manual or automatic as specified for each in the various mechanical sections. In general, and unless otherwise specified for a particular item in the various mechanical sections of the specifications, motor starters and controls shall be specified and provided under the various electrical sections of these specifications.

L. Provide manufacturer's warranty for all motors for minimum of 5 years including all labor and materials.

2.3. MOTOR INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install securely on firm foundation. Mount ball bearing motors to support shaft regardless of shaft position.

C. Check line voltage and phase and ensure agreement with nameplate. Check that proper thermal overloads have been installed prior to operating motors.

D. Use adjustable motor mounting bases for belt-driven motors.

E. Align pulleys and install belts.

F. Tension belts according to manufacturer's written instructions.

2.4. WIRING DIAGRAMS

A. The Contractor is responsible for obtaining and submitting wiring diagrams for all major items of equipment.

B. Wiring diagrams shall be provided with shop drawings for all equipment requiring electric power.

C. Provide wiring diagrams for all major mechanical items of equipment to electrical contractor and ATC subcontractor for coordination.

2.5. VARIABLE FREQUENCY DRIVE MOTOR BEARING PROTECTIVE RINGS

A. For all motors driven by a variable frequency PWM drive include a maintenance free, circumferential, conductive micro fiber shaft grounding ring to discharge shaft currents. Grounding rings shall be manufactured by AEGIS SGR or approved equal.

B. Furnish units with one year warranty.

C. Size and select Bearing Protective Rings per the manufacturer requirements based on the motor size, shaft diameter, and shaft shoulder length. For motors with slingers furnish and install NEMA /IEC kit as required.

D. Furnish and apply Colloidal silver shaft coating to all shafts with Bearing Protective Rings to improve shaft voltage discharge capability.

2.6. FILTER MEDIA DURING CONSTRUCTION

A. Filter media installed during construction: Minimum MERV 8.

PART 3. EXECUTION

3.1. EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.

B. Install equipment according to approved submittal data. Portions of the work are shown only in diagrammatic form. Refer conflicts to Architect.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

D. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

E. Install equipment giving right of way to piping installed at required slope.

F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

G. Do not install equipment, ductwork, or piping over electrical gear, electrical panels, motor controllers, and similar electrical equipment. Install equipment, ductwork, and

piping to maintain clear space above and in front of all electrical components per the National Electric Code.

3.2. SUPPORTS, HANGERS AND FOUNDATIONS

A. Provide supports, hangers, braces, attachments and foundations required for the work. Support and set the work in a thoroughly substantial and workmanlike manner without placing strains on materials, equipment, or building structure, submit shop drawings for approval. Coordinate all work with the requirements of the structural division.

B. Supports, hangers, braces, and attachments shall be standard manufactured items or fabricated structural steel shapes. All interior hangers shall be galvanized or steel with rust inhibiting paint. For un-insulated copper piping provide copper hanger to prevent contact of dissimilar metals. All exterior hangers shall be constructed of stainless steel utilizing stainless steel rods, nuts, washers, bolts, etc.

C. Concrete housekeeping pads and foundations shall be not less than 4 inches high and shall extend a minimum of 6 inches beyond equipment bases. Provide wire-mesh reinforcement; chamfer exposed edges and corners; and finish exposed surfaces smooth.

D. Where new concrete housekeeping pads are placed on existing concrete, saw cut the existing concrete to the perimeter dimension of the new pad to a depth of ½ inch. Break out the top ½ inch area of the existing concrete. Add stubs of #4 rebar angled into the existing concrete at a depth of approximately 50 percent of the existing slab thickness. The top portion of the rebar stub shall extend into the new pad by approximately 50 percent of its thickness. Furnish one rebar stub per every two square feet of new pad. Chemically bond the new concrete to the existing concrete.

3.3. PROVISIONS FOR ACCESS

A. The contractor shall provide access panels and doors for all concealed equipment, valves, strainers, dampers, filters, controls, control devices, cleanouts, fire dampers, damper operators, and other devices requiring maintenance, service, adjustment, balancing or manual operation.

B. Where access doors are necessary, furnish and install manufactured painted steel door assemblies consisting of hinged door, key locks, and frame designed for the particular wall or ceiling construction. Properly locate each door. Door sizes shall be a 12 inches x 12 inches for hand access, 18 inches x 18 inches for shoulder access and 24 inches x 24 inches for full body access where required. Review locations and sizes with Architect prior to fabrication. Mark each access door within finished spaces with a small color coded and numbered tab. Provide a chart or index for identification. Provide U.L. approved and labeled access doors where installed in fire rated walls or ceilings. Doors shall be Milcor Metal Access Doors as manufactured by Inland-Ryerson, Mifab, or approved equal.

1. Acoustical or Cement Plaster: Style B

2. Hard Finish Plaster: Style K or L

i. Masonry or Dry Wall: Style M

C. Where access is by means of liftout ceiling tiles or panels, mark each ceiling grid using small color-coded and numbered tabs. Provide a chart or index for identification. Place markers within ceiling grid not on ceiling tiles.

D. Access panels, doors, etc. described herein shall be furnished under the section of specifications providing the particular service and to be turned over to the pertinent trade for installation. Coordinate installation with installing contractor. All access doors shall be painted in baked enamel finish to match ceiling or wall finish.

E. Submit shop drawings indicating the proposed location of all access panels/doors. Access doors in finished spaces shall be coordinated with air devices, lighting and sprinklers to provide a neat and symmetrical appearance.

F. Where access doors are installed in wet locations (i.e. shower rooms, toilet rooms, , and similar spaces, etc…) provide aluminum access doors/frames.

3.4. PAINTING AND FINISHES

A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc. shall be stainless steel.

B. Clean surfaces prior to application of insulation, adhesives, coatings, paint, or other finishes.

C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pretreatment.

D. Protect all finishes and restore any finishes damaged as a result of work under Division 23 to their original condition.

E. The preceding requirements apply to all work, whether exposed or concealed.

F. Remove all construction marking and writing from exposed equipment, ductwork, piping and building surfaces. Do not paint manufacturer's labels or tags.

G. All exposed ductwork, piping, equipment, etc. shall be painted. Colors shall be as stated in this division or as selected by the Architect and conform to ANSI Standards.

H. All exterior roof mounted equipment, piping, and vents shall be painted to match roof in color as selected by Architect.

I. All exposed ductwork, piping, equipment, etc. in finished spaces shall be painted. Colors shall be as selected by the Architect and conform to ANSI Standards.

J. All exposed ductwork, piping, equipment, etc., in Mechanical Rooms, Boiler Rooms, Penthouses, and Storage where PVC jacketed shall not require painting. Label and

identify and color code as specified.

3.5. CLEANING OF SYSTEMS

A. Thoroughly clean systems after satisfactory completion of pressure tests and before permanently connecting fixtures, equipment, traps, strainers, and other accessory items. Blow out and flush piping until interior surfaces are free of foreign matter.

B. Flush piping in re-circulating water systems to remove cutting oil, excess pipe joint compound, solder slag and other foreign materials. Do not use system pumps until after cleaning and flushing has been accomplished to the satisfaction of the Engineer. Employ chemical cleaners, including a non-foaming detergent, not harmful to system components. After cleaning operation, final flushing and refilling, the residual alkalinity shall not exceed 300 parts per million. Submit a certificate of completion to Engineer stating name of Service Company used.

C. Maintain strainers and dirt pockets in clean condition.

D. Clean fans, ductwork, enclosures, flues, registers, grilles, and diffusers at completion of work.

E. Install filters of equal efficiency to those specified in permanent air systems operated for temporary heating during construction. Replace with clean filters as specified prior to acceptance and after cleaning of system.

F. Pay for labor and materials required to locate and remove obstructions from systems that are clogged with construction refuse after acceptance. Replace and repair work disturbed during removal of obstructions.

G. Leave systems clean, and in complete running order.

H. All HVAC piping/equipment strainers must be pulled and cleaned prior to substantial completion. In addition six (6) months after substantial completion all HVAC piping/equipment strainers must be pulled and cleaned a second time. Document and submit verification of strainer cleaning to Engineer, Owner, and General Construction.

3.6. COLOR SELECTION

A. Color of finishes shall be as selected by the Architect.

B. Submit color of factory-finished equipment for acceptance prior to ordering.

3.7. PROTECTION OF WORK

A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

B. Cover temporary openings in piping, ductwork, and equipment to prevent the entrance of water, dirt, debris, or other foreign matter. Deliver pipes and tubes with factory applied end caps.

C. Cover or otherwise protect all finishes.

D. Replace damaged materials, devices, finishes and equipment.

E. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, where stored inside.

3.8. OPERATION OF EQUIPMENT

A. Clean all systems and equipment prior to initial operation for testing, balancing, or other purposes. Lubricate, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.

B. Where specified, or otherwise required, provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment. Where factory start-up of equipment is not specified, provide field start-up by qualified technician.

C. Submit factory start-up sheets or field start-ups sheets for all equipment prior to the commencement of testing and balancing work. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

D. Do not use mechanical systems for temporary services or temporary conditioning during construction, unless approved by Owner in writing. Refer to Division 01 Section "Temporary Facilities and Controls" for temporary heating/cooling during construction.

E. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items such as filters.

3.9. DEMONSTRATION AND TRAINING VIDEO RECORDINGS

A. General: Record demonstration and training video recordings. Record each training module separately.

1. At beginning of each training module, record each chart containing learning objective and lesson outline.

B. Video Recording Format: Provide high-quality color video recordings with menu navigation in format acceptable to Engineer

C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.

D. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.

E. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

3.10. IDENTIFICATIONS, FLOW DIAGRAMS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS

A. Contractor shall submit for approval schematic piping diagrams of each piping system installed in the building. Diagrams shall indicate the location and the identification number of each valve in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under safety glass and hung in each Mechanical Room where directed. Contractor shall deliver the tracing or sepia from which the diagrams were reproduced to the Owner.

B. All valves shall be plainly tagged. For any bypass valves, install sign indicating valve position as "Normally Open" or "Normally Closed" as required.

C. All items of equipment, including motor starters, disconnects and ATC panels shall be furnished with white on black plastic permanent identification cards. Lettering shall be a minimum of ¼ inch high. Identification plates shall be secured, affixed to each piece of equipment, starters, disconnects, panels by screw or adhesive (tuff bond #TB2 or as approved equal).

D. Provide six (6) copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the Record and Information Booklet as hereinafter specified.

E. All piping and ductwork installed under this contract shall be stenciled with direction of flow arrows and with stenciled letters naming each pipe and ductwork and service. Refer to Division 23 Section, "HVAC Piping, Fittings, Valves, Etc." and Division 23 Section, "HVAC Air Distribution". Color-code all direction of flow arrows and labels. In finished spaces omit labeling and direction of flow arrows. Paint in color as selected by Architect.

F. Submit list of wording, symbols, letter size, and color coding for mechanical identification. Submit samples of equipment identification cards, piping labels, ductwork labels, and valve tags to Engineer for review prior to installation.

G. Provide at least 16 hours of straight time instruction to the operating personnel. This instruction period shall consist of not less than two (2) consecutive 8 hour days. Time of instruction shall be designated by the Owner. Additional instruction time for the automatic temperature control (ATC) system is specified in Division 23 Section, "Instrumentation & Controls of HVAC & Plumbing Systems".

H. Contractor shall demonstrate Sequences of Operation of all equipment in presence of Owner's representative, Engineer, and ATC subcontractor.

3.11. WALL AND FLOOR PENETRATION

A. All penetrations of partitions, ceilings, roofs and floors by ducts, piping or conduit under Division 23 shall be sleeved, sealed, and caulked airtight for sound and air transfer control. Penetrations of mechanical room partitions, ceilings, and floors shall be as specified in Division 23 Section, "Vibration Control for HVAC, Plumbing and Fire Protection Equipment".

B. All penetration of fire rated assemblies shall be sleeved, sealed, caulked and protected to maintain the rating of the wall, roof, or floor. Fire Marshal approved U.L. assemblies shall be utilized. See Division 07 Section, "Fire Protection, HVAC & Plumbing Penetration Firestopping".

C. Where piping extends through exterior walls or below grade, provide waterproof pipe penetration seals, as specified in another division of these specifications.

D. Provide pipe escutcheons and duct flanges for sleeved pipes and ducts in finished areas.

E. Piping sleeves:

1. Galvanized steel pipe, standard weight where pipes are exposed and roofs and concrete and masonry walls. On exterior walls provide anchor flange welded to perimeter.

2. Twenty-two (22) gauge galvanized steel elsewhere.

F. Ductwork sleeves: 20 gauge galvanized steel.

G. Extend all floor sleeves through floor at least 3/4-inches above finished floor, caulk sleeve the entire depth and furnish and install floor plate.

3.12. RECORD DRAWINGS

A. Upon completion of the mechanical installations, the Contractor shall deliver to the Architect one complete set of prints of the mechanical contract drawings which shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings.

B. Contractor shall incorporate all sketches, addendums, value engineering, change orders, etc., into record drawings prior to delivering to Architect.

3.13. WARRANTY

A. Contractor's attention is directed to warranty obligations contained in the GENERAL CONDITIONS.

B. The above shall not in any way void or abrogate equipment manufacturer's guarantee or warranty. Certificates of equipment manufacturer's warranties shall be included in the operations and maintenance manuals.

C. The Contractor guarantees for a two year period from the time of final acceptance by the Owner.

1. That the work contains no faulty or imperfect material or equipment or any imperfect, careless, or unskilled workmanship.

2. That all work, equipment, machines, devices, etc. shall be adequate for the use to

which they are intended, and shall operate with ordinary care and attention in a satisfactory and efficient manner.

3. That the contractor will re-execute, correct, repair, or remove and replace with proper work, without cost to the Owner, any work found to be deficient. The contractor shall also make good all damages caused to their work or materials in the process of complying with this section.

4. That the entire work shall be water-tight and leak-proof.

3.14. LUBRICATION

A. All bearings, motors, and all equipment requiring lubrication shall be provided with accessible fittings for same. Before turning over the equipment to the Owner, the Contractor shall fully lubricate each item of equipment, shall provide one year's supply of lubricant for each, and shall provide Owner with complete written lubricating instructions, together with diagram locating the points requiring lubrication. Include this information in the Record and Information Booklet.

B. In general, all motors and equipment shall be provided with grease lubricated roller or ball bearings with Alemite or equal accessible or extended grease fittings and drain plugs.

3.15. OPERATIONS AND MAINTENANCE MANUALS

A. The Contractor shall have prepared six (6) hardcopies and one (1) electronic copy of the Operations and Maintenance Manuals and deliver these copies of the booklet to the Owner. The booklet shall be as specified herein. The booklet must be approved and will not be accepted as final until so stamped.

B. The booklet shall be bound in a three ring loose-leaf binder similar to National No. 3881 with the following title lettered on the front: Operations and Maintenance Manuals – DTCC Arts & Science Building HVAC Renovation - HVAC. No sheets larger than 8-1/2 inches x 11 inches shall be used, except sheets that are neatly folded to 8-1/2 inches x 11 inches and used as a pull-out. Provide divider tabs and table of contents for organizing and separating information.

C. Provide the following data in the booklet:

1. As first entry, an approved letter indicating the starting/ending time of Contractor’s warranty period.

2. Maintenance operation and lubrication instructions on each piece of equipment furnished.

3. Complete catalog data on each piece of heating and air conditioning equipment furnished including approved shop drawing.

4. Manufacturer's extended limited warranties on equipment including but not limited to variable frequency drives, air conditioning compressors, storage tanks, heat pumps, and VRV Equipment.

5. Chart form indicating frequency and type of routine maintenance for all mechanical equipment. The chart shall also indicate model number of equipment, location and service.

6. Provide sales and authorized service representatives names, address, and phone numbers of all equipment and subcontractors.

7. Provide supplier and subcontractor's names, address, and phone number.

8. Catalog data of all equipment, valves, etc. shall include wiring diagrams, parts list and assembly drawing.

9. Provide and install in locations as directed by the Owner, valve charts including valve tag number, valve type, valve model number, valve manufacturer, style, service and location. Each valve chart shall be enclosed in a durable polymer based frame with a cover safety glass.

10. Copy of the approved balancing report including duct leakage data.

11. ATC systems including as-built ATC drawings of systems including internal of all panels.

12. Access panel charts with index illustrating the location and purpose of access panels.

13. Approved Health Department, Boiler Inspector, and Electrical Certificates.

14. Start-up reports for equipment.

15. Water treatment test reports.

16. Provide and install in locations as directed by Owner, filter charts, including filter type, size, model number, manufacturer, quantity and size for each filter utilized on the project. Filter charts shall be enclosed in a durable polymer based frame with a cover safety glass.

17. Insert color graphic with embedded parameters for ATC system into record and information booklet.

18. Filter charts indicating equipment served, size, and type of filter required.

19. Documentation of strainer pulling and cleaning.

D. Submit Record and Information Booklets prior to anticipated date of substantial completion for Engineer review and approval. Substantial completion requires that Record and Information booklets be reviewed and approved.

3.16. INSTALLATION AND COORDINATION DRAWINGS

A. Prepare, submit, and use composite installation and coordination drawings to assure proper coordination and installation of work. Drawings shall include, but not be limited,

to the following:

1. Complete Ductwork, Plumbing, Sprinkler and HVAC Piping Drawings showing coordination with lights, electrical equipment, HVAC equipment and structural amenities.

B. Draw plans to a scale not less than 3/8-inch equals one foot. Include plans, sections, and elevations of proposed work, showing all equipment, piping and ductwork in areas involved. Fully dimension all work including lighting fixtures, conduits, pullboxes, panelboards, and other electrical work, walls, doors, ceilings, columns, beams, joists and other architectural and structural work.

C. Identify all equipment and devices on wiring diagrams and schematics. Where field connections are shown to factory-wired terminals, include manufacturer's literature showing internal wiring.

D. Refer to Division 01 Section "Project Management and Coordination" for additional requirements related to coordination drawings.

3.17. PIPING SYSTEMS TESTING

A. The entire new HVAC piping systems shall be tested hydrostatically before insulation covering is applied and proven tight under the following gauge pressures for a duration of four (4) hours. Testing to be witnessed by Owner's representative and documented in writing.

SYSTEM	TEST PRESSURE
Heating, Chilled, & Glycol Water Supply & Return Piping, Including Chemical Treatment Piping	100 psi
Refrigerant Piping	550 psig with Nitrogen

B. Ductwork pressure testing shall be as specified in another division of these specifications.

C. Testing and acceptance thereof shall be in accordance with local requirements and shall meet approval of authority having jurisdiction. Submit certificates and approved permits and insert one (1) copy in the Operations and Maintenance Manuals.

D. Refrigerant piping shall be tested utilizing nitrogen per equipment manufacturer's requirements.

3.18. EQUIPMENT BY OTHERS

A. This Contractor shall make all system connections required to equipment furnished and installed under other divisions or furnished by the Owner. Connections shall be complete in all respects to render this equipment functional to its fullest intent.

B. It shall be the responsibility of the supplier of this equipment to furnish complete instructions for connections. Failure to do so will not relieve this contractor of any responsibility for improper equipment operation.

3.19. ADDITIONAL FILTERS AND BELTS

A. One complete set of additional filters and belts shall be turned over to the owner upon final acceptance of the building by the owner. Provide correspondence to the Engineer (copy) documenting that additional filters and belts have been turned over to Owner.

B. All filters and belts shall be tagged and identified for equipment served. Furnish filters in protection wrap.

3.20. PHASING

A. Refer to Architectural Specifications and contract drawings for any required phasing.

B. Maintain building egress and traffic ways at all times. Coordinate egress requirements with the State Fire Marshal, the Owner and Authorities having jurisdiction.

C. Provide dust barriers/partitions, penetration closures, etc, to ensure safety of building occupants and protection of existing surroundings.

D. The Building shall remain watertight at all times.

E. Refer to phasing plans for additional requirements.

F. Provide necessary piping, valves, steam traps, drips, piping, conduit, controllers, ATC wiring, etc. as required. Drain and refill piping systems as often as necessary to accommodate phasing and to minimize time length of outages. Provide steam traps, drips, valves, etc., to maintain existing steam system in operation until all equipment is connected to the hot water system. Temporarily feed new systems with existing system where required or shown on contract drawings.

G. At completion of the first phase the ATC System shall be sufficiently complete to turn over HVAC equipment. All wiring, testing, balancing, commissioning, programming, graphics, and ATC computer shall be completed and operational for all equipment in each phase prior to Owner taking ownership of the same.

H. Within thirty days of Award of Contract, the Contractor shall submit a minimum of six (6) copies of the proposed Phasing Plan (Drawings and detailed written description) to the Architect for review and approval based on the general and specific requirements indicated on the Drawings and Specifications. The phasing plan shall reflect the work of all trades. The phasing plan shall be updated as often as needed (i.e. major deviations and/or modified sequence of events) and reviewed during each progress meeting so the facility and Architect can be aware of the areas of construction and progress as it relates to the approved schedule.

I. Due to phased construction, some systems must be operated at part load conditions until later phases are completed. Contractor must carefully operate all variable speed pumps and variable speed fans so as not to operate below minimum speeds as required by pump/fan manufacturer.

J. While work is in progress, except for designated short intervals during which connections

are made, continuity of service shall be maintained to all existing systems. Interruptions shall be coordinated with the Owner as to time and duration. The contractor shall be responsible for any interruptions to service and shall repair any damages to existing systems caused by his operations.

3.21. STRAINER CLEANING

A. All equipment strainers must be pulled and cleaned at substantial completion. Document in writing and via digital photographs that all strainers have been pulled and cleaned.

B. One year after project substantial completion all strainers shall be pulled again and cleaned. Document in writing and via digital photographs that all strainers were pulled and clean at the one year after project substantial completion data.

C. Insert documentation that the strainers have been pulled and cleaned in the Record and Information Books.

D. Re-purge hydronic systems of all air after strainers are pulled and cleaned.

3.22. OUTAGES

A. Provide a minimum of fourteen (14) days' notice to schedule outages. The Contractor shall include in their bid outages and/or work in occupied areas to occur on weekends, holidays, or at night. Coordinate and get approval of all outages with the Owner.

B. Submit Outage Request form, attached at end of this Section, to Owner for approval.

END OF SECTION

OUTAGE REQUEST

DATE APPLIED: _____BY: _____

DATE FOR OUTAGE: _____ FIRM: _____

START OUTAGE-TIME: _____ DATE:_____

END OUTAGE -- TIME: _____ DATE:_____

AREAS AND ROOMS: _____

FLOOR(S): _____

AREA(S): _____

ROOM(S): _____

WORK TO BE PERFORMED: _____

SYSTEM(S): _____

REQUEST APPROVED BY: _____

(FOREMAN OR OTHER PERSON IN CHARGE)

(FOR OWNER'S USE ONLY):

APPROVED: _____

YES _____ NO ____ BY: _____DATE: _____

DATE/TIME-AS REQUESTED: _____ OTHER : _____

OWNER'S PRESENCE REQUIRED: _____

YES: ____ NO: ____ NAME: _____

POINT OF CONTACT: _____ PHONE: _____

DIVISION 23 SECTION 230505
HVAC PIPING, FITTINGS & VALVES
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SECTION 230505 - HVAC PIPING, FITTINGS AND VALVES

PART 1. GENERAL

1.1. SUMMARY

A. The conditions of the contract and other general requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 23 Section, Common Work Results for HVAC and Division 01, General Requirements.

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

1.2. SYSTEM DESCRIPTION CONDITIONS

A. Provide all labor and materials necessary to furnish and install all piping systems on this project as herein specified and/or shown on the drawings. Final connections to equipment furnished in other sections of the specifications shall be included under this section.

B. All piping and insulation installed in ceiling plenums must be plenum rated and comply with NFPA and International Building Code (IBC).

C. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

D. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

E. Use non-conducting dielectric connections whenever jointing dissimilar metals in open systems.

F. Provide pipe hangers and supports in accordance with ASTM B31.9 and MSS SP69 unless indicated otherwise.

G. Use spring loaded "silent" check valves on discharge of all pumps.

H. Use 3/4 inch (20 mm) ball valves with cap and chain for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

I. At all runout piping serving equipment, use swing joints with elbows to prevent excessive movement of piping due to expansion.

1.3. QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulation. Provide certificate of compliance from authority having jurisdiction indicating approval of welders.

C. Welders Certification: In accordance with ASME Section 9.

D. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

1. All castings used for coupling housings, fittings, and valve bodies shall be date stamped for quality assurance and traceability.

E. Maintain one copy of each document on site.

1.4. DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to site under as hereinbefore specified.

B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

C. Provide temporary protective coating on cast iron and steel valves.

D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed systems.

1.5. ENVIRONMENTAL REQUIREMENTS

A. Do not install underground piping when bedding is wet or frozen.

1.6. EXTRA MATERIALS

A. Provide one (1) repacking kit for each size valve.

1.7. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. PIPE MATERIALS

A. All materials, unless otherwise specified, shall be new and of the best quality of their respective kinds, and shall conform to the requirements and ordinances of local, state and insurance authorities having jurisdiction.

1. Heating & Chilled Water Supply & Return Piping, Chemical Treatment Piping, (Inside of Building):

a. Pipe: Schedule 40 Black steel pipe, ASTM A53
1-1/2 inch and smaller - Type F, ASTM A53 steel (CW) with threaded joints
2 inch and larger - Grade B, Type E, ASTM A53 steel (ERW) with welded, flanged or grooved joints.

b. Fittings & Joints: 2-1/2 inches & larger, schedule 40 wrought steel ASTM A234 Grade WPB or Std. B16.9 long radius welding; factory-fabricated from ASTM A53 pipe; or ASTM A536 ductile iron; 2 inches & smaller 125 lb. std. cast iron screwed, ASTM Standard B16.4; or Vic-Press precision, cold drawn, stainless steel with elastomer O-ring seals. Joints shall be threaded or AWS D1.1 welded. Victaulic, Appollo/Shurjoint, or approved equal grooved joints shall be acceptable.

c. Flanges: Wrought steel Class 150 welding neck. ASTM Standard B16.5.

d. Grooved Joint Couplings: Two ductile iron housings, pressure responsive elastomer gasket, and ASTM A449 zinc electroplated steel bolts and nuts. Couplings shall comply with ASTM F1476 Standard Specification for the Performance of Gasketed Mechanical Couplings for Use in Piping Applications.

i. Rigid Type: Coupling housings shall be cast with offsetting, angle-pattern bolt pads to provide joint rigidity and support and hanging in accordance with ASNI B31.1 and B31.9.

1) Victaulic Style 107H, Apollo/Shurjoint Z-07, Installation-Ready or approved equal, for direct stab installation without field disassembly, with grade EHP gasket, suitable for water service to +250 degrees F.

ii. Flexible Type: For use in locations where vibration attenuation and stress relief are required, and for the elimination of flexible connectors. Victaulic Installation-Ready Style 177 or Style 77, or approved equal.

iii. 14” and Larger: AGS Series, two segment coupling with lead-in chamfer on housing key and wide width FlushSeal gasket. Victaulic Style W07 (rigid) and Style W77 (flexible), Apollo/Shurjoint 7707/7707N, or approved equal.

iv. Flange adapters shall be suitable for direct connection to ANSI Class 125 or 150 flanged components. Victaulic Style 741/W741, Apollo/Shurjoint 7041, or approved equal.

v. Rolled form grooves only. Cut grooves are prohibited.

vi. Verify gasket compatibility on Chemical Treatment piping.

e. Gate Valves: 2-1/2 inches & larger - IBBM, 150 lb. OS&Y grooved end or flanged; 2 inches & smaller - 150 lb. Bronze body bronze trim. Basis of Design: Victaulic Series 771V or approved equal.
For valves 4 inch and larger located in mechanical equipment spaces 10 feet-0 inch or greater above finished floor, valve shall have chain wheel operators with chains extending to within 6 feet-0 inch above finished floor. Chain wheels and guides shall be galvanized.

f. Ball Valves: Shut-off valves 2 inches and smaller shall be ball valves. Ball valves shall be 600cwp, 150swp full port, with RPTFE seats, chrome plated ball and stem 2 ½ and larger, class 125 cast iron OS&Y IBBM gate valve, brass or bronze body, standard port, 2 piece body. Ball valves shall be VicPress end, threaded end or solder end as required to accommodate piping. Ball valves shall be as manufactured by

Victaulic, Crane, Apollo, Nibco, Watts or engineer approved equal.

g. Globe Valves: 2-1/2 inches & larger – IBBM 125 lb.std. flanged, with No. 1 disc; 2 inches & smaller - bronze 150 lb. std. screw ends, with #1 disc.

h. Check Valves: 2-1/2 inches & larger – IBBM or stainless steel trim, 125 lb.std. grooved end or flanged spring-assisted swing check suitable for vertical or horizontal installation, with metal disc; 2 inch & smaller - 125 lb. std. screwed. Provide "silent" spring loaded check valves at all pump discharges. Victaulic Series 716/W715 or approved equal.

i. Balancing Valves: Victaulic Series 377/365, DeZurik Series 100, Fig. 118 or approved equal, ductile iron or cast iron construction, stainless steel bearings, nickel seats (3 inches and larger) non-lubricated, eccentric plug with EPDM, chlorobutyl rubber or Bunz-N resilient faced plugs suitable for 230 degrees F, semi-steel screwed with fig. 159, removable lever and open. nut for valves 3 inches and smaller. For valves 4-inch and larger, provide gear operators and grooved ends or flanged connections. Provide chain operated valves for sizes 4-inches and larger located 10 feet-0 inches or more above finished floor. Chains shall extend to within 6 inch-0 inches above finished floor. All valves shall have adjustable memory stop. Chain wheel and guide shall be galvanized.

j. Butterfly Valves: Victaulic Vic300 MasterSeal/ AGS-Vic300, DeZurik, Apollo 215L series, high performance or Keystone K-Loc, type with infinite position lever (for 3-inches and smaller) and pressure-responsive seat or double seat type and memory stop. Provide gear operator on valves 4-inches and larger.

   i. Valve stem shall be stainless steel, and shall be offset from the disc centerline to provide complete 360 degree circumferential seating.

   ii. Valve shall be rated to +250 deg F in sizes through 12-inches.

   iii. Seat shall be elastomer, of a grade suitable for the intended service. The seat shall be pressure responsive in sizes through 12 inches.

   iv. For valves 4 inches and larger located 10 feet-0 inches or more above finished floor shall be provided with chain operators with chains extending to within 6 feet-0 inches above finished floor. Chain wheel and guide shall be galvanized.

k. Combination Shut-off/Balancing Valves:

Victaulic/ TA Hydronics, Taco Circuit Setter, Bell & Gossett Circuit Setter Plus, Flowset Accuset, Gerand, or as approved equal, 2-inch-3-inch 300 lb. rated Ametal (copper-alloy) body globe type or ball valve with bronze body/brass ball construction with glass and carbon filled TFE seats, in-line flow meter and balancing and shut-off valve with built in ball valve for flow adjustment. Valve shall have memory stop, calibrated nameplate, Schrader valve connections and preformed molded insulation. Valves shall be leaktight at full rated working pressure. Balance valve size shall be selected based on manufacturer's acceptable flow range and design flow rate. Pressure drop through combination shut off balance valves shall not exceed 5 feet of head at design flow rate. Coil-Hook-up Connections: Victaulic Koil-Kits Series 799 or 79V or approved equal may be used at coil connections. The kit shall include a

autoflow balancing valve, Series 78Y Strainer-Ball, Series 78U Union-Port fitting, with Series 78T ball valve and required coil hoses. A Style 793 and/or 794 differential pressure controller shall be provided as required.

l. Extended Valve Stems: Provide and install round collar type extended valve stems on all valves installed in insulated piping. Valve stem and collar shall be selected to suit insulation thickness and maintain valve handles outside of insulation.

m. Alternate:

i. At contractors option all HVAC water supply and return lines may be copper type L (ASTM Std. B88) with wrought copper fittings (ASTM Std. B 16.22) with brazed or 95-5 silver solder joints lead and antimony based solders are prohibited and all bronze valves may be used on piping 2 inches and less in size.

ii. At Contractors option, Viega Pro Press/ Mega Press, or Apollo Press/Apollo Power Press, Pressure Seal mechanical fittings may be utilized. Viega, ProPress Pressure Seal Fittings: Bronze or copper shall conform to ASME B16.51, ICC LC 1002, and IAPMO PS 117. ProPress fittings ½-inch thru 4- inch for use with ASTM B88 copper tube type L and ½-inch up to 1-1/4-inch annealed copper tube. ProPress fittings shall have an EPDM sealing element and Smart Connect (SC) feature. 2-1/2-inch thru 4-inch shall have a 420 stainless steel grip ring, PBT separator ring, EPDM sealing element and Smart Connect (SC) feature.

2. Refrigeration Piping:

a. Concealed: Tube Size ¾ -inch & Smaller:
ASTM B280, copper tube; Type ACR, soft annealed temper fittings; cast copper-alloy fittings for flared copper tubes; flared joints. Fittings shall be ASME B16.22, wrought copper. Joints shall be brazed, AWS A5.8, BCUP silver/phosphorous/copper alloy with melting range 1190 to 1480 degrees F.

b. Concealed: Tube Size 7/8 inch through 4-1/8inches:
Copper tube, Type ACR, soft annealed temper; wrought-copper, brazed-joint fittings; brazed joints.

c. Exposed: Tube Size ¾ Inch and Smaller:
Copper pipe, Type ASTM B88, Type K with brazed wrought-copper fittings conforming to ASME B16.22. Filler metal shall be brazing type conform to AWS A5.8.

d. Exposed: Tube Sizes 7/8 Inch and Larger:
Copper pipe, Type ASTM B88, Type K with brazed wrought-copper fittings conforming to ASME B16-22. Filler metal shall be brazing type conforming to AWS A5.8.

e. Brazed Joints: Braze joints using American Welding Society (AWS) classification BCuP-4 for brazing filler metal.

f. Flexible connectors: 500-psig (3450-kPa) minimum operating pressure; stainless-steel core and high-tensile stainless-steel-braid covering; dehydrated, pressure tested, minimum 7 inches (180 mm) long.

g. Diaphragm Packless Valves:
500-psig (3450-kPa) working pressure and 275 degrees Fahrenheit (135

degrees C) working temperature; globe design with straight-through or angle pattern; forged-brass or bronze body and bonnet, phosphor bronze and stainless-steel diaphragms, rising stem and handwheel, stainless-steel spring, nylon seat disc, and with solder-end connections.

h. Packed-Angle Valves: 500-psig (3450-kPa) working pressure and 275 degrees Fahrenheit (135 degrees C) working temperature; forged-brass or bronze body, forged-brass seal caps with copper gasket, back seating, rising stem and seat, molded stem packing, and with solder-end connections.

i. Check Valves: Smaller than NPS 1 (DN 25): 400-psig (2760-kPa) operating pressure and 285 degrees Fahrenheit (141 deg Celsius) operating temperature; cast-brass body, with removable piston, polytetrafluoroethylene seat, and stainless-steel spring; globe design. Valve shall be straight-through pattern, with brazed-end connections.

j. Check Valves: NPS 1 (DN 25) and Larger: 400-psig (2760-kPa) operating pressure and 285 degrees Fahrenheit (141 deg Celsius) operating temperature; cast-bronze body, with cast-bronze or forged-brass bolted bonnet; floating piston with mechanically retained polytetrafluoroethylene seat disc. Valve shall be straight-through or angle pattern, with solder-end connections.

k. Service Valves: 500-psig (3450-kPa) pressure rating; forged-brass body with copper stubs, brass caps, removable valve core, integral ball check valve, and with brazed-end connections.

l. Service valves for VRV branch selector boxes and indoor heat pumps shall be bi-directional Sporlan model EBVT with access fitting. Valves shall be rated for 700psig, shall be U.L. listed, suitable for full refrigeration service temperature range of -40°F to 325°F. Valves shall include the following additional features:

i. Welded body joint with forged brass body construction with extended copper fittings.
ii. Dual Teflon seals.
iii. Full size ports to minimize pressure drop.
iv. ¼ turn operation with stainless steel stop plate.
v. Internal ball relief port to allow positive shut-off in either direction, even during system evacuation.
vi. Suitable for R-410A refrigerant.
vii. Date code stamped into valve body.

3. Cooling Coil A/C Condensate Drain and Floor Drain Piping that is Collecting A/C Condensate Piping:

a. Pipe & Fittings: All A/C condensate drain piping, including floor drain piping that is collecting A/C condensate, shall be constructed of Type L copper tubing, with sweat fittings made with 95-5 solder. Washout plugs (cleanouts) shall be strategically located to allow periodic flush out of system. At a minimum, provide washout plugs at equipment connections and at direction changes of 90 degrees F or greater.

b. Provide backwater valve (ball float type) at connections of condensate piping to stormwater piping and air gap fitting. Backwater valve shall be Model Z1099 as manufactured by Zurn or approved equal. Backwater valve shall have drain coated cast iron body, plastic ball float, bronze

backwater bushing and replaceable neoprene seat.

4. Gas Fired Condensing Boiler Condensate Piping

a. Piping shall be PVC pipe, ASTM D1785 schedule 40 with ASTM D2466 socket fittings for schedule 40. Join PVC pipe/fittings utilizing solvent cement ASTM D2564 with ASTM F656 primer.

B. Steel pipe shall be similar and equal to National Tube Company, Grinnell, Republic, or Bethlehem black or zinc-coated (galvanized) as hereinafter specified. Pipe shall be free from all defects which may affect the durability for the intended use. Each length of pipe shall be stamped with the manufacturer's name.

C. Copper pipe shall be Revere, Anaconda or Chase with approved solder fittings.

D. Welding fittings for steel pipe shall meet the requirements of ASTM Standard A-23 and shall be standard catalog products. Fittings fabricated by metering and notching pipe will not be accepted.

2.2. PIPE HANGERS, ROLLER SUPPORTS, ANCHORS, GUIDES, AND SADDLES

A. All hangers for metallic piping shall be adjustable, wrought clevis type, or adjustable malleable split ring swivel type, having rods with machine threads. Hangers shall be Grinnell Company's Figure 260 for pipe ¾-inch and larger, and Figure 65 for pipe 2-inches and smaller, or approved equal. Adjustable pipe stanchion with U-bolt shall be Grinnell Company's Figure 191. Pipe roller supports shall be Grinnell's Figure 181 or Figure 271. Exterior pipe hangers shall be galvanized or stainless steel construction. For copper piping in direct contact with the hanger, hanger construction shall be copper coated to prevent contact of dissimilar metals similar to Grinnell's Figure CT-65. Hanger spacing and rod sizes for steel and copper pipe shall not be less than the following:

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
3/4 & 1	6	5	3/8
1 - ½	6	8	3/8
2	8	8	3/8
2 – ½	10	9	½

NOMINAL PIPE SIZE IN	STD. STEEL PIPE	MAXIMUM SPAN FT. COPPER TUBE	MINIMUM ROD DIAMETER INCHES OF ASTM A36 STEEL THREADED RODS
3	12	10	½
4	14	12	5/8
5	14	12	5/8
6	16	14	3/4
8	18	16	7/8
10	20	18	7/8
12	20	18	7/8

B. Anchors, guides, and roller supports shall be installed in accordance with the contract drawings and manufacturer's recommendations to provide pipe support and control pipe movement for all piping systems. Anchors and guides shall be securely attached to the pipe support structure. Submit shop drawing for proposed pipe support structure for guides and anchors for approval of the Structural Engineer. Pipe alignment guides shall be Fig. 255 Grinnell, or as approved equal. Guides shall be sized to accommodate the pipe with insulation. Guides shall be steel factory, fabricated, with bolted two section outer cylinder and base for alignment of piping and two section guiding spider for bolting to pipe.

C. Hangers for pipe sizes ½ to 1 ½ inch (13 to 38 mm): Carbon steel, adjustable swivel, split ring.

D. Hangers for cold pipe sizes 2 inches (50 mm) and over: Carbon steel, adjustable, clevis.

E. Hangers for cold pipe sizes 2 to 4 inches (50 to 100 mm): Carbon steel, adjustable, clevis.

F. Hangers for cold pipe sizes 6 inches (150 mm) and over: adjustable steel yoke, cast iron roll, double hanger.

G. Multiple or Trapeze hangers: Steel channels with welded spacers and hanger rods.

H. Multiple or Trapeze hangers for hot pipe sizes 6 inches (150 mm) and over: Steel channels with welded spacers and hanger rod, cast iron roll.

I. Wall support for pipe sizes to 3 inches (76 mm): cast iron hook

J. Wall support for pipe sizes 4 inches (100 mm) and over: Welded steel bracket and wrought steel clamp.

K. Wall support for hot pipe sizes 6 inches (150 mm) and over: welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.

L. Vertical Support: Steel riser clamp.

M. Floor support for cold pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

N. Floor support for hot pipe sizes to 4 inches (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

O. Floor support for hot pipe sizes 6 inches (150 mm) and over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.

P. Copper pipe support: Carbon steel ring, adjustable, copper plated.

Q. Hanger rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

R. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

S. For exterior pipe supports provide stainless steel brackets and anchors.

2.3. HYDRONIC EXPANSION LOOPS

A. Provide hydronic flexible expansion loops of size and material noted on drawings as manufactured by Metroloop or approved equal. Flexible loops shall be designed to impart no thrust loads on the anchors. The loop shall consist of two flexible sections of hose and braid, two 90 degree elbows, and a 180 degree return. Loops shall be installed in a neutral, precompressed, or pre-extended condition as required for application. Loops are to be installed within four pipe diameters, both upstream and downstream, from a pipe guide.

B. Where indicated provided nested loops and support the 180 degrees return bend. Nested loops shall be sized to absorb the axial compression movement as scheduled on the contract drawings.

2.4. VALVES

A. Provide parts list and assembly drawings (exploded view) for all valves in shop drawing submittals. Provide valves of the same type by the same manufacturer.

B. Check valves in base mounted pump discharges shall be of the vertical type and shall be Victaulic Series 716/ W715, Miller "non-slam" check valves, Apollo/Shurjoint SJ-900, or approved equal suitable for service intended. Check valves in circulator discharges shall be horizontal type.

C. Provide at each base mounted pump a suction diffuser of size and type shown on drawings. Units shall consist of a ductile cast iron angle type body with inlet vanes, magnetic insert, and blowdown connection tapped gauge post, 125 psi ANSI flange and a combination stainless steel diffuser strainer with 5/32 or 3/16-inch diameter opening for pump protection. Unit shall be equipped with a disposable fine 20-mesh stainless steel start up strainer which shall be removable after 30 days. Flow direction shall be from inside the strainer to outside for ease of service and cleaning. The body shall fit the pump and connecting pipe size. The unit shall be provided with a base support boss or an adjustable support foot to relieve piping strains from the pump suction. Suction diffuser shall be Victaulic 731 Series, Taco "SD" Series Catalog 300-4.1, Bell and Gossett Model FLG, Armstrong, Patterson, Apollo/Shurjoint 725F, or engineer approved equal.

D. Multi-purpose valve (non-slam check valve, throttling valve, shut-off valves and calibrated balancing valve) shall be provided at discharge side of constant speed pumps. The valve shall be of heavy-duty cast iron construction with standard ANSI flanged connections and rated for a maximum working pressure of 175 psig at 240oF. The valve shall be fitted with a stainless steel stem or stem sleeve and brass seat with "O" ring seal. Valve shall be Taco "Plus One" Number 300-4.2, Bell and Gossett 3DS Triple Duty Valve, Armstrong, Patterson, or as approved equal, and shall have check and plug valve features plus a memory stop with pointer and scale. Provide additional shut-off valve to allow servicing of check valve if a multipurpose valve is utilized in lieu of separate check, shut-off, and balance valve. Provide additional shut-off valve downstream of multi-purpose valve to allow servicing of multi-purpose check valve feature. Provide pre-manufactured, removable insulation covers for all multipurpose valves.

E. Triple Duty Valve Assembly: Assembly shall consist of a Victaulic Master Seal, Apollo/Shurjoint SJ-900, or approved equal butterfly valve with memory stop and a Series 779 Venturi-Check, rated for water service to 230 degrees Fahrenheit (110 degrees Celsius) and pressures to 300 psig (2065-kPa).

1. For 14” through 24” sizes, Victaulic AGS-Vic300, Apollo/Shurjoint SJ-300N-L/SJ-300N-W, or approved equal butterfly valve with Series W715 AGS check valve, rated for pressures to 230 psig (1575-kPa).

F. Do not install multipurpose valves or balance valves on the discharge of variable speed pumps.

2.5. STRAINERS

A. Strainers shall be of the basket or "Y" type and shall be heavy and durable, constructed of ductile iron to ASTM A536 or the best grade gray iron with the bottoms drilled and plugged. Bodies shall have arrows clearly cast on the sides to show flow direction. Strainers shall be equipped with easily removable covers and brass sediment baskets made of stainless steel or brass not less than #22 gauge in thickness. Total area of basket perforations shall be not less than two times the cross section of the entering pipe. Flow shall be into basket, and then out through the perforations. Strainers shall be suitable for water or the intended fluid. Strainers 2 inches and smaller shall have threaded or solder ends, 2 inches and larger shall have flanged ends.

B. Strainer screens shall be stainless steel with perforations and shall be 1/16-inch for pipe sizes 5 inches and less, 1/8-inch (40 percent open area) perforations for pipe sizes 6-inch

and greater.

C. Provide valved and capped (with chain) blowdowns in each strainer. Blowdown valves shall be Apollo 78-100/200 series or as approved equal.

D. Strainers shall be manufactured by Victaulic Style 732/W732, Watts, Mueller, Armstrong, Yarway, Spirax/Sarco, Apollo/Shurjoint 726, or as approved equal.

2.6. UNIONS, FLANGES, AND COUPLINGS

A. Unions in steel pipe 2-inches and smaller shall be malleable iron with brass inserted seats designed for a working pressure of 150 psig.

B. Unions in copper pipe 2-inches and smaller shall be sweat fittings with bronze seats designed for a working pressure of 125 psig.

C. Unions in stainless steel pipe 2-inches and smaller shall be hexagonal threaded type stainless steel unions, with VicPress ends. Basis of Design: Victaulic Style P584.

D. Flanges for steel pipe over 2 inches shall be 150 psig, forged steel, slip on. Gaskets shall be 1/16 inch thick pre-formed neoprene.

E. Flanges for copper pipe over 2 inches shall be bronze. Gaskets shall be 1/16 inch thick preformed neoprene.

2.7. MANUAL AIR VENTS

A. Manual air vents shall be similar to the hereinafter specified gauge valves. Provide 1/4-inch size on ¾-inch pipe and smaller, ½ -inch size on 1-inch pipe and larger. Install at all high points of piping. Valves shall be Crane No. 88, or as approved equal, with threaded ends, bronze body, bronze or brass bonnet and bronze stem.

2.8. AUTOMATIC AIR VENTS

A. Provide at air separators, expansion tanks and where shown on the drawings, float actuated non-modulating high capacity air vent to purge free air from the system and provide a positive shut-off at pressures up to 150 psig at a maximum temperature of 250 degrees Fahrenheit. The high capacity air vent shall prevent air from entering the system if the system pressure drops below atmospheric pressure. The air vent shall be pilot operated for intermittent purging of free air up to pressures of 2 psig during normal system operation and diaphragm operated for full capacity purging of free air at pressures between 2 and 150 psig. The high capacity air vent shall be constructed of cast iron and fitted with components of type 313 stainless steel, brass, EPDM and silicone rubber. Pipe discharge to closest floor drains with Type K copper tubing. The high capacity vent shall be Model 107 by Bell and Gossett, Model 13w by Spirax Sarco, Taco, Spirotherm Spirotop, or as approved equal.

2.9. THERMOMETERS

A. Unless otherwise indicated, thermometers shall be ASTM E1, in a glass type, organic filled, 9-inch scale size, corrosion-resistant metal case, with "any-angle" mounting with

positive locking device. Trerice Industrial Thermometers, Weksler Instruments, Ernst Gage Co., Miljoco, or approved equal. Insertion stem length shall suite the pipe size and configuration. Thermometer wells shall be brass with brass union hubs in copper and in ferrous piping. Where piping is insulated or otherwise covered, use wells with lagging extension. Where wells are installed in pipe tees at turns, increase pipe size so that well does not restrict flow. Accuracy shall be 2 percent.

B. Unless otherwise indicated, thermometer ranges shall be as follows:

1. Chilled water systems: 0 degrees F to 100 degrees Fahrenheit, 1 degrees Fahrenheit Division

2. Heating Water: 30 degrees Fahrenheit to 240 degrees Fahrenheit, 2 degrees Fahrenheit Division.

C. Provide heat conducting compound in wells.

2.10. PRESSURE GAUGES

A. Unless otherwise indicated, pressure gauges shall be the bronze bourdon tube type, 4-1/2-inch dial, stem mounting, cast aluminum adjustable pointer, 1 percent accuracy over middle half of scale range, 1-1/2 percent over balance: Trerice Model 600C; Weksler Instruments, Ernst Gage Co., Miljoco, or as approved equal.

B. Gauges shall have pressure, vacuum, compound, or retard ranges as required, select ranges so that the normal readings are at the approximate midpoint and maximum system pressures do not exceed full scale.

C. Furnish and install a gauge valve at each pressure gauge. Gauge valves shall be Crane Model No. 88, Needle Valve, Ernst Gage Co. FLG 200, Wexler Instrument Corp. Type BBV4, or approved equal, rated for pressure intended.

D. Gauge connections for pressure gauges, thermometers, or control instruments shall be made using tee fittings, except that gauge connections up to 1-inch size in steel may be using threaded extra heavy pipe couplings welded directly to the main, provided that the main is at least 2-inch size for 2-inch connections, 3-inch size for 3/4-inch connections, and 4-inch size for 1-inch connections. Minimum gauge connection shall be 2-inch ips.

E. Provide snubbers on all gauges. Snubbers shall be No. 872 by Trerice, RS1/RS6 by Wexler Instruments, Miljoco or as approved equal.

2.11. FLOW METERS

A. Griswold or Bell & Gossett Venturi disturbed flow measurement quickset flow meters shall be utilized in lieu of sentinel type flow meters. Units shall consist of a spun steel venturi welded into the pipe. Disturbed fluid shall be channeled through the throat of the venturi with a multi-point Piezo Ring. Accuracy shall be ± 1% PSID with no straight pipe run required. Furnish differential pressure gauge supplied with carrying case and hoses.

2.12. PIPING SPECIALTIES

A. Furnish and install flexible pipe connections, as specified and/or shown on the drawings, at suction and discharge connections of all base mounted and vertical in-line pumps, connections to energy recovery ventilators, and SZVAV units, all vibrating equipment, and elsewhere as shown. Pump flexible connections shall be utilized at pumps and hose kits at heat pumps. Refer to Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for specifications.

B. Pressure relief valves shall be provided in the number and sizes required to relieve 110 percent of the full input to the systems. Valves shall be rated; and installed in accordance with ASME, and CSD-1 including all amendments. Pipe discharge full size to floor drain, (with union) and support discharge pipe to prevent exerting any strain on relief valve body, piping to be Type-L copper. Water safety relief valves shall be Watts Series 740, Conbraco, Series 154A, Bell and Gossett, or approved equal. Provide pressure gauge adjacent to all safety relief valves.

2.13. ESCUTCHEONS

A. Provide chromium plated escutcheons properly fitted and secured with set screws on all exposed piping which passes through walls, floors or ceilings of finished spaces.

B. All escutcheon plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface. Plastic escutcheon plates will not be accepted.

2.14. DIELECTRIC CONNECTIONS:

A. Furnish and install electrically insulated dielectric waterway fittings, unions or flanges, as manufactured by Victaulic Company Style 47, EPCO Sales, Inc., or approved equal at the following locations:

1. Where steel piping systems join copper piping.

2. Where copper tube connects to domestic water storage tanks, water heaters, heat exchangers, expansion tanks, and other steel vessels.

3. Avoid the installation of steel nipples, cast iron or steel valves and specialties, or other ferrous components in predominately copper piping systems. Where such installation is necessary, isolate the component with dielectric connections. Do not mix steel pipe and copper tube in the same run of pipe or in the same section of a piping system.

4. Dielectric Waterway: Copper silicon casting conforming to UNS C87850 with grooved and/or threaded ends. UL classified in accordance with NSF-61 for potable water service, and shall meet the low-lead requirements of NSF-372. Basis of Design: Victaulic Series 647.

2.15. SLEEVES

A. Sleeves shall be provided around all pipes through walls, floors, ceilings, partitions, roof structure members or other building parts. Sleeves shall be standard weight galvanized iron pipe two sizes larger than the pipe or insulation so that pipe or insulation shall pass

through masonry or concrete walls or floors. Provide 20 gauge galvanized steel sheet or galvanized pipe sleeves for all piping passing through frame walls.

B. Sleeves through floors shall be flush with the floor except for sleeves passing through Equipment Rooms which shall extend ¾-inch above the floor. Refer to Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for mechanical equipment room penetrations additional requirements. Space between the pipe and sleeve shall be caulked. Escutcheon plates shall be constructed to conceal the ends of sleeves. Each trade shall be responsible for drilling existing floors and walls for necessary sleeve holes. Drilling methods and tools shall be as hereinbefore specified.

C. Sleeves through walls and floors shall be sealed with a waterproof caulking compound.

D. Firestop at sleeves that penetrate smoke barriers smoke partitions and/or rated walls/floors.

2.16. PRESSURE REDUCING VALVES

A. Provide pressure reducing valves as indicated, of size and capacity selected by the installer to maintain operating pressure on the system. Body shall be cast-iron or bronze construction, renewable stainless steel seat, non-corrosive disc, water tight cage assembly, adjustable pressure ranges and inlet strainer Watts Regulator Model 223-S, Armstrong, Bell and Gossett, Apollo 36LFPR, or as approved equal.

B. Provide pressure gauge adjacent to all pressure reducing valves to verify proper set point.

2.17. WATER PROOF PIPE PENETRATION SEALS

A. Provide and install waterproof pipe penetration seals at all pipes that enter the building below grade or through exterior wall.

B. Link seals are to be Metraflex Metraseals, Model MS, Linkseal, or approved equal, black EPDM seal material, glass reinforced plastic pressure plates, zinc plated nuts and bolts, seals are to be resistant to sunlight and ozone, pressure rated to make a hydrostatic seal of up to 20 psig and up to 40 feet of head, temperature rated from –40 degrees F to 250 degrees Fahrenheit.

2.18. TEST PLUGS

A. Where indicated, furnish and install P/T plugs or Pete's Plugs as manufactured by IMAC Systems or approved equal.

B. Description: Nickel-plated, brass-body test plug in NPS 2 (DN15) fitting. Test plugs shall be as manufactured by Trerice, Watts, Natural Meter, Apollo Brass Test Plugs, or approved equal. Test-station fitting made for insertion in piping tee fitting.

C. Body: Length as required to extend beyond insulation. Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS ¼ (DN 8) or NPS ½ (DN15) as required, ASME B1.20.1 pipe thread.

E. Pressure Rating: 500 psig minimum.

F. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

G. Core Inserts: One or two self-sealing valves, suitable for inserting 1/8 inch OD probe from dial-type thermometer or pressure gage. Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

H. Core Insert: Self-sealing valve, suitable for inserting 1/8 inch OD probe from dial-type thermometer or pressure gage.

I. Core Material for Air, Water, Oil, and Gas: 20 to 300 degrees F chlorosulfonated polyethylene synthetic rubber.

J. Test-Plug Cap: Gasketed and threaded cap, with retention chain or strap.

K. Test Kit: Pressure gage and adapter with probe, two bimetal dial thermometers, and carrying case.

L. Pressure Gage and Thermometer Ranges: approximately two times the system's operating conditions.

M. Self-closing valves with caps and retaining straps.

2.19. FLO-CONTROL VALVES

A. Furnish and install flo-control valves as shown on contract drawings to prevent gravity circulation in forced hot water systems. Flo-control valves shall be Bell & Gossett flo-control valves, TACO flo checks, or approved equal.

B. Flo-control valves shall be suitable for installation in vertical or horizontal piping. Disc shall be precision machined bronze. Valve seats shall be heavy wall brass. Flo-control valves shall be suitable for a maximum operating temperature of 275 degrees F and a maximum working pressure of 125 psig. Flow-control valves shall not be selected based on line size. Select flow-control valves at design flow rate to limit pressure drop to 6 Ft head.

C. Flo-control valves shall be constructed to allow cleaning without breaking pipe connections. Flo-control valves shall be installed with clearances from center line of valves to ceiling as required by manufacturer. Flo-control valves shall feature a manual open position for gravity circulation.

2.20. TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.

2. Pressure rating at least equal to pipes to be joined.

3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Plastic-to-Metal Transition Fittings:

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

a. Charlotte Pipe and Foundry Company.
b. Harvel Plastics, Inc.
c. Spears Manufacturing Company.

2. Description: PVC or CPVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket end.

D. Plastic-to-Metal Transition Unions:

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

a. Colonial Engineering, Inc.
b. NIBCO INC.
c. Spears Manufacturing Company.

2. Description: PVC or CPVC four-part union. Include brass threaded end, solvent-cement-joint plastic end, rubber O-ring, and union nut.

PART 3. EXECUTION

3.1. GENERAL PIPING INSTALLATION REQUIREMENTS

A. All pipes shall be cut accurately to measurements established at the building, and shall be worked into place without springing or forcing, properly clearing all windows, doors and other openings. Excessive cutting or other weakening of the building structure to facilitate piping installation will not be permitted. All pipes shall be so installed as to permit free expansion and contraction without causing damage. All horizontal mains shall pitch down in the direction of flow with a grade of not less than 1 inch in 40 feet. All open ends of pipe lines, equipment, etc., shall be properly capped or plugged during installation to keep dirt or other foreign material out of the system. All pipes shall be run parallel with the lines of the building and as close to walls, columns and ceilings as may be practical, with proper pitch. All piping shall be arranged so as not to interfere with removal of other equipment on devices not to block access to doors, windows, manholes, or other access openings. Flanges or unions, as applicable for the type of piping specified, shall be provided in the piping at connections to all items of equipment, coils, etc., and installed so that there will be no interference with the installation of the equipment, ducts, etc. All valves and specialties shall be placed to permit easy operation and access and all valves shall be regulated, packed and glands adjusted at the completion of the work before final acceptance. All piping shall be installed so as to avoid air or liquid pockets throughout the work. Ends of pipe shall be reamed so as to remove all burrs.

B. All piping shall be graded to convey entrained air to high points where automatic air vents shall be provided. The size of supply and return pipes for each piece of equipment shall in no case be smaller than the outlets in the equipment.

C. All piping shall be run to provide a minimum clearance of 2-inches between finished covering on such piping and all adjacent work. Group piping wherever practical at common elevations.

D. All valves, strainers, caps, and other fittings shall be readily accessible.

E. Drain valves with hose connections shall be provided at low points for drainage of piping systems. Blow down valves shall be provided at the ends of all mains and branches so as to properly clean by blowing down the lines throughout in the direction of normal flow.

F. Discharge lines from all relief valves shall be piped to within 4-inches of floor and extend to floor drains wherever floors are not pitched to drains. Pitch the relief valve piping away from the relief valve to issue that no fluid can be trapped in valve discharge. Support all relief valve piping to prevent exerting strain on the relief valve body. The end of the relief valve discharge piping shall not be threaded to prevent capping or plugging.

G. All branches from water mains shall be taken from the top of the supply mains at an angle of forty-five (45) degrees above the horizontal, unless otherwise directed. Branches feeding down shall be taken from the side or bottom of the main on water mains only. All connections shall be carefully made to insure unrestricted circulation, eliminate air pockets or trapped condensate, and permit the complete drainage of the system.

H. Cutoff valves shall be provided on each branch line from the mains on all heating/air conditioning lines.

I. Shut-off valves shall be installed at the inlet and outlet of each coil and piece of equipment to permit isolation for maintenance and repair. Units having multiple coils shall have separate valves for each coil.

J. Balancing valves shall be installed in all heating/air conditioning water branches and at all pumps, and where indicated on the drawings.

K. Unions shall be installed on all bypasses, ahead of all traps, at all connections to equipment, where shown on drawings or where required to facilitate removal of equipment whether shown or not.

L. Spring clamp plates (escutcheons) shall be provided where pipes are exposed in the building and run through walls, floors, or ceilings. Plates shall be chrome plated spun brass of plain pattern, and shall be set tight on the pipe and to the building surface.

M. If the size of any piping is not clearly evident in the drawings, the Contractor shall request instructions for the Engineer as to the proper sizing. Any changes resulting from the Contractor's failure to request clarification shall be at his expense. Where pipe size discrepancies or conflicts exist in the drawings, the larger pipe size shall govern.

N. Approved expansion loops shall be provided to permit free expansion and contraction of all piping systems.

O. Install all valves with stem upright or horizontal, not inverted.

P. Where pipe support members are welded to structural building framing, scrape, brush clean, weld and apply one coat of zinc rich primer.

Q. Provide clearance for installation of insulation and access to valves and fittings.

R. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

S. All water containing pipes shall be routed clear of combustion air dampers and louvers to prevent freezing condition when dampers are open.

T. Provide manual air vents at top of piping systems.

3.2. THERMOMETER AND PRESSURE GAGE INSTALLATION REQUIREMENTS.

A. Install thermometers and adjust vertical and tilted positions.

B. Install separable sockets in vertical position in piping tees where fixed thermometers are indicated.

1. Install with socket extending to one-third diameter of pipe.

2. Fill sockets with oil or graphite and secure caps.

C. Install pressure gages in piping tees with pressure-gage valve located on a pipe at most readable location.

D. Adjust faces of thermometer and gages to proper angle for best visibility.

E. Clean windows of thermometer and gages and clean factory-finished surfaces. Replace cracked and broken window, and repair scratched and marred surfaces with manufacturer's touch up paint.

3.3. VALVE INSTALLATION REQUIREMENTS

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance of valves. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves from fully open to fully closed positions. Examine guides and seats made accessible by such operation.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

G. Install valves as indicated, according to manufacturer's written instructions.

H. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

I. Install valves with unions or flanges at each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

J. Locate valves for easy access and provide separate support where necessary.

K. Install valves in horizontal piping with stem at or above the center of the pipe.

L. Install valves in a position to allow full stem movement.

M. For chain wheel operators, extend chains to 60 inches above finished floor elevation.

N. Adjust or replace packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if leak persists.

O. Install flow control valves with clearances from center line of valve to ceiling to allow servicing as required by manufacturer.

3.4. REFRIGERANT PIPING AND ACCESSORIES INSTALLATION REQUIREMENTS

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

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise. All exposed piping shall be hard copper tubing with brazed joints. Refer to Architectural Contract Documents to determine exposed areas.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to units to allow service and maintenance.

G. Install piping free of sags and bends. Install VEE clevis hangers and VEE troughs on pipes less than ¾”inch in diameter.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Install refrigerant piping in protective conduit where installed below ground.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.

2. Install horizontal suction lines with a uniform slope downward to compressor.

3. Install traps and double risers to entrain oil in vertical runs.

4. Liquid lines may be installed level.

O. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

Q. Identify refrigerant piping and valves.

R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section, “Common Work Results for HVAC”.

S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section, “Common Work Results for HVAC”.

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section, “Common Work Results for HVAC”.

U. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6m) long.

2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6m) or longer.

3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6m) or longer, supported on a trapeze.

4. Spring hangers to support vertical runs.

5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

V. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS ½ (DN 15): Maximum span, 60 inches (1500mm); minimum rod size, ¼ inch (6.4mm).

2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500mm); minimum rod size, ¼ inch (6.4mm).

3. NPS 1 (DN 25): Maximum span, 72 inches (1800mm); minimum rod size, ¼ inch (6.4mm).

4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400mm); minimum rod size, 3/8 inch (9.5mm).

5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400mm); minimum rod size, 3/8 inch (9.5mm).

6. NPS 2 (DN 50): Maximum span, 96 inches (2400mm); minimum rod size, 3/8 inch (9.5mm).

7. NPS 2-½ (DN 65): Maximum span, 108 inches (2700mm); minimum rod size, 3/8 inch (9.5mm).

8. NPS 3 (DN 80): Maximum span, 10 feet (3m); minimum rod size, 3/8 inch (9.5mm).

9. NPS 4 (DN 100): Maximum span, 12 feet (3.7m); minimum rod size, 1/2 inch (13mm).

W. For all interior refrigerant pipe/tubing that is less than 3/4inch in diameter, utilize VEE type clevis hanger Model 200 V and VEE type trough Model 200 VT; as manufactured by Carpenter and Patterson or approved equal. VEE trough materials shall be carbon steel with pre-galvanized finish. Install as required to maintain maximum hanger spacing requirements.

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

Y. Furnish and install complete refrigerant piping systems between the indoor units and outdoor units, branch selector boxes, indoor units, and compressor units. Support piping in accordance with Division 23 Section, HVAC Piping, Fittings, Valves, Etc. Piping shall be sized as recommended by unit manufacturer taking into account length of vertical and horizontal runs, and refrigerant type. Provide and install dual sets of refrigerant piping on all units required to have dual independent circuits.

Z. Furnish and install all required piping accessories including, but not limited to, thermal expansion valves, Sporlan, or approved equal; Packless isolation valves at condenser and evaporator coil, Henry or approved equal, charging valve with chained seal cap, Henry or approved equal, sight glasses, Henry or approved equal; filter dryer with replaceable cartridge, Sporlan, or approved equal, liquid line solenoid valve l20V/1/60 Hz., Sporlan, or approved equal. Contractor shall provide traps and double suction risers if required by equipment manufacturer. Pitch piping for proper oil return. Submit shop drawings on all components, and piping arrangements.

AA. All accessories shall be ARI rated. Furnish required nitrogen and refrigerant to fully test and charge system. Flood piping system with nitrogen when brazing.

BB. Refrigerant piping shall be Type 1 hard temper (ACR) copper tubing with wrought copper brazed fittings. Make joints with brazed wrought copper fittings.

CC. Refrigerant piping shall be cleaned, dehydrated and evacuated. Piping shall be evacuated and held to less than 2.5 mm Hg vacuum for a period of not less than 12 hours without appreciable pressure rise. Vacuum shall then be broken with refrigerant or dry nitrogen and re-evacuated to 2.5 mm Hg vacuum for an additional 12 hours. Piping test to be witnessed by Owner's representative and documented in writing. Submit results of tests to Architect/Engineer.

DD. All refrigerant/suction lines sets shall be fully insulated. Exterior pipe insulation shall be fully jacketed as specified in Division 23 Section, “HVAC Insulation”. Exposed interior pipe insulation shall be fully jacketed as specified in Division 23 Section, “HVAC Insulation”.

EE. Follow ASHRAE 15, latest edition procedures for charging and purging of systems and for disposal of refrigerant.

FF. Provide replaceable cartridge filter-driers, with isolation valves and valved bypass.

GG. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.

HH. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.

II. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.

JJ. Fully charge completed system with refrigerant after tested.

KK. Provide electrical connection to solenoid valves.

LL. Extend refrigerant piping to accommodate relocated existing condensing units. Pipe extensions or replacement sizing shall be per the existing unit manufacturer's requirements. Contractor shall take into account length of vertical and horizontal runs from existing indoor units to relocated existing outdoor units.

MM. All relocated condensing units shall be re-piped, re-charged, tested and made fully operational at time of start-up.

NN. Refrigerant relief piping shall be routed to building exterior as indicated on contract documents and in accordance with ASHRAE 15, latest edition.

OO. Install liquid indicators in liquid line leaving condenser, in liquid line leaving receiver, and on leaving side of liquid solenoid valves.

PP. Install strainers immediately upstream from each automatic valve, including expansion valves, solenoid valves, hot-gas bypass valves, and compressor suction valves.

QQ. Install strainers in main liquid line where multiple expansion valves with integral strainers are used.

RR. Install strainers in suction line of steel pipe.

SS. Install moisture-liquid indicators in liquid lines between filter-dryers and thermostatic expansion valves and in liquid line to receiver.

TT. Install receivers, sized to accommodate pump-down charge, on systems 5 tons (17.5 kW) and larger and on systems with long piping runs.

UU. Install flexible connectors at or near compressors where piping configuration does not absorb vibration.

VV. Test and inspect refrigerant piping according to ASME B31.5, Chapter VI.

1. Test refrigerant piping, specialties and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure.

2. Test high- and low-pressure side piping of each system at not less than the lower of the design pressure or the setting of pressure relief device protecting high and low side of system.

    a. System shall maintain test pressure at the manifold gage throughout duration of test.
    b. Test joints and fittings by brushing a small amount of soap and glycerin solution over joint.
    c. Fill system with nitrogen to raise a test pressure of 150 psig (1035 kPa) or higher as required by authorities having jurisdiction.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

WW. Adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.

XX. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

YY. Adjust set-point temperature of the conditioned air or chilled-water controllers to the system design temperature.

ZZ. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.

2. Check compressor oil level above center of sight glass.

3. Open compressor suction and discharge valves.

4. Open refrigerant valves, except bypass valves that are used for other purposes.

5. Check compressor-motor alignment, and lubricate motors and bearings.

AAA. Before installing copper tubing other than Type ACR, clean tubing and fittings with trichloroethylene.

BBB. Replace core of filter-dryer after system has been adjusted and design flow rates and pressures are established.

CCC. Charge system using the following procedures:

1. Install core in filter-dryer after leak test but before evacuation.

2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.

3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).

4. Charge system with a new filter-dryer core in charging line. Provide full-operating charge.

3.5. PIPE JOINTS INSTALLATION REQUIREMENTS

A. Welded Joints: Joints in piping 2-1/2-inches and larger shall be fusion welded. Welding shall be in accordance with recommendations of the American Welding Society. Welding fittings shall conform in physical and chemical properties to the latest revisions of the American Society for Testing Materials.

B. Qualify welding procedures, welders and operators in accordance with ASME B31.1, or ASME B31.9 as applicable, for shop and project site welding of piping work. Certify welding of piping work using Standard Procedure Specifications by, and welders tested under supervision of, National Certified Pipe Welding Bureau (NCPWB). Submit welders qualifications for approval.

C. Grooved Joints: Grooved joint shall be installed in accordance with the manufacturer’s

written recommendations. Grooved ends shall be clean and free from indentations, projections, or roll marks. The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service. The coupling manufacturer's factory trained representative shall provide on-site training for the contractor's field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed. (A distributor's representative is not considered qualified to conduct the training.)

D. Screwed Joints: All screwed joints shall be made with tapered threads properly cut. Screwed joints shall be made perfectly tight with a stiff mixture of graphite and oil, applied with a brush to the male threads on the fittings.

E. Soldered Joints and Copper Piping: Joints in copper piping shall conform to the following minimum standards.

1. The pipes shall be cut to a length making certain that the ends are square, using a fins hacksaw blade or tube cutter. The ends of all pipes shall be reamed and all burrs removed.

2. The outside end of the pipe and the cut end of the fitting shall be cleaned with steel wool, sand cloth, or steel wire brush. All dark spots shall be removed.

3. The flux shall be applied evenly and sparingly to the outside end of the pipe and the inside of the outer end of the fitting until all surfaces to be jointed are completely covered. The piping and fitting shall be slipped together and reworked several times to insure an even distribution of the flux.

4. The correct amount of solder per joint for each size pipe shall be used in accordance with the manufacturer's recommendations.

5. Solder joints shall be made by using a direct flame from a torch.

6. On pipe sizes larger than ¼-inch, the fittings and valves in the pipe shall be moved or tapped with a hammer when the solder starts to melt to insure an even distribution of the solder.

7. The excess solder shall be removed while it is still in the plastic state leaving a fillet around the cup of the fitting.

8. Solder joints shall be suitable for working pressure of 100 psig and for working temperature of not less than 250 degrees F. The type of solder and flux used will be submitted for approval. Type 95-5 shall be the minimum standard.

9. Lead and antimony-based solders shall not be used for potable water systems. Brazing and silver solders are acceptable.

F. Where copper piping joins steel piping, approved bronze adapters shall be used.

G. Prohibited Connections: No direct weld, soldered, or brazed connections, without unions or flanges, shall be made to valves, strainers, apparatus, or related equipment. Right and

left couplings, long threads, or caulking of pipe threads or gasket joints will not be permitted.

3.6. HANGERS, SUPPORTS, ANCHORS, GUIDES INSTALLATION REQUIREMENTS

A. General: All hangers shall be of an approved type arranged to maintain the required grading and pitching of lines to prevent vibration and to provide for expansion and contraction. Provide protection saddles between hangers and insulation on heating water insulated pipe. Saddles shall be Grinnells Figure 173/273 or approved equal. Provide approved spacers between saddles and pipe where flexible insulation is specified. Provide insulation protection shields for insulated piping without saddles. Shield shall be Grinnell Figure 167 or as approved equal.

B. Spacing: Regardless of spacing, hangers shall be provided at or near all changes in direction, both vertical and horizontal, for all piping. For cast iron soil pipe, one hanger shall be placed at each hub or bell.

C. Vertical Lines: Shall be supported at their bases, using either a suitable hanger placed in a horizontal line near the riser, or a base type fitting set on a pedestal, foundation or support. All vertical lines extending through more than one floor level shall be supported at each floor with a riser clamp. Riser clamp shall be Grinnell Co.'s Figure 261, or approved equal. All vertical drops to pump suction elbows shall be supported by floor posts.

D. Racks and Brackets: All horizontal piping on vertical walls shall be properly supported by suitable racks securely anchored into the wall construction. Where not practical to obtain ceiling anchorage, all piping near walls shall be supported by approved brackets securely anchored into the wall construction. Washer plates (Fib. 60, 60L) and other miscellaneous attachments, fasteners, etc., shall be Grinnell or as approved equal. All exterior hanger and bracket systems in their entirety shall be galvanized.

E. Pipe Hangers and supports shall be attached to the panel point at the top chord of bar joist or at a location approved by the structural engineer.

F. Select hangers and components for loads imposed. Secure rods with double nuts.

G. Support of horizontal piping shall allow for vertical adjustment after installation of piping.

H. Support overhead piping with clevis hangers.

I. Do not support all parallel piping from the same joist. Stagger all supports in accordance with the structural engineer's recommendations.

J. Install guides on piping adjoining expansion fittings and loops.

K. Attach guides to pipe and secure to building structure.

L. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

M. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

N. Construct concrete anchors of poured in place concrete of dimensions indicated and include embedded fasteners.

O. Install pipe anchors according to expansion fitting manufacturer's written instructions if expansion fittings are indicated.

P. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

Q. Refer to structural documents for appropriate connection/attachment materials to building.

3.7. AIR VENTING INSTALLATION REQUIREMENTS

A. The top of each hydronic water supply and return piping and other points as indicated or where necessary for the removal of air from the system or equipment, shall be vented using an approved type of manual air vent.

B. In addition to manual air vents at high points of system, each item of water heat transfer equipment shall be manually vented using an approved type manual air vent. All air vents shall be accessible.

3.8. EXPANSION LOOPS AND SWING CONNECTION INSTALLATION REQUIREMENTS

A. Install expansion fittings according to manufacturer's written instructions.

B. Install expansion fittings in sizes matching pipe size in which they are installed.

C. Align expansion fittings to avoid end loading and torsional stress.

D. Install pipe bends and loops cold sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

E. Attach pipe bends and loops to anchors.

1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

F. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

G. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

H. Connect mains and branch connections to terminal units with at least four pipe fittings,

including tee in main.

3.9. PIPING IDENTIFICATION INSTALLATION REQUIREMENTS

A. All piping shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color code and system identification shall comply with ANSI Standards and piping identification system shall comply with ASME A13.1-81., scheme for the identification of piping systems and ASHRAE Fundamentals Handbook, latest edition.

B. Markings shall be plain block letters, stenciled on pipes, and shall be located near each branch connection, near each valve, and at least every 10 feet on straight runs of pipe. Where pipes are adjacent to each other, markings shall be neatly lined up. All markings shall be located in such manner as to be easily legible from the floor. Pipe identification schedule shall be as follows:

OUTSIDE DIAMETER OF PIPE OR COVERING (INCHES)	LENGTH OF COLOR FIELD (INCHES)	SIZE OF LETTERS (INCHES)
½ to 1 ¼	8	½
1-½ to 2	8	¾
2 ½ to 6	12	1 ¼
8 to 10	24	2 ½
Over 10	32	3 ½

3.10. VALVE IDENTIFICATION REQUIREMENTS

A. All valves shall be tagged with a numbered tag.

B. The tags shall be made of 1-inch diameter brass tags fastened to the valve by means of brass chains. Numbers shall agree with valve numbers on diagrammatic herein before specified.

C. Provide a minimum of six (6) valve charts with valve numbers indicating valve type, size,

manufacturer and service.

D. Additional valve charts shall be mounted behind glazed wooden frames and be hung in each mechanical equipment room including each air handling unit mechanical equipment room. Additional copies shall be provided in each copy of the O&M manuals.

3.11. CLEANING PIPING AND EQUIPMENT

A. All heating water and chilled water systems shall be cleaned by filling with a solution of one (1) pound of trisodium phosphate to each 50 gallons of water and circulating this solution for a period of six (6) hours during which time the system shall reach operating temperature. The systems shall then be flushed with fresh water and refilled with fresh water and/or where indicated antifreeze solution and purged of all air.

B. All chilled water, heating water, piping system shall be flushed clean with fresh water. See Division 22 Sections, Plumbing Fixtures and Plumbing Equipment for domestic potable water cleaning and sterilization.

C. Any equipment, such as coils that have small tubing, shall be bypassed to prevent deposition of debris from the piping. Water balancing shall not be scheduled until the completion of the cleaning and treatment process.

D. All strainers shall be inspected and cleaned prior to testing and balancing. In addition, prior to substantial completion, contractor must inspect and clean all strainers.

3.12. PRESSURE SEAL FITTING INSTALLATION REQUIREMENTS

A. Viega, ProPress Pressure Seal bronze or copper fittings: Sealing element shall be verified for the intended use. Tube ends shall be cut on a right angle (square) to the tube. Tube ends shall be reamed and chamfered, all grease, oil or dirt shall be removed from the tube end with a clean rag. Visually examine the fitting sealing element to ensure there is no damage, and it is properly seated into the fitting. Utilizing a Viega Insertion Depth Inspection Gauge mark the tube wall, with a felt tip pen, at the appropriate location, or insert the tube fully into the fitting and mark the tube wall at the face of the fitting. Always examine the tube to ensure it is fully inserted into the fitting prior to pressing the joint. ProPress fittings ½-inch thru 4-inch shall be installed according to the most current edition of the Viega installation guidelines, using appropriate sized rigid ProPress tools. Installers shall attend a Viega ProPress installation training class.

B. After ProPress Pressure Seal fittings have been installed a “two step test” shall be followed. Pressurize the system with application appropriate test medium, water between 15 and 85 psi, or air/dry nitrogen between .5 and 45 psi. Check the pressure gauge for pressure loss. If the system does not hold pressure, walk the system and check for un-pressed fittings. Should you identify an un-pressed fitting ensure the tube is fully inserted into the fitting, and properly marked, prior to pressing the joint. After appropriate repairs have been made, retest the system per specification requirements, not to exceed 600 psi with water.

END OF SECTION

DIVISION 23 SECTION 230548
VIBRATION CONTROLS FOR HVAC, PLUMBING & FIRE PROTECTION EQUIPMENT
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SECTION 230548 - VIBRATION CONTROLS FOR HVAC, PLUMBING AND FIRE PROTECTION EQUIPMENT

PART 1. RELATED DOCUMENTS

1.1. GENERAL

A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 0I Specification Sections apply to work of this section.

B. All work under this section shall also be subject to the requirements of Division 23 Section, Common Work Results for HVAC.

1.2. SUMMARY

A. Provide all labor and materials necessary to furnish and install vibration control systems on this project as herein specified and/or shown on the drawings.

B. Mount all mechanical equipment on suitable vibration isolators so as to prevent transmission of vibration into or through the building structure. Isolators shall be as manufactured by Mason Industries, Inc., Korfund, Inc., Amber Booth, Vibration Mounting and Controls, or approved equal, and shall be selected by the isolator manufacturer for each item of equipment in accordance with requirements hereinafter specified.

C. The equipment manufacturer shall supply all pump and motor bases, fan and motor bases, cradles, isolation pipe/duct hangers, spring and/or neoprene isolators, neoprene pads, flexible connectors, etc. as a coordinated package by a single manufacturer.

D. Select isolators for uniform static deflections according to distribution of weight; and for not less than the indicated isolation efficiency with the lowest rotational speed of equipment as the disturbing frequency.

E. Isolators and bases shall be stable during stopping and starting of equipment without transverse or eccentric movement of equipment, and shall be designed to resist horizontal forces of equipment which may operate unbalanced.

F. In general, select isolators on the basis of criteria as specified in the ASHRAE Applications Handbook, Latest Edition.

1.3. SUBMITTALS

A. Shop Drawings: Indicate inertia bases and locate vibration isolators, with static and dynamic load on each.

B. Product Data: Provide schedule of vibration isolator type with location and load on each.

C. Manufacturer’s Installation Instructions: Indicate special procedures and setting dimensions.

D. Manufacturer's Certificate: Certify that isolators are properly installed and adjusted to meet or exceed specified requirements.

1.4. PROJECT RECORD DOCUMENTS

A. Record actual locations of hangers including attachment points.

1.5. COLOR CODING

A. All springs shall be color coded for load carrying capacity.

1.6. ALTERNATES

A. Refer to Division 01 Section, Alternates - Alternates for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. MANUFACTURER

A. Isolators shall be the equivalent of the following types by Mason Industries, Inc., Korfund, Inc. or approved equal.

2.2. CORROSION PROTECTION FOR STEEL PARTS

A. Where steel parts are exposed to weather or humid environments provide hot-dipped galvanized coating of at least 2 ounces of zinc per square foot of surface. Coat springs with neoprene.

2.3. SPRING MOUNTS AND SOUND PADS

A. Provide all spring mounts with leveling devices, minimum .25 inch thick neoprene sound pads, and zinc chromate plated hardware.

B. All sound pads shall be size for minimum deflection of .05 inch; meet requirements for neoprene pad isolators.

2.4. SPRINGS

A. All springs shall have minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between .3 and .6 of maximum deflection.

2.5. NEOPRENE

A. Grade durometer 40, 50 OR 60 AND OIL RESISTANT.

2.6. FLOOR MOUNTED ISOLATORS:

A. Neoprene Isolation Pads: Provide pads at least ¼ " thick with cross-ribbed or waffle design. For concentrated loads provide steel bearing plates bonded or cold cemented to the pads. Neoprene isolation pads shall be Type Super W.

B. Neoprene Isolators: Rubber (neoprene)-in-shear mounting: Provide molded neoprene isolators having steel base plates with mounting holes and, at the top, steel mounting plates with mounting holes or threaded inserts. Provide elements of type and size coded with molded letters or color-coded for capacity identification. Embed metal parts completely in neoprene. Double deflection neoprene mountings shall have a minimum static deflection of 0.35". Bolt holes shall be provided for these areas where bolting is required. On equipment such as small vent sets and close coupled pumps, steel rails shall be used above the mounting to compensate for the over-hang. Mountings shall be type ND or rails type DNR.

2.7. SPRING ISOLATORS

A. General: Provide spring isolators or protected spring isolators that are adjustable and laterally stable with free-standing springs of horizontal stiffness at minimum 80 percent of the vertical (axial) stiffness. For machine-attached and floor-attached restraining elements, separate from metal-to-metal contact by neoprene cushions 1/8 inch thick minimum. Provide neoprene acoustic friction pads at least ¼ inch thick.

B. Spring Isolator: Spring type isolators shall be free standing and laterally stable without any housing and complete with ¼ " neoprene acoustical friction pads between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflections, compressed spring height and solid spring height. Mountings shall be type SLF as manufactured by Mason Industries, Inc. or as approved equal.

2.8. SUSPENSION ISOLATORS

A. General: Provide hangers with suspension isolators encased in open steel brackets. Isolate hanger rods from isolator steel brackets with neoprene-lined opening.

B. Suspension Neoprene Isolators: Provide double-deflection elements with minimum 3/8 inch deflection.

C. Suspension Spring Isolators: Vibration hangers shall contain a steel spring and 0.3" deflection neoprene element in series. The neoprene element shall be molded with a rod isolation bushing that passes through the hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing thru a 30o arc before contacting the hole and short circuiting the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include a scale drawing of the hanger showing the 30o capability. Hangers shall be type 30N.

D. Precompressed Suspension Spring Isolators: Vibration hangers shall be as described in "C" above, but they shall be precompressed to the rated deflection so as to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a scale drawing of the hanger showing the 30o capability. Hangers shall be type PC30N.

2.9. THRUST RESTRAINTS

A. Adjustable spring thrust restraints, able to resist the thrust force with at least 25 percent unused capacity. The operating spring deflection shall be not less than 50 percent of the static deflection of the isolation supporting the machinery. The spring element shall be contained within a steel frame and designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of ¼" movement at start and stop. The assembly shall be furnished with one rod and angle bracket for attachment to both the equipment and ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrically on either side of the unit. Horizontal thrust restraints shall be type WB.

2.10. INERTIA BASES

A. Structural Bases: Vibration isolator manufacturer shall furnish integral structural steel bases. Bases shall be rectangular in shape for all equipment other than centrifugal refrigeration machines and pump bases which may be "T" or "L" shaped. Pump bases for split case pumps shall include supports for suction and discharge base ells. All perimeter members shall be beams with a minimum depth equal to 1/10th of the longest dimension of the base. Beam depth need not exceed 14" provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of one inch- bases shall be type WF.

B. Structural Rails: Vibration isolator manufacturer shall provide steel members welded to height saving brackets to cradle machines having legs or bases that do not require a complete supplementary base. Members shall be sufficiently rigid to prevent strains in the equipment. Inverted saddles shall be type ICS.

C. Concrete Bases: Vibration isolator manufacturer shall furnish rectangular structural beam or channel concrete forms for floating foundations. Bases for split case pumps shall be large enough to provide support for suction and discharge base ells. The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity. In general, bases shall be a minimum of 1/12th of the longest dimension of the base, but not less than 6". Forms shall include minimum concrete reinforcement consisting of half inch bars or angles welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom, or additional steel as is required by the structural conditions. Forms shall be furnished with steel members to hold anchor-bolt sleeves when the anchor bolts fall in concrete locations. Height saving brackets shall be employed in all mounting locations to maintain a 1" clearance below the base. Concrete shall be 3,000 psi concrete. Mass of concrete inertia bases shall be minimum of 2 times weight of isolated equipment. Bases shall be type K.

2.11. FLEXIBLE CONNECTORS FOR PIPING

A. General: Straight or elbow flexible connectors rated for temperatures, pressures, and fluids to be conveyed. Provide flexible connectors with the strength 4 times operating pressure at highest system operating temperature. Provide elbow flexible connectors with a permanently set angle.

B. Elastomeric Flexible Connectors: Flexible neoprene connectors shall be manufactured of multiple plys of nylon tire cord fabric and neoprene both molded and cured in hydraulic rubber presses. No steel wire or rings shall be used as pressure reinforcement. Straight connectors shall have two spheres. Connectors up to and including 1 ½ " diameter may have threaded ends. Connectors 2" and larger shall be manufactured with floating galvanized flanges recessed to lock the connector's raised face neoprene flanges. Hoses shall be installed on the equipment side of the shut-off valves. Connectors shall be rated a minimum of 150 psi at 220oF. Flanged equipment shall be directly connected to neoprene elbows in the size range 2 ½ " through 12" if the piping makes a 90o turn at the equipment. All straight through connections shall be made with twin-spheres properly pre-extended as recommended by the manufacturer to prevent additional elongation under pressure. 12" and larger sizes operating above 100 psi shall employ control cables with end fittings isolated by means of ½ " thick bridge bearing neoprene washer bushings designed for a maximum of 1000 psi.

C. Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies.

D. Elbows shall be Mason-Flex type MFNEC, straight connectors Mason-Flex type MFTFU or MFTNC, and control cable assemblies type ACC.

E. Metal Flexible Connectors: Fabricated of Grade E phosphor bronze, monel or corrugated stainless steel tube covered with comparable bronze or stainless steel braid restraining and pressure cover. Sizes 3" and larger shall be flanged. Sizes 2 ½ " and smaller shall have male nipples. Lengths shall be as indicated:

Nominal Diameter (Inches)	Length (Inches)
½ "	12"
3/4"	12"
1 ½ "	12"
1 ½ "	12"
2"	12"
2 ½ "	12"
3"	18"
4"	18"
5"	24"

6"	24"
8"	24"

F. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be type BSS.

2.12. NEOPRENE PAD ISOLATORS

A. Rubber or neoprene waffle pads.

1. 30 durometer

2. Minimum 2 inch (13mm) thick

3. Maximum loading 40 psi (275 kPa)

4. Height of ribs shall not exceed 0.7 times width.

B. Configuration: ½ inch (13mm) thick waffle pads bonded each side of ¼ inch (6 mm) thick steel plate.

2.13. RUBBER MOUNTS

A. Molded rubber designed for 0.6 inches (13 mm) deflection with threaded insert.

PART 3. EXECUTION

3.1. GENERAL PROVISIONS

A. Install vibration-and-noise isolation materials and equipment as indicated and in accordance with machinery manufacturer's instructions.

B. Where neoprene elements of vibration isolator may be subjected to high pipe temperatures above 160°F, provide metal heat shields or thermal isolators.

C. A minimum of 4" thick reinforced concrete housekeeping pads shall be provided under all floor mounted equipment. Rest subbases on structural floor and reinforce with steel rods interconnected with floor reinforcing bars by tie bars hooked at both ends. Provide at least one (1) inch clearance between subbases and inertia bases, steel bases, and steel saddles with machinery in operation.

D. All vibration isolators exposed to weather or humid environment shall be hot dipped galvanized with springs coated with neoprene in accordance with paragraph hereinbefore described.

E. Concrete inertia bases shall be a minimum of two (2) times the weight supported. Clearance between the underside of the inertia base and the housekeeping pad below shall not be less than 1 inch. Concrete shall be 3000 psi. Install inertia bases in accordance with the recommendations of the machinery manufacturer and the inertia base manufacturer.

F. Anchor Bolts and Grout: Secure machinery to foundations and inertia bases with anchor bolts. Grout equipment with baseplates, the full area under baseplates with premixed non-shrinking grout. After grout has set, remove wedges, shims, and jack bolts and fill spaces with grout.

G. Common Machinery Foundations: Mount electrical motors on the same foundations as driven machinery. Support piping connections, strainers, valves, and risers on the same foundation as the pumps.

H. Vertical Stops: For machinery affected by wind pressure or having an operational weight different from installed weight, provide resilient vertical limit stops which prevent spring extension when weight is removed. Provide vertical stops for machinery containing liquid, such as water chillers, evaporative coolers, boilers, and cooling towers. Spring isolated or protected spring isolated machinery must rock and move freely within limits of stops or seismic restraint devices.

I. Thrust Restraints: Where required, provide pairs of thrust restraints, symmetrically installed on both sides of the steady state line of thrust.

J. Machinery: Provide vibration isolators, flexible connectors and seismic snubbers in accordance with manufacturer's recommendations. Machinery with spring isolators or protected spring isolators shall rock or move freely within limits of stops or seismic snubber restraints.

K. Stability: Isolators shall be stable during starting and stopping of machinery without traverse and eccentric movement of machinery that would damage or adversely affect the machinery or attachments.

L. Lateral Motion: The installed vibration isolation systems for each piece of floor or ceiling mounted machinery shall have a maximum lateral motion under machinery start up and shut down conditions of not more than ¼ -inch. Restrain motions in excess by approved spring mountings.

M. Unbalanced Machinery: Provide foundation suspension systems specifically designed to resist horizontal forces for machinery with large unbalanced horizontal forces. Vibration isolator systems shall conform to the machinery manufacturer's recommendations.

N. Nonrotating Machinery: Mount nonrotating machinery in systems which includes rotating or vibrating machinery on isolators having the same deflection as the hangers and supports for the pipe connected to.

O. Roof and Upper Floor Mounted Machinery: On the roof or upper floors, mount machinery on isolators with vertical stops. Rest isolators on beams or structures designed and installed in accordance with the SMACNA ASMM Plate 61.

P. Vibration isolation ceiling hangers shall be installed so that the hanger rods do not touch the sides of the isolator housing, thereby seriously degrading the vibration isolation performance. Vibration isolation ceiling hangers shall be located so that the hanger housing may rotate 360o without touching any object.

Q. Electrical Connections: Provide flexible conduit or multiple conductor cable connections for machinery with sufficient extra length to permit 2 inch minimum displacement in any direction without damage.

R. Systems Not To Be Vibration Isolated: Do not provide vibration isolation for electrical raceways and conduits or for fire protection, storm, sanitary, and domestic water piping systems which do not include pumps or other vibrating, rotating, or pulsating equipment including control and pressure reducing valves.

S. Install in accordance with manufacturer's instructions.

T. Install isolation for motor driven equipment.

U. Bases:

1. Set steel bases for one inch (25mm) clearance between housekeeping pad and base.

2. Set concrete inertia bases for 2 inch (50mm) clearance between housekeeping pad and base.

3. Adjust equipment level.

V. Install spring hangers without binding.

W. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.

X. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.

Y. Connect wiring to isolated equipment with flexible hanging loop.

3.2. PIPE ISOLATION

A. Horizontal Pipe Isolation:

1. Precompressed Suspension Spring Isolators:

a. For the first three pipe hangers in the main lines near the mechanical equipment provide precompressed suspension spring isolators. Floor supported piping shall rest on trained spring isolators. All precompressed suspension spring isolators hangers or the first three trained spring isolators mounts as noted above, will have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceiling under occupied spaces, the first three hangers shall have 0.75" deflection for pipe sizes up to and including 3", 1.5" deflection for pipe sizes up to and including 6" and 2.5" deflection thereafter. All other

hangers and mounts will have a minimum steel spring deflection of 0.75". Hangers shall be located as close to the overhead supports as practical.

2. Combination Spring and Neoprene Suspension Hanger:

   a. For horizontal runs in other than those hereinbefore specified provide suspension spring hangers (combination spring and neoprene) with .75" minimum steel spring deflection.
   b. Chilled and Hot Piping:
      i. For the first 20 feet of the branch connection of the main supply and return piping at each floor.
      ii. For all piping over 2" diameter.

B. Floor-Supported Piping:

1. Floor supports for piping in equipment rooms and adjacent to isolated equipment shall use vibration isolators as described hereinbefore and selected to the guidelines of hangers.

2. The first three adjacent floor supports shall be the restrained spring type with a blocking feature that prevents load transfer to equipment flanges as the piping is filled and drained.

3. Where piping is subject to larger thermal movement a slide plate shall be installed on the top of the isolator. Slide plate shall be teflon, graphite or steel.

4. Provide a thermal barrier where neoprene products are installed directly beneath steam or hot water lines.

C. Pipe Risers: Provide pipe riser supports with bearing plates and two layers of ¼ " thick ribbed or waffled neoprene pad loaded to not more than 50 psi. Separate isolation pads with ¼ " steel plate. Weld pipe riser clamps at anchor points to the pipe and to pairs of vertical acoustical pipe anchor mountings which shall be rigidly fastened to the steel framing.

D. Supports at Base of Pipe Risers: Piping isolation supports at the base of risers shall be two layers of ½" thick heavy-duty neoprene pad separated by ¼ " thick steel plate. Use bearing plates sized to provide a pad loading of not more than 500 psi. Weld the stanchion between the pipe and isolation support to the pipe and weld or bolt to the isolation support. Bolt isolation support to the floor slab with resilient sleeves and washers. Where supplementary steel is required to support piping, provide a maximum deflection of 0.08 inches at the mid-span of this steel under the load. Rigidly support piping from the supplementary steel with the supplementary steel isolated from the building structure with isolators.

E. Pipe Anchors: Attach each end of the pipe anchor to an omni-directional pipe isolator which in turn shall be rigidly fastened to the steel framing or structural concrete. Provide a telescoping pipe isolator of two sizes of steel tubing separated by a minimum ½ " thick pad of heavy-duty neoprene or heavy-duty neoprene and canvas. Provide vertical

restraints by similar material to prevent vertical travel in either direction. The load on the isolation material shall not exceed 500 psi.

3.3. FLEXIBLE PIPE CONNECTORS

A. Provide flexible connectors in accordance with manufactures instructions where piping systems serving vibration isolated equipment and as shown on the drawings. Flexible connectors shall be installed near the connection to the equipment. Where liquid pulsation dampening is required, flexible connectors with spherical configuration may be used. Provide restraints for pipe connectors at pumps to prevent connector failure upon pump start-up.

3.4. ISOLATION FOR SPECIFIC EQUIPMENT

A. The vibration isolator manufacture shall provide isolators for all pieces of equipment provided for the job. Isolator shall be selected by the isolator manufacturer on the basis of criteria as specified in the ASHRAE Applications Handbook, latest edition, unless a more stringent requirement is indicated on the drawings.

B. Pumps:

1. All base mounted pumps shall be mounted on concrete inertia blocks supported on stable steel springs in series with ribbed neoprene pads selected for not less than 1.5 inch static deflection under full operating load. Mason Industries type SLF or as approved equal.

2. Floor support of the initial pipe elbows at the pump discharge and suction diffuser at the pump intake shall be made from the isolated inertia base, not from the equipment room floor. Mason Industries Type K or as approved equal.

3. Provide flexible pipe connections at pump suction and discharge. Mason Industries Type BSS or MFTNC/MFTFU with control rods type ACC or as approved equal.

4. Provide discharge and suction vibration isolators at all vertical in-line pumps.

C. Energy Recovery Ventilators, Single Zone VAV Units:

1. All energy recovery ventilators and single zone VAV units shall be supported on 1-inch ribbed neoprene pads following the manufacturer's specific installation instructions for specific equipment is acceptable.

D. Fans:

1. All fans suspended from the ceiling, joists or roof structure, including outside air fans, return fans, relief air, ventilation fans, and exhaust fans, shall be suspended using hangers incorporating steel springs in series with neoprene, selected for not less than 3.5" static deflection under full load (Mason Industries Type 30N or equivalent).

E. Condensing Units: All condensing units shall be supported on stable steel springs in series with ribbed neoprene pads and structural rails selected for not less than 2.5" deflection under full operating load. All exterior isolators for condensing units shall be hot dipped galvanized including all hardware. Mason Industries Type SLF springs or as approved equal. Provide neoprene coated springs.

F. All horizontal, vertical, and recessed unit heaters shall be suspended using hangers incorporating steel springs in series with neoprene selected for not less than 1" static deflection under full load (Mason Industries Type 30N or equivalent).

G. Ductless Units: Indoor ductless units shall be supported with rubber grommet type suspension isolators. Outdoor ductless units shall be supported on ribbed neoprene pads resting on roof curbs (roof application) or concrete pads as indicated.

3.5. MANUFACTURER'S FIELD SERVICES

A. Inspect isolated equipment after installation and submit report. Include static deflections.

END OF SECTION

DIVISION 23 SECTION 230593
TESTING, ADJUSTING & BALANCING FOR HVAC & PLUMBING
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SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC AND PLUMBING

PART 1. GENERAL

1.1. GENERAL

A. This section covers performance testing, adjusting and balancing of heating, ventilating, air conditioning and domestic re-circulating systems as specified in Division 23 Section, Heating, Ventilating, and Air Conditioning Equipment and in Division 22 Section, Plumbing Fixtures and Plumbing Equipment.

B. For Common Work Results of HVAC, See Division 23. See Division 01 for General Requirements.

C. The mechanical contractor shall select and employ an impartial, independent balancing agency to provide testing and balancing services for the heating, ventilating and air conditioning (HVAC) systems and other specified systems of this project.

D. The work included in this section consists of furnishing labor, instruments, and tools required in testing, adjusting and balancing the HVAC and plumbing systems, as described in these specifications or shown on accompanying drawings. Services shall include checking equipment performance, taking the specified measurements, and recording and reporting the results.

E. The items requiring testing, adjusting, and balancing include, but are not limited to, the following:

1. Air Systems:

   a. Air Flow Monitoring Stations
   b. Coils (Air Temperatures & Static Pressure Drops)
   c. Diffusers, Registers and Grilles
   d. Ductless Split System Units (Indoors and Outdoor units)
   e. Energy Recovery Ventilators
   f. Exhaust Fans
   g. Intake Hoods
   h. Outside Air Intakes
   i. Power Relief Fans
   j. Relief Fans
   k. Single Zone VAV Units
   l. Unit Heaters
   m. Variable Refrigerant Volume Systems
   n. Ventilation Fans
   o. Zone Branch and Main Ducts

2. Hydronic Systems:

   a. Existing Boilers
   b. Chilled Water System
   c. Coils
   d. Condensate Pumps

e. Condensate overflow safety switches
f. Differential Pressure Bypass Valves
g. Energy Recovery Ventilators
h. Flow Measuring Stations
i. Flow Meter Fittings
j. In-line Pumps
k. Pumps
l. Single Zone VAV Units
m. System Mains and Branches
n. Unit Heaters
o. In addition, any existing fans, equipment or air devices specified to be re-used under this project shall be tested and balanced, similar to new fans.

1.2. EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:

1. Systems are started and operating in a safe and normal condition.

2. Temperature control systems are installed complete and operable.

3. Proper thermal overload protection is in place for electrical equipment.

4. Final filters are clean and in place. If required, install temporary media in addition to final filters.

5. Duct systems are clean of debris.

6. Fans are rotating correctly.

7. Fire dampers, and volume dampers are in place and open.

8. Air coil fins are cleaned and combed.

9. Access doors are closed and duct end caps are in place.

10. Air outlets are installed and connected.

11. Duct system leakage is minimized.

12. Hydronic systems are flushed, filled, and vented.

13. Pumps are rotating correctly.

14. Proper strainer baskets are clean and in place.

15. Service and balance valves are open.

B. Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.

C. Beginning of work means acceptance of exiting conditions.

1.3. QUALIFICATIONS OF THE BALANCE AGENCY

A. The balancing agency shall be a member of the Associated Air Balance Council (AABC).

B. The certified test and balance engineer shall be responsible for supervision and certification for the total work herein specified.

C. All final reports shall be signed by the certified test and balance engineer.

1.4. PRE-BALANCING CONFERENCE

A. Convene a conference one week prior to commencing work of this Section with all appropriate individuals.

1.5. STANDARDS

A. The balancing agency shall perform the services specified herein in accordance with the Associated Air Balance Council's National Standards, including revisions, to the date of the contract.

B. All terms in this specification shall have their meaning defined as stated in the National Standards.

C. ADC: Test Code for grilles, registers, and diffusers.

D. ASHRAE III: Practice for measurement, testing, adjusting and balancing of building heating, ventilation, air conditioning, and refrigeration systems.

E. NEBB: Procedure standards for testing, adjusting, and balancing of environmental systems.

F. SMACNA: HVAC systems testing, adjusting, and balancing.

G. AABC: Associated Air Balance Council

1.6. COORDINATION

A. It will be necessary for the balancing agency to perform its services in close coordination with the mechanical contractor.

B. The plans and specifications have indicated meters, valves, dampers, and other devices for the purpose of adjusting the system to obtain optimum operating conditions. It will be the responsibility of the mechanical contractor to install these devices in a manner that will leave them accessible and readily adjustable. The balancing agency shall provide guidance if there is a questionable arrangement of a control or balancing device.

C. The general contractor, mechanical contractor, temperature control contractor and suppliers of the HVAC equipment shall all cooperate with the balancing agency to provide all necessary data on the design and proper application of the system components.

1.7. INSTALLATION TOLERANCE

A. Unless otherwise indicated, all air devices shall be adjusted to within plus or minus 10 percent of design. All fans shall be adjusted to within plus or minus 5 percent of design. All pumps and Hydronic equipment shall be adjusted to within plus or minus 5 percent of design.

1.8. RESPONSIBILITIES OF THE MECHANICAL CONTRACTOR

A. The mechanical contractor shall sufficiently complete the installation and start all HVAC systems to insure they are working properly and shall perform all other items as described hereinafter to assist the balancing agency in performing the testing and balancing of the HVAC system.

B. Record equipment manufacturer's standard start-up information and submit to Engineer for review. Testing and balancing work shall not commence on any equipment until start-up reports have been completed, reviewed by Engineer, and forwarded to Testing and Balancing Agency.

C. Air Distribution Systems

1. Verify installation for conformity to design.

2. Terminate all supply, return, outside air, exhaust air, relief air, ventilation air ducts, and pressure test them for leakage. Test pressure and leakage rate shall be as specified in Division 23 Section, HVAC Air Distribution System under Leakage Tests. Pressure testing shall be performed by mechanical contractor and witnessed by Test and Balance Engineer.

3. Ensure that all volume dampers, and fire dampers are properly located and functional. Dampers serving requirements of minimum and maximum outside - return - relief, and exhaust air shall provide tight closure and full opening, with a smooth and free operation.

4. Verify that all supply - return - exhaust and transfer grilles; registers, and diffusers are installed and operational.

5. Ensure that air-handling systems, units, and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., are blanked and/or sealed to eliminate excessive bypass or leakage of air.

6. Ensure that all fans are operating and free of vibration. All fans and drives shall be checked for proper fan rotation and belt tension. Overload protection shall be of proper size and rating. A record of motor current and voltage shall be made to verify that the motors do not exceed nameplate rating. Record thermal overload ratings for all motors in the Test and Balance Report.

7. Make any necessary changes to the sheaves, belts, and dampers, as required by the balancing agency, at no additional cost to the owner.

8. Install clean filters.

D. Water Circulating Systems

1. Verify installation for conformity to design.

2. Check all pumps to verify pump alignment and rotation.

3. Ensure that systems are clean, with the proper strainer screens installed for normal operation.

4. Check all pump motors for current and voltage, to ensure that motors do not exceed nameplate rating.

5. Provide thermal overload protection of proper size and rating. Record thermal overload ratings for all motors. Insert data in Test and Balance Report.

6. Ensure that all water circulating systems shall be full and free of air; that expansion tanks are set for proper water level; and that all air vents were installed at high points of systems and are operating.

1.9. RESPONSIBILITIES OF THE TEMPERATURE CONTROL CONTRACTOR

A. The temperature control contractor shall complete the installation of the temperature control system, and operate and test all control systems to ensure they are functioning properly as designed. The temperature control contractor shall assist the balancing agency in testing and balancing the HVAC systems, as described hereinafter.

1. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset, freeze stats and duct smoke detectors.

2. Verify that all controlling instruments are calibrated and set for design operating conditions.

3. Calibrate temperature sensors after installation, and before the temperature sensors control verification tests are performed. The balancing agency shall prove the accuracy of final settings by taking temperature readings. The readings shall be in a typical conditional space for each separately controlled zone.

4. The temperature control contractor shall allow sufficient time in the project to provide assistance and instruction to the balancing agency in the proper use and setting of control components such as, but not limited to, computers, static pressure controllers, or any other device that may need set points changed so that the testing and balancing work can be performed.

B. All control sequences, software, equipment, and components shall be started-up by a qualified technician. Start-up report shall be submitted to Engineer prior to the commencement of testing and balancing work. Testing and balancing shall not commence until start-up reports are completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

1.10. NOTIFICATION FOR TESTING AND BALANCING WORK TO BEGIN

A. The mechanical contractor shall notify the balancing agency in writing when all heating, ventilating, and air conditioning systems are complete and ready for testing and balancing. The mechanical contractor shall attest that he has completed all items as herein described.

B. The following must be completed prior to start of system balancing:

1. All duct work and associated grilles/registers/diffusers installed and completed.

2. Piping systems completed, flushed and filled.

3. Equipment properly started by qualified personnel or start-up technicians.

4. Ceiling tiles installed.

5. Automation system (temperature controls) installed and completed for both air and water systems.

6. All equipment controlled in automatic ("Auto") mode.

7. Access granted to the balancing contractor to the automation/controls system provided.

1.11. DEFICIENCIES

A. Any deficiencies in the installation or performance of a system or component observed by the TAB agency shall be brought to the attention of the appropriate responsible person.

B. The work necessary to correct items on the deficiency listing shall be performed and verified by the affected Contractor before the TAB Agency returns to retest. Unresolved deficiencies shall be noted in the final report.

1.12. ADJUSTING

A. Ensure recorded data represents actual measured observed conditions.

B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring all sensors to specified settings.

E. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

F. Check and adjust systems approximately six months after final acceptance and submit report.

G. Permanently mark the locations of all duct traverses on the exterior surface of the duct insulation.

1.13. GENERAL COMMISSIONING REQUIREMENTS

A. Refer to Division 01 Section, "General Commissioning" for description of work under this Division affected by General Commissioning.

PART 2. PRODUCTS (NOT APPLICABLE)

PART 3. EXECUTION

3.1. GENERAL

A. Perform all testing and balancing in complete accordance with AABC National Standards for Field Measurements and Instrumentation.

B. Furnish all test instruments and equipment. All instruments must have been calibrated within twelve (12) months prior to use and shall be checked for accuracy prior to and during the work. Submit certificate for calibration of all equipment utilized on project with date of calibration clearly identified.

C. Review all systems designs and equipment, manufacturers' data, and be completely familiar with the work before proceeding.

D. Report all malfunctions or deficiencies to the contractor so that corrective action can be taken. Test and Balance Report shall not be submitted for review until all malfunctions or deficiencies are corrected. Repeat tests where required until design conditions are achieved.

E. Where systems or equipment cannot be balanced or adjusted to design conditions, determine the cause and submit a complete report to the Engineer.

F. Retest or rebalance the system as required during the warranty period.

G. Test and balance all systems under adequate load condition. If, in the opinion of the Engineer, there is insufficient load to properly test and balance the systems, perform sufficient preliminary balancing and adjustment to permit operation of the systems until such time as final testing and balancing can be done. Provide in writing the future date when systems shall be tested under sufficient load.

H. At project completion provide a complete set of ½ scale drawings indicating the locations of all duct traverses.

3.2. 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 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.

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

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

H. 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.

I. Examine terminal units, and verify that they are accessible and their controls are connected and functioning.

J. Examine strainers. Verify that startup screens are replaced by permanent screens and indicated perforations.

K. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

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

M. Examine system pumps to ensure absence of entrained air in the suction piping.

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

O. 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.

3.3. AIR SYSTEM PROCEDURES

A. The balancing agency shall perform the following testing and balancing functions in accordance with the Associated Air Balance Council's National Standards:

1. Fan Speeds - Test and adjust fan RPM to achieve design CFM requirements.

2. Current and Voltage - Measure and record motor current and voltage. Check and record thermal overload ratings for all motors.

3. Pitot-Tube Traverse - Perform a Pitot-tube traverse of main supply, return and exhaust ducts to obtain total CFM. If a Pitot-tube traverse is not practical, the summation of the outlets or inlets may be used. An explanation why a traverse was not made must appear on the appropriate data sheet.

4. Outside Air - Test and adjust system minimum outside air by Pitot-tube traverse. If a Pitot-tube traverse is not practical, the percentage of outside air may be determined by calculations from the return air, outside air, and mixed air temperatures. Make allowances for heat of compression and motor heat where applicable.

5. Static Pressure - Test and record system static pressures, including suction and discharge static pressure of each fan. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make fan RPM allowances for 50 percent loading of filters.

6. Air Temperature - Take wet-bulb and dry-bulb air temperatures on the entering and leaving side of each cooling coil and/or heat recovery coil. Dry-bulb temperature shall be taken on the entering and leaving side of each heating coil.

7. Zone Ducts - Adjust zone ducts to within design CFM requirements. At least one zone balancing damper shall be completely open.

8. Main Ducts - Adjust main ducts to within design CFM requirements and traverse for total CFM quantities.

9. Branch Ducts - Adjust branch ducts to within design CFM requirements. Multi-diffuser branch ducts shall have at least one outlet or inlet volume damper completely open.

10. Tolerances - Test and balance each diffuser, grille, and register to within 10 percent of design requirements. Test and balance all fans to within 5 percent of design requirements.

11. Identification - Identify the location and area of each grille, diffuser, and register. This information shall be recorded on air outlet data sheets.

12. Description - Record the size, type, and manufacturer of each diffuser, grille, and register on air outlet data sheets.

13. Minimizing Drafts - Adjust all diffusers, grilles, and registers to minimize drafts in all areas.

14. Test and Balance Engineer shall witness and record all leakage testing of ductwork. Leakage test data shall be included in final Test and Balance Reports.

15. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable air volume systems at maximum air flow rate, full cooling, and at minimum airflow rate, full heating.

16. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

17. For heat pumps, assist start-up organization or manufacturer's representative with start-up. Record air flow rates and electrical characteristics prior to refrigerant pressure measurement and settings.

18. For all equipment specified with condensate overflow safety switches/floats test operation of such device and record results. Verify interlock with ATC system.

19. Outside air and exhaust/relief air measurements must be measured and submitted in all modes of operation including the following:

    a. Min Min Outside Air/Exhaust/Relief air mode (square footage outside air).
    b. Min Max Outside Air/Exhaust/Relief air mode (square footage and people outside air).
    c. Maximum outside air/exhaust/relief mode (full 100% economizer mode).

20. For all outside air modes of operation record and submit full static pressure profiles, amperage, BHP, air flow rates, external static pressure, and internal static pressure. Verify airflow rates with air flow monitoring stations and record results.

3.4. WATER SYSTEM PROCEDURES

A. The various water circulating systems shall be filled, purged of air, and put into operation before hydronic balancing by the mechanical contractor.

B. The flow of water through all coils shall be adjusted by manipulating balancing valves until the rated pressure drop through the coil or metering device is obtained. Perform balancing by measurement of temperature differential in conjunction with air balancing.

C. The balancing agency shall perform the following testing and balancing functions in accordance with the AABC National Standards.

D. All Hydronic equipment, domestic re-circulating pumps, and HVAC pumps shall be Tested and Balanced as described below:

1. Water Treatment - Examine the water in the system and determine if the water has been treated and cleaned. If it has not, request the mechanical contractor to clean and treat the water prior to TAB work

2. Strainers - Request that the mechanical contractor clean all strainers.

3. Air Vents - Check all air vents at the high points of the water system and determine if they are installed and operating.

4. Valves - Set all balancing valves to the full-open position for balancing.

5. Pumps - Adjust all pumps and domestic hot water re-circulating water pumps to meet design GPM requirements. Check pumps for proper operation. Pumps shall be free of vibration and cavitation. Measure and record operating current and voltage. Check and record thermal overloads installed on all pumps. Record in Test and Balance Report.

6. Tolerances - Proceed to balance all coils, pumps, balance valves, and boilers to within 5 percent of design requirements.

7. Marking - Mark all settings and record all data after completing the flow readings and coil adjustments.

8. Where available pump capacity (due to diversity) is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

9. Test all A/C condensate pumps for proper operation.

10. Test condensate overflow safety switches.

E. Boilers:

1. Verify that boilers have been filled and started by others, and are in operation.

2. Current and Voltage - As applicable, test and record motor voltage and amperage, and compare data with the nameplate limits to ensure motor is not in or above the service factor.

3. Test and adjust water flow through water boilers.

4. Test and record temperature and pressure profiles of water boilers.

F. Coils:

1. Tolerances - Test, adjust, and balance all hydronic coils within 5 percent of design requirements.

2. Verification - Verify the type, location, final pressure drop and GPM of each coil. This information shall be recorded on coil data sheets.

3.5. TESTING AND BALANCING OF EXISTING SYSTEMS

A. The balancing agency shall perform testing and balancing of existing air handling, fan and pump systems to the extent indicated. Existing air devices and terminals shall be re-tested and balanced where effected by new ductwork modifications.

B. Test and Balance Agency shall assist the mechanical contractor in selection of new sheaves and belts, if required. Re-sheaving of existing air handling units or fans shall be done at no additional cost to owner. Where required, new sheave and belt size calculations shall be forwarded to the Engineer for review and approval.

C. The Test and Balance Agency shall perform water system procedures (here-in before specified) on the following hydronic systems.

1. Boiler #1 and #2.

2. Existing Chilled Water System Flow Rates that feed this building from the central plant.

3.6. FIRE AND SMOKE TESTING PROCEDURES

A. The TAB agency shall test fire/smoke damper to assure operation. It shall verify that an access door has been installed for each fire and smoke damper. For fire dampers, the TAB agency shall open the access door, disconnect the fusible link, and allow the damper to close. Operation should be smooth and the damper must close completely. The TAB agency shall then reset the damper. For the smoke damper, the TAB agency shall open the access door, activate the damper, and observe operation. The damper must close quickly and completely. The TAB agency shall then reset the damper and observe its complete opening. Record results of tests within TAB report.

3.7. LIFE SAFETY CONTROLS TESTING PROCEDURES

A. The TAB agency shall test and record life safety control operation on the HVAC equipment. It shall verify the installation of required smoke detectors in air handling equipment (AHE), and shall verify operation of the smoke detector by activating the smoke detector and observing air handler shutdown. With the controls and alarm contractors, the TAB agency shall verify the operation of interconnected systems such as the AHU smoke detector's activation of the fire alarm system and the alarm system's activation of the life safety control sequences. Record results of tests within TAB report.

3.8. VERIFICATION OF TEMPERATURE CONTROL

A. The balancing agency shall be assisted by the temperature control contractor in verifying the operation and calibration of all temperature control systems. The following tests shall be conducted:

1. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset.

2. Verify that all controlling instruments are calibrated and set for design operating conditions.

3. Verify the accuracy of the final settings by taking temperature readings. The readings shall be in a typical conditioned space for each separately controlled zone.

4. Test and calibrate all air flow monitoring stations for proper air flow.

5. Test and calibrate all static pressure sensors for proper set point and control.

6. Test and calibrate all differential pressure sensors. Record set point in Record

and Information Books.

3.9. TEST AND BALANCE REPORTS

A. The test and balance report shall be complete with logs, data, and records as required herein. All logs, data, and records shall be typed on white bond paper and bound. The report shall be certified accurate and complete by the balancing agency's certified test and balance engineer.

B. Six (6) copies of the test and balance report are required and shall be submitted to the Engineer. If, in the opinion of the Engineer, test results or portions thereof are incomplete or inconclusive, repeat necessary portions of the work to the satisfaction of the Engineer.

C. The report shall contain the following general data in a format selected by the balancing agency:

1. Project Number
2. Contract Number
3. Project Title
4. Project Location
5. Project Architect
6. Project Mechanical Engineer
7. Test & Balance Agency
8. Test & Balance Engineer
9. General Contractor
10. Mechanical Subcontractor
11. Dates tests were performed
12. Certification
13. Duct Leakage Tests
14. Phone Numbers of all Individuals Listed Above

D. The test and balance report shall be recorded on report forms conforming to the recommended forms in the AABC National Standards.

3.10. TEST REPORT FORMS

A. Air Moving Equipment and Fan Test Forms - Submit fan curve showing design and operating points of operation. Also, record the following on each air-handling equipment

test form:

1. Manufacturer, model number, serial number, arrangement.

2. All design and manufacturer-rated data.

3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.

4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, filters, mixing boxes, and similar devices.

5. Outside-air, return-air, and exhaust air total CFM.

6. Actual operating current, voltage and brake horsepower of each fan motor. For packaged equipment, this includes supply fans, relief air fans, and condenser fans.

7. Final RPM of each fan.

8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.

9. Belt size, quantity and make.

10. Static-pressure controls final operating set points (if applicable).

11. Total and external static pressure.

12. Room differential static pressures.

B. Pump Test Forms - Submit pump curve showing design, operating, and no-flow points of operation. Also, record the following items on each pump test form:

1. Manufacturer, size, model, service and serial number.

2. All design and manufacturer's rated data.

3. Pump operating suction and discharge pressure and final total dynamic head.

4. No flow (pump discharge valve closed) suction and discharge pressure and corresponding total dynamic head. This procedure is to determine actual impeller size. Record impeller size.

5. Rated and actual operating current, voltage, and brake horsepower of each pump motor.

6. Total operating head pressure.

7. Shutoff, discharge and suction pressures.

8. Shutoff, total head pressure.

C. Boiler Test Forms - Record the following items on each chiller and boiler test form:

1. Manufacturer model number, serial numbers.
2. All design and manufacturer's rated data.
3. Service and location.
4. Actual pressure drop and related GPM primary side.
5. Actual pressure drop and related GPM, secondary side.
6. Primary side entering and leaving temperatures.
7. Secondary side entering and leaving temperatures.
8. Temperature control settings.
9. Electrical characteristics.

D. Heating and Cooling-Coil Test Forms - Record the following items on each test form:

1. Manufacturer, location, service.
2. All design and manufacturer's rated data.
3. Rated and actual water pressure drop through each coil and related GPM.
4. Rated and actual static pressure drop across each coil.
5. Rated and actual entering and leaving water temperatures across each coil.
6. Wet-bulb and dry-bulb temperatures entering and leaving each cooling coil; dry-bulb temperatures entering and leaving each heating coil.
7. Air flow (Design and Actual).
8. For DX-coil, provide design and actual saturated suction temperature.
9. For DX-Coil, provide design and actual discharge pressures.

E. Air Monitoring Station Test Forms:

1. Identification /location.
2. Manufacturer.
3. Systems.
4. Size and Model Number.

5. Area.

6. Design Velocity.

7. Design Airflow.

8. Test Velocity.

9. Test Airflow.

10. Static Pressure Drop and Velocity Pressure.

11. Station Calibrated Setting.

F. Flow Measuring Station Test Forms:

1. Identification/location.

2. Manufacturer.

3. Size and Model Number.

4. Design and Actual Flow Rate.

5. Design and Actual Pressure Drop.

6. ATC flow rate versus field measured flow rate.

G. Electric Motors Test Forms: (Applies to all motors, including pumps, fans and HVAC equipment)

1. Manufacturer.

2. Model/Frame.

3. HP/BHP.

4. Phase, voltage, amperage; nameplate, actual, no load.

5. RPM.

6. Service factor.

7. Starter size, rating, heater elements.

8. Sheave Make/Size/Bore.

9. Thermal overload settings

H. V-Belt Drive Test Forms:

1. Identification/location.

2. Required driven RPM.

3. Driven sheave, diameter and RPM.

4. Belt, size and quantity.

5. Motor sheave diameter and RPM.

6. Center to center distance, maximum, minimum, and actual.

I. Duct Traverse Test Forms:

1. System zone/branch.

2. Duct size.

3. Area.

4. Design velocity.

5. Design air flow.

6. Test velocity.

7. Test airflow.

8. Duct static pressure.

9. Air temperature.

10. Air correction factor.

J. Duct Leakage Test Forms:

1. Description of ductwork under test.

2. Duct design operating pressure.

3. Duct design test static pressure.

4. Duct capacity, air flow.

5. Maximum allowable leakage duct capacity times leak factor.

6. Test apparatus.

   a. Blower.
   b. Orifice, tube size.
   c. Orifice size.
   d. Calibrated.

7. Test static pressure.

8. Test orifice differential pressure.

9. Leakage.

K. Air Distribution Test Sheet:

1. Air terminal number.

2. Room number/location.

3. Terminal type.

4. Terminal size.

5. Area factor.

6. Design velocity.

7. Design air flow.

8. Test (final) velocity.

9. Test (final) air flow.

10. Percent of design air flow.

L. Ductless Unit Test Forms:

1. Manufacturer

2. Type, air conditioning, heat pump

3. Identification number

4. Location

5. All design and manufacturer's rated data.

6. Rated and actual entering and leaving dry bulb temperatures.

7. Rated and actual entering and leaving wet bulb temperatures.

8. Air flow (design and actual)

9. Provide actual saturated suction temperature.

10. Actual operating current, voltage and brake horsepower of each fan motor.

11. Final fan RPM.

12. For Air Cooled Variable Refrigerant Volume System test current, voltage, RPM, and breaker horsepower for outdoor unit.

M. Energy Recovery Ventilators Test Forms: Submit fan curve showing design and operating points of operation. Also, record the following on each air-handling equipment test form:

1. Manufacturer, model number, serial number, arrangement.

2. All design and manufacturer-rated data.

3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.

4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, filters, energy wheels, and similar devices.

5. Outside-air, and exhaust air total CFM.

6. Actual operating current, voltage and brake horsepower of each fan motor.

7. Final RPM of each fan.

8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.

9. Belt size, quantity and make.

10. Total and external static pressure.

11. Rated and actual static pressure drop across each energy wheel.

12. Wet-bulb and dry-bulb temperatures entering and leaving each cooling coil and energy recovery wheel. Dry-bulb temperatures entering and leaving each heating coil.

13. Record carbon dioxide set points and actual readings for exhaust air stream at each ERV and global CO2 sensor.

14. Record the supply fan and exhaust fan maximum hertz/speed and minimum hertz/speed. Provide measurements to ATC subcontractor for fan tracking control.

N. Condensate Over Flow Switches/Floats

1. Manufacturer

2. Type

3. Location

4. Equipment shut down verification

5. ATC interlock verification

O. Single Zone VAV Unit Test Forms: Submit fan curve showing design and operating points of operation. Also, record the following on each air-handling equipment test form:

1. Manufacturer, model number, serial number, arrangement.

2. All design and manufacturer-rated data.

3. Total actual CFM by traverse if practical. If not practical, the sum of the outlets may be used, or a combination of each of these procedures. For specific systems, such as ones with diversity, see the AABC National Standards.

4. Suction and discharge static pressure of each fan, as applicable. Include pressure drops across coils, filters, energy wheels, and similar devices.

5. Outside-air, and exhaust air total CFM.

6. Actual operating current, voltage and brake horsepower of each fan motor.

7. Final RPM of each fan.

8. Fan and motor sheave manufacturer, model, size, number of grooves, bore, and center distance.

9. Belt size, quantity and make.

10. Total and external static pressure.

11. Rated and actual static pressure drop across each energy wheel.

12. Wet-bulb and dry-bulb temperatures entering and leaving each cooling coil, heat pipe and energy wheel. Dry-bulb temperatures entering and leaving each heating coil.

13. Record carbon dioxide set points and actual readings for exhaust air stream at each single zone VAV unit and global CO2 sensor.

14. Entering and leaving air temperatures at hot gas re-heat coils.

15. Record the supply fan and exhaust fan maximum hertz/speed, and minimum hertz/speed. Provide measurements to ATC subcontractor for fan tracking control.

16. Test minimum air flow rate, maximum air flow rate and economizer air flow rate.

END OF SECTION

DIVISION 23 SECTION 230600
HEATING, VENTILATING, AND AIR CONDITIONING EQUIPMENT
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SECTION 230600 – HEATING, VENTILATING, AND AIR CONDITIONING EQUIPMENT

PART 1. GENERAL

1.1. GENERAL

A. The Conditions of the Contract and other General Requirements apply to the work specified in this section. All work under this section shall also be subject to the requirements of Division 23 Section, Common Work Results for HVAC and Division 01 Section General Requirements.

1.2. DESCRIPTION

A. The work to be performed shall include all labor, materials and equipment necessary to furnish and install complete, all mechanical equipment as shown on drawings, hereinafter specified or reasonably implied, and leaving the same in satisfactory operation condition. It is the intent that systems be installed complete with all items necessary to accomplish this purpose.

1.3. SUBMITTALS

A. Shop Drawings: Indicate assembly, equipment dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.

B. Product Data:

1. Provide literature which indicates dimensions, weights, capacities, ratings, performance, gages and finishes of materials, and electrical characteristics and connection requirements.

2. Provide data of filter media, filter performance data, filter assembly, and filters frames.

3. Provide fan and pump curves with specified operating point clearly plotted.

4. Submit sound power level data for both fan outlet and casing radiation at rated capacity. Submit sound power levels by octave band or sound pressure levels by octave band for all equipment.

5. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

1.4. OPERATION AND MAINTENANCE DATA

A. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.5. DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of General Requirements.

B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

C. Store all equipment in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

D. Comply with manufacturer's installation instructions for rigging, unloading and transporting equipment.

E. Protect all motors, shafts, and bearings from weather and construction dust.

1.6. ENVIRONMENTAL REQUIREMENTS

A. Do not operate any equipment for any purpose, temporary or permanent, until ductwork/piping is clean, filters/strainers are in place, bearings lubricated, and equipment has been test run under observation.

1.7. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

1.8. EXTRA MATERIALS

A. Provide one set of seals for each type and model of pump provided on the project.

PART 2. PRODUCTS

2.1. DUCTLESS SPLIT SYSTEM HEAT PUMP (INVERTER TYPE) (CEILING CASSETTE TYPE)

A. The heat pump air conditioning system shall be a Mitsubishi Electric, Sanyo, Daikin, Samsung, or approved equal split system. The system shall consist of a slim silhouette, compact ceiling recessed packaged evaporator section with matching Slim Line outdoor unit. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label. All wiring to be in accordance with the National Electrical Code (N.E.C.). The units shall be rated in accordance with ARI standard 240 and bear the ARI label. A full charge of R-410A for 100 feet of refrigerant tubing shall be provided in the condensing unit. A dry nitrogen holding charge shall be provided in the condensing unit. A dry nitrogen holding charge shall be provided in the evaporator. System SEER shall meet or exceed Federal Standards latest edition

B. The units shall have a manufacturer's warranty for a period of two (2) years from date of installation. The compressor shall have a warranty of six years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of Mitsubishi Electronics America, Inc. This warranty does not include labor. Manufacturer shall have

ten years experience in the U.S. market. Capacity shall be as scheduled on the contract drawings.

C. The indoor unit shall be completely factory assembled and wired. The casing shall be galvanized sheet with grey heat insulation. This unit shall fit in the ceiling and have the capability of attaching a branch supply duct as well as a fresh air duct. The evaporator fan shall be an assembly with a high performance, fan direct driven by a single motor. The fans shall be statically and dynamically balanced and run on permanently lubricated bearings. The indoor unit shall have an adjustable air outlet system offering 4-way air flow, 3-way air flow, or 2-way air flow. The auto air swing vanes shall automatically swing up and down for uniform air distribution. Return air shall be filtered by a long-life filter to provide approximately, 2500 hours of use in a normal office environment before cleaning. The indoor unit shall be covered with a flat panel which protrudes only 1 inch below the ceiling to provide a neat and clean installation. The coils shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tubes joints shall be brazed with phoscopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan shall extend under the coil and piping. An integral drain pan pump capable of lifting condensate 12 inches shall be provided. An integral booster heater shall not be provided to supplement the unit during the heating mode. The unit variable speed compressor shall allow full heating capability and defrost without the need for a booster heater. The unit electrical power requirements shall be as scheduled on the contract drawings.

D. The control system shall consist of two (2) microprocessors interconnected by a single non-polar two wire cable as supplied. Wiring shall run from indoor unit to controller direct. NO SPLICES. When running longer lengths or more than one set of hardwired remote controller wires together, a double insulated, two wire cable equivalent to that provided e.g. Belden 9407 cable, is mandatory or use shielded two wire cable. One microprocessor shall be factory wired and located within the indoor unit. It shall have the capability of sensing return air temperature and indoor coil temperature; receive and process commands from the hardwired remote controller provide emergency operation; control the booster heater and control the outdoor unit. The microprocessor within the wall mounted hardwired remote controller shall provide automatic cooling and heating system changeover; display set point and room temperature; a 24 hour on/off timer so that automatic operation can be set on the timer at one hour intervals from one to twenty-four hours; have self-diagnostic function display; check mode for memory of most recent problem; System shall control continued operation of the air sweep louvers; and provide on-off and system/mode function switching. The heating system shall be controlled so that only warm air is discharged whenever the fan speed exceeds the very low (VLO) speed. Normal operation of the hardwired remote controller provides individual system control in which one hardwired remote controller and one indoor unit are installed in the same room. The hardwired remote controller shall have the capability of controlling up to a maximum of 50 systems at a maximum developed control cable distance of 1650 feet. The control voltage between the hardwired remote controller and the indoor unit shall be 12 volts, D.C. The control voltage between the indoor unit and the outdoor unit shall be 12 volts D.C. Both 12 VDC shall be generated from the indoor unit microprocessor board. The system shall be capable of automatic restart when power is restored after power interruption. System shall include twenty function self-diagnostics including total hours of compressor run time.

E. The outdoor unit shall be completely factory assembled, piped, and wired. The casing shall be fabricated of galvanized steel, bonderized and finished with baked enamel. The unit shall be furnished with one (1) direct drive, propeller type fan arranged for horizontal discharge. The motors shall have inherent protection be of the permanently lubricated type, and resiliently mounted for quiet operation. Each fan shall be provided with a raised guard to prevent contact with moving parts. The variable speed compressor shall be of the high-performance, rotary type with crankcase heater, accumulator and internal thermal overloads. The variable speed compressor shall be mounted so as to avoid the transmission of vibration. The refrigeration system shall be equipped with pressure switch and have the capability to operate with a maximum height difference of 130 feet and overall refrigerant tubing length of 130 feet between indoor and outdoor sections without the need for line size changes, traps or additional oil. Refrigerant flow from the condenser to be controlled by means of a capillary tube. The condenser coil shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The coil shall be protected with an integral metal guard. The unit shall be controlled by the microprocessor located in the matching indoor unit. A built-in, low-ambient controller shall allow cooling to 23 degrees F outdoor temperature. The unit electrical power requirements shall be as scheduled on the contract drawings. The outdoor unit shall be placed on vibration isolators and mounted on a concrete pad.

F. High condensate water safety shutdown: Each indoor unit's detection unit shall be interlocked to alarm and stop the outdoor unit if a high condensate water level is sensed.

2.2. DUCTLESS SPLIT SYSTEM AIR CONDITIONER (INVERTER TYPE) (WALL MOUNTED)

A. The air conditioning system shall be a Mitsubishi Electric Series split type system, Sanyo, LG, Daikin, Samsung, or approved equal. The system to consist of a slim silhouette, compact wall mounted packaged evaporator section and matching Slim Line air cooled outdoor unit. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label. All wiring to be in accordance with the National Electrical Code (N.E.C.). The units shall be rated in accordance with ARI Standard 210 and bear the ARI label. A full charge of R-410A for 100 feet of refrigerant tubing shall be provided in the condensing unit. A dry nitrogen holding charge shall be provided in the evaporator. System SEER shall meet or exceed Federal Standards, latest edition.

B. The units shall have a manufacturer's warranty for a period of one (1) year from date of installation. The compressor shall have a warranty of six (6) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of Mitsubishi Electronics America, Inc. This warranty does not include labor. Manufacturer shall have ten years experience in the U.S. market.

C. The unit performance shall be as scheduled on the contract drawings.

D. The indoor unit shall be completely factory assembled, and wired. The casing shall have a white finish. The evaporator fan shall be an assembly of line flow fans direct driven by a single motor. The fans shall be statically and dynamically balanced and run on a permanently lubricated bearing. An adjustable guide vane shall be provided with the ability to change the air flow from horizontal to vertical. A motorized air sweep louver shall

provide an automatic change in air flow by directing the air from side to side for uniform air distribution. Return air shall be filtered by means of an easily removable washable filter. The evaporator coil shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phoscopper or silver alloy. The coil shall be pressure tested at the factory. A condensate pan with drain shall be provided under the coil. Split system unit manufacturer shall furnish condensate lift pumps for field installation with the indoor unit. Condensate pumps shall be complete with float switch sensor, alarm, reed switch, relay, contact, adaptors and detection unit, etc., for a completely operational system. Contractor shall mount, pipe, and wire condensate pump per split system manufacturer's recommendations. Condensate pump shall be model EE as manufactured by Sauermann or approved equal.

E. The control system shall consist of two (2) microprocessors interconnected by a single non polar two wire cable as supplied. Wiring shall run from indoor unit to controller direct. NO SPLICES. When running longer lengths or more than one set of hardwired remote controller wires together, a double insulated, two wire cable equivalent to that provided e.g. Belden 9407 cable, is mandatory or use shielded two wire cable. One microprocessor shall be factory wired and located within the indoor unit. It shall have the capability of sensing return air temperature and indoor coil temperature; receive and process commands from the hardwired remote controller; provide emergency operation; and control the outdoor unit. The microprocessor within the wall mounted hardwired remote controller shall provide automatic cooling; display set point and room temperature; a 24 hour on/off timer so that automatic operation can be set on the timer at one hour intervals from one to twenty four hours; have self-diagnostic function display; check mode for memory of most recent problem; control operation of the air sweep louvers; and provide on off and system/mode function switching. Normal operation of the hardwired remote controller provides individual system control in which one hardwired remote controller and one indoor unit are installed in the same room. The hardwired remote controller shall have the capability of controlling up to a maximum of 50 systems at a maximum developed control cable distance of 1650 feet. Control voltage between the hardwired remote controller and the indoor unit shall be 12 volts, D.C. The control voltage between the indoor unit and the outdoor unit shall be 12 volts, D.C. Both 12VDC shall be generated from the indoor unit microprocessor board. The system shall be capable of automatic restart when power is restored after power interruption. System shall include twenty function self-diagnostics including total hours of compressor run time.

F. The outdoor unit shall be completely factory assembled, piped and wired. The casing shall be fabricated of galvanized steel, bonderized and finished with baked enamel. The unit shall be furnished with one (1), direct drive, propeller type fan arranged for horizontal discharge. The motors shall have inherent protection be of the permanently lubricated type, and resiliently mounted for quiet operation. Each fan shall be provided with a raised guard to prevent contact with moving parts. The variable speed compressor shall be of the high performance, rotary type with crankcase heater, accumulator and internal thermal overloads. The variable speed compressor shall be mounted so as to avoid the transmission of vibration. The refrigeration system shall be equipped with high pressure switch and have the capability to operate with a maximum height difference of 130 feet and overall refrigerant tubing length of 130 feet between indoor and outdoor sections without the need for line size changes, traps or additional oil. Refrigerant flow from the condenser to be controlled by means of a capillary tube. The condenser coil shall be of nonferrous

construction with smooth plate fins bonded to copper tubing. The coil shall be protected with an integral metal guard. The unit shall be controlled by the microprocessor located in the matching indoor unit. A built in, low ambient controller will allow cooling to 0 degrees F outdoor temperature. The outdoor condensing unit shall be placed on vibration isolators and mounted on rooftop equipment rail or concrete pad as indicated on contract drawings.

G. High condensate water safety shutdown: Each indoor unit's detection unit shall be interlocked to alarm and stop the outdoor unit if a high condensate water level is sensed.

2.3. DUCTLESS SPLIT SYSTEM AIR CONDITIONER (INVERTER TYPE) (CEILING CASSETTE TYPE)

A. The air conditioning systems shall be a Mitsubishi split type system, Sanyo, LG, Daikin, Samsung, or approved equal. The system shall consist of a compact ceiling mounted packaged evaporator section and matching Slim Line air cooled outdoor unit. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label. All wiring to be in accordance with the National Electrical Code (NEC). The units shall be rated in accordance with ARI Standard 210 and bear the ARI label. A full charge of R-410A for 100 feet of refrigerant tubing shall be provided in the condensing unit. A dry nitrogen holding charge shall be provided in the evaporator. System SEER shall meet or exceed 1992 Federal Standards.

B. The units shall have a manufacturer's warranty for a period of one (1) year from date of installation. The compressor shall have a warranty of six (6) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of Mitsubishi Electronics America, Inc. This warranty does not include labor. Manufacturer shall have ten years experience in the U.S. market.

C. Capacity shall be as scheduled on the contract drawings.

D. The indoor unit shall be completely factory assembled and wired. The casing shall be galvanized sheet with grey heat insulation. This unit shall fit in the ceiling and have the capability of attaching a branch supply duct as well as a fresh air duct. The evaporator fan shall be an assembly with a high performance, fan direct driven by a single motor. The fan shall be statically and dynamically balanced and run on permanently lubricated bearings. The indoor unit shall have an adjustable air outlet system offering 4-way air flow, 3-way air flow, or 2-way air flow. The auto air swing vanes shall automatically swing up and down for uniform air distribution. Return air shall be filtered by a long-life filter to provide approximately 2,500 hours of use in a normal office environment before cleaning. The indoor unit shall be covered with a flat panel which protrudes only 1 inch below the ceiling to provide a neat and clean installation. The coils shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phoscopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan shall extend under the coil and piping. An integral drain pan pump capable of lifting condensate 12 inches shall be provided. The unit electrical power requirements shall be as indicated on the contract drawings.

E. The control system shall consist of two (2) microprocessors interconnected by a single non

polar two wire cable as supplied. Wiring shall run from indoor unit to controller direct. NO SPLICES. When running longer lengths or more than one set of hardwired remote controller wires together, a double insulated, two wire cable equivalent to that provided e.g. Belden 9407 cable, is mandatory or used shielded two wire cable. One microprocessor shall be factory wired and located within the indoor unit. It shall have the capability of sensing return air temperature and indoor coil temperature; receive and process commands from the hardwired remote controller; provide emergency operations, and control the outdoor unit. The microprocessor within the wall mounted hardwired remote controller shall provide automatic cooling, display set point and room temperature; a 24-hour on/off timer so that automatic operation can be set on the timer at one-hour intervals from one to twenty-four hours; have self-diagnostic function display; check mode for memory of most recent problem; control operation of the air sweep louvers; and provide on-off and system/mode function switching. Normal operation of the hardwired remote controller provides individual system control in which one hardwired remote controller and one indoor unit are installed in the same room. The hardwired remote controller shall have the capability of controlling up to a maximum of 50 systems at a maximum developed control cable distance of 1650 feet. The control voltage between the hardwired remote controller and the indoor unit shall be 12 volts, D.C. The control voltage between the indoor unit and the outdoor unit shall be 12 volts, D.C. Both 12VDC shall be generated from the indoor unit microprocessor board. The system shall be capable of automatic restart when power is restored after power interruption. System shall include twenty function self diagnostics including total hours of compressor run time.

F. The outdoor unit shall be completely factory assembled, piped, and wired. The casing shall be fabricated of galvanized steel, bonderized and finished with baked enamel. The unit shall be furnished with one (1) direct drive, propeller type fan arranged for horizontal discharge. The motor shall have inherent protection, be of the permanently lubricated type and resiliently mounted for quiet operation. Each fan shall be provided with a raised guard to prevent contact with moving parts. The variable speed compressor shall be of the high performance, rotary type with crankcase heater, accumulator and internal thermal overloads. The variable speed compressor shall be mounted so as to avoid the transmission of vibration. The refrigeration system shall be equipped with high pressure switch and have the capability to operate with a maximum height difference of 130 feet and overall refrigerant tubing length of 130 feet between indoor and outdoor sections without the need for line size changes, traps or additional oil. Refrigerant flow from the condenser to be controlled by means of a capillary tube. The condenser coil shall be nonferrous construction with smooth plate fins bonded to copper tubing. The tubing shall be inner grooves for high efficiency heat exchange. The coil shall be protected with an integral metal guard. The units shall be controlled by the microprocessor located in the matching indoor unit. A built-in, low-ambient controller shall allow cooling to 0 degrees F outdoor temperature. The unit electrical power requirements shall be as scheduled on the contract drawings. The outdoor condensing unit shall be placed on vibration isolators and mounted on roof-top equipment rail or concrete pad as indicated.

G. High condensate water safety shutdown: Each indoor unit's detection unit shall be interlocked to alarm and stop the outdoor unit if a high condensate water level is sensed.

2.4. FANS

A. General

1. Provide fans as indicated on the drawings. All fans shall have been tested and their performance rated in accordance with Air Movement and Control Association, Inc., Bulletin 210-85 Test Code and shall be licensed to bear the AMCA Seal. All fans shall carry the AMCA Certified Rating Seal for air and sound. Sound power levels shall be submitted for approval. Fan curves shall be submitted with all fan shop drawings.

2. Fan manufacturer shall submit under what duct configuration (unducted, partially ducted, or ducted) the manufacturer certified the performance of a particular fan or group of fans.

3. When indicated on Contract Drawings provide inverter duty rated motors for all variable speed fans.

B. Roof Mounted Supply Fan

1. Belt Drive

a. Furnish and install belt driven, roof mounted supply air fans of the size, capacity, and electrical characteristics as shown on the contract drawings.
b. Fans shall be of the belt driven, double width/double inlet, forward curved, centrifugal blower type.
c. The hood shall be constructed of heavy gauge primed and painted galvanized steel and adequately sized to prevent rain and snow from entering the building. The cover shall be constructed of heavy gauge galvanized steel, removable for service and insulated to prevent condensation.
d. Hood bases shall have prepunched mounting holes.
e. Permanent washable 1-inch aluminum filters shall be provided.
f. Fan wheels shall be of the forward curved type, constructed of heavy gauge steel, and statically and dynamically balanced to ensure smooth, vibration free operation.
g. A disconnect switch shall be factory installed and wired from the fan motor to a junction box installed within the motor compartment. A fan conduit chase shall be provided through the curb cap to the motor compartment for ease of installation.
h. Furnish each roof supply fan with a duct adapter kit to allow installation of ductwork prior to fan installation.
i. Motors shall be permanently lubricated, heavy duty, ball bearing type carefully matched to the fan load and furnished at the specified voltage, phase and enclosure.
j. The fan shaft shall be ground and polished steel mounted in heavy duty, sealed ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speeds. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor sheaves shall be adjustable for final system balancing. Drives shall be sized for a minimum of 150 percent of driven horsepower. The entire fan and motor assembly shall be mounted on vibration isolators to prevent noise transmission.
k. The roof mounted supply fans shall bear the AMCA Certified Ratings Seal

for air performance.

l. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future identification.

m. Provide 12- inch high, fully insulated, aluminum roof curbs with each supply fan. Fan and roof curb shall be provided by the same manufacturer.

n. Motor operated dampers shall be provided by ATC subcontractor and installed by mechanical contractor.

o. Fans shall be Model RSF as manufactured by Greenheck Fan Corporation, ACME Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

C. Power Roof Ventilators

1. Belt Drive

a. Furnish and install belt driven power roof ventilators of the size, capacity, and electrical characteristics a shown on contract drawings.

b. Roof fans shall be centrifugal belt driven type.

c. The fan wheel shall be centrifugal backward inclined, constructed of aluminum and shall include a wheel cone carefully matched to the inlet cone for precise running tolerances. Wheels shall be statically and dynamically balanced.

d. The fan housing shall be constructed of heavy gauge aluminum with a rigid internal support structure. The fan shroud shall have a rolled bead for added strength.

e. Motors shall be heavy duty ball bearing type, carefully matched to the fan load, and furnished at the specified voltage, phase and enclosure. Motor and drives shall be mounted on vibration isolators, out of the airstream. Fresh air for motor cooling shall be drawn into the motor compartment from an area free of discharge contaminants. Motors shall be readily accessible for maintenance. Motors shall be two (2) speed type where indicted on drawings.

f. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators.

g. Precision ground and polished fan shaft shall be mounted in permanently sealed, lubricated pillow block ball bearings. Bearings shall be selected for a minimum (L50) life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulley shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor pulleys shall be adjustable for final system balancing.

h. A disconnect switch shall be factory installed and wired from the fan motor to a junction box installed within the motor compartment. A fan conduit chase shall be provided through the curb cap to the motor compartment for ease of installation.

i. All fans shall bear the AMCA Certified Ratings Seal for sound and air performance.

j. Each fan shall bear a permanently affixed manufacturer's nameplate containing the model number and individual serial number for future

identification.

k. Provide 12-inch high, fully insulated, aluminum roof curbs with each ventilator. Fan and roof curb shall be provided by the same manufacturer.

l. Provide 2-inch aluminum birdscreen with each fan.

m. Motor operated dampers shall be provided by ATC subcontractor and installed by mechanical contractor.

n. Fans shall be Model GB as manufactured by Greenheck Fan Corporation, ACME Engineering, Penn Ventilator, Cook, Twin City Fan and Blower or approved equal.

2.5. BASE MOUNTED PUMPS - END SUCTION

A. Furnish and install base mounted centrifugal end suction pumps to circulate hydronic water to the various items of equipment throughout the building, associated with the HVAC system. Pumps shall have sizes and capacities as indicated on the drawings.

B. All pumps shall be suitable for the service and temperatures designated and shall conform to the following requirements. Each pump shall have a factory installed seal flushing line running from the seal area to the pump suction to insure removal of trapped air from the seal area, removal of sediment, and cooling of the seal to extend seal life. Provide and install Cuno five (5) micron filters in seal flushing lines. Provide two (2) sets of cartridges for each side - stream filter.

C. Pumps shall be cast iron bronze fitted and shall be suitable for up to 175 psi working pressure and up to 250 degrees F water temperature. Pumps shall have center-line discharge for positive venting and flanged bodies. Pumps shall incorporate a grease lubrication system and be so designed that the bearing assembly can be removed in one piece. A water slinger shall be provided between the mechanical seal and bearing areas. Pump shafts shall be stainless steel with a cupro-nickel sleeve, and be coupled to the motor shaft by a noiseless, non-metallic coupler with guard. Impellers shall be one piece cast bronze, dynamically balanced. Motors shall be 1750 rpm. For variable speed pumps, motors shall be inverter duty rated.

D. Pumps shall be designed so that they shall not overload at low heads and shall not develop excessive pressure under throttled flow conditions or overload motor anywhere on the operating curve. Operating performance curves shall be submitted for approval. Provide gauge tappings on each pump flange. Furnish dust caps at all oil fill tubes. Pump motors shall be non-overloading throughout the range of the curves.

E. When pumps are operated in parallel, pumps must be selected so as not to “run-out” to the end of the pump curve. Submit pump curves for parallel pump operation and single pump operation.

F. Units shall be provided with motors of not less than the horsepower indicated, suitable for the service and available electrical characteristics. Units shall be controlled as hereinafter specified. After installation and prior to operation, each pump shall be aligned. Motors shall be as specified hereinbefore.

G. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.

H. Impeller: Bronze, fully enclosed, keyed to shaft.

I. Baseplate: Cast iron or fabricated steel with integral drain rim.

J. Pumps shall be primed and painted in baked enamel, rust resistant paint.

K. Electrical characteristics shall be as scheduled on the contract drawings. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA-70.

L. Pumps shall be FE series as manufactured by Taco, 2000 Series by Allis Chalmers, Aurora, Bell & Gossett, PACO, Armstrong, Patterson, or as approved equal.

2.6. VERTICAL IN-LINE PUMPS

A. Furnish and install vertical centrifugal in-line single stage pump(s), with capacities and characteristics as shown on the plans. Pumps shall be Taco Model VI, Bell and gossett, Thrush, Patterson, Armstrong or approved equal.

B. Pump volute or casing shall be constructed of class 35 cast iron. The pump shall be fitted with replaceable bronze wear rings, drilled and tapped for gauge ports at both the suction and discharge flanges and for drain port at the bottom of the casing. The pump shall be capable of being serviced without disturbing system piping. Pumps shall be bronze fitted for use in closed systems and all bronze construction in open systems.

C. The impeller shall be bronze and hydraulically balanced by either back vanes or back wear ring and balancing holes. The impeller shall be dynamically balanced and shall be fitted to the shaft with a key.

D. The pump shall be close coupled to a NEMA standard JM regreasble high efficiency motor. The pump shall incorporate a dry shaft design to prevent the circulating fluid from contacting the shaft. The shaft shall be covered with a replaceable bronze shaft sleeve. Motors shall be 1750 rpm. Pumps shall be designed so that they shall not overload at low heads and shall not develop excessive pressure under throttled flow conditions or overload motor anywhere on the pump curve.

E. The pump shall have a factory installed seal flushing line running from the seal area to the pump suction to insure removal of trapped air from the seal area, removal of sediment and cooling of the seal to extend seal life. Provide and install Cuno 5 micron filters in seal flushing line.

F. The pump seal shall be EPT Ceramic rated to 250 degrees F. Pumps shall be finished in a baked enamel finish designed to resist rusting. Pumps shall be suitable for up to 175 psi working pressure and up to 250 degrees F water temperature.

G. Electrical characteristics shall be as scheduled on the contract drawings. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA-70.

2.7. VARIABLE SPEED DRIVES

A. Provide variable speed drive controllers for pumps and relief air fans **as** indicated on contract drawings.

B. ERV variable speed drives shall be factory furnished by ERV unit manufacturer.

C. The adjustable frequency controller (AFC) shall convert three phase 60 Hertz utility power to adjustable voltage and frequency, three phase, AC power for stepless motor control from 5 percent to 110 percent of base speed.

D. The single zone VAV air handling units shall be factory furnished with variable frequency drives for the supply and return air fan.

E. The AFC shall be a voltage source type with a PWM output utilizing power transistor semi-conductors.

F. The AFC together with all options and modifications shall mount within a standard NEMA 1 enclosure suitable for continuous operation at ambient temperature of 0 to 40 degrees C. with relative humidity to 95 percent non-condensing. All high voltage components within enclosure shall be isolated with steel covers. The complete unit shall be UL approved and UL labeled. Variable speed drives installed outside exposed to weather shall be installed in a NEMA-4X enclosure.

G. Circuits shall provide DV/DT and DI/DT protection for semi-conductors. AFC shall be capable of starting into a rotating load without delay. Protective circuits shall cause instantaneous trip (IET) should any of the following faults occur:

1. Motor overload.

2. Shortcircuit.

3. Motor overtemperature fault.

4. Reverse phase.

5. 110 percent of controller maximum sine wave current rating is exceeded.

6. Output phase to phase and phase to ground short circuit condition.

7. High input line voltage.

8. Low input line voltage.

9. Loss of input phase.

10. External fault. This protective circuit shall permit, by means of the terminal strip, wiring of remote NC safety contacts such as high static, firestat, etc., to shut down the drive.

H. The following adjustments shall be available in the controller and retained in non-volatile memory:

1. Maximum frequency (15 to 400 Hz) factory set at 60 Hz.

2. Minimum frequency (3 to 60 Hz) factory set at 6 Hz.

3. Acceleration (.1 to 360 seconds) factory set at 20 seconds.

4. Deceleration (.1 to 360 seconds) factory set at 20 seconds.

5. Volts/Hertz ratio factory set for 460V at 60 Hz.

6. Voltage offset or boost factory set at 100 percent torque.

7. Current limit (50 percent to 110 percent sine wave current rating) factory set at 100 percent current.

I. The AFC shall have the following basic features:

1. Door-mounted operators controls consisting of a membrane command center which allows manual stop/start and speed control, local/remote indication and manual/or automatic speed control selection. In addition, the command center shall serve as a means to configure controller parameters such as min speed, max speed, acceleration and deceleration times, Volts/Hz ratio, torque boost etc. Potentiometers shall not be allowed for these settings.

2. Main input disconnect to provide a positive disconnect between the controller and all phases of the incoming A-C line. This disconnect shall be mounted inside the controller enclosure and have through-the-door interlocking toggle with provisions for padlocking.

3. Electronic motor overload relay.

4. Automatic restart after power outage, drive fault or external fault, with drive in automatic mode. The circuit shall allow the user to select up to (10) restart attempts as well as the dwell time between attempts. The reset time between fault occurrences shall also be selectable. All settings shall be via the membrane command center.

5. Door-mounted LED display for digital indication of:

   a. Frequency output
   b. Voltage output
   c. Current output
   d. First fault indication
   e. Fan or Pump Speed (RPM)

6. Relay contacts for remote indication of drive fault and motor finning.

7. Three critical frequency avoidance bands, field programmable via the membrane command center. Each critical frequency avoidance band shall have a bandwidth adjustable via keypad entry of up to 10 Hz.

8. Three programmable preset speeds which shall force the AFC to a preset speed upon a user contract closure.

9. Isolated process follower to enable VFC to follow a 4-20 mA signal.

10. The AFC shall have the capability to ride through power dips up to 500 msec without a controller trip depending on load and operating condition.

11. Line reactor to minimize line surges, line notching, and voltage distortions. Line reactor shall be installed upstream of the drive.

J. Manual bypass-to-line with magnetic contactors to transfer motor from the variable frequency controller to full speed operation on utility supplied input power while the motor is at any speed. Two motor contactors, electrically interlocked shall be utilized, one contactor between the controller output and the motor and the other between the bypass power line and the motor, providing across-the-line starting.

K. Motor protection per National Electrical Code shall be provided in both the "controller" mode and the "bypass" mode by a motor overload relay. The 115 volt A-C relay control logic, allowing common start/stop commands in the "controller" mode and the "bypass" mode shall also be included within the enclosure.

L. The bypass shall include a door interlocked, main power input circuit breaker providing positive shutdown of all power to both the bypass circuitry and the VFC. The bypass circuit shall also include a second input disconnect to the VFC. This disconnect shall provide the ability to safely trouble shoot and test the controller, both energized and de-energized, while operating the bypass mode.

M. The VFC and all components shall be supplied within a single NEMA 1 enclosure, and shall be U.L. Listed as a single unit. Furnish all components necessary to provide a minimum lead length between motor and drive of 400 ft. The VFC shall not generate damaging transistor pulses greater than the limits set by NEMA MG-1 at 400 Ft lead length.

N. The VFC manufacturer shall maintain and staff nationwide service centers. These service engineers shall be employed by the manufacturer and provide start-up service including physical inspection of drive and connecting wiring and final adjustments to meet specified performance requirements.

O. The VFC shall carry a full parts and labor warranty for two years from date of Owner acceptance of the building.

P. The variable speed drive shall be ABB, or approved equal of Accutrol, Cutler Hammer, Graham, York, Baldor, AC Tech, Trane, Emerson, Danfos, Yaskawa, Toshiba, or as approved equal.

Q. The variable speed drive manufacturer shall coordinate with the ATC contractor and provide all necessary devices whether optional or not to perform complete and automatic operation as described in the sequence of operation. All safeties, including freezestats, duct smoke detectors, and high static pressure sensors shall be enabled when variable speed drives are in manual or bypass.

R. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.

1. Network Communications Ports: Ethernet and RS-422/485.

2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet; protocols accessible via the communications ports.

S. Variable speed drives shall be carefully selected for the duty required. Variable speed drives shall be specifically designed for the specified equipment to be controlled. Pump drives shall be selected for pumps and fan drives shall be selected for fans.

2.8. COMBINATION COALESCING AIR AND DIRT SEPARATOR

A. Furnish and install as shown on the drawings a Spirotherm steel, Taco Series 4900, Caleffi , Armstrong, Wessels, or approved equal air elimination and dirt separator. All fittings shall be fabricated steel, rated for 150 psig design pressure and selected for less than 1 foot of water pressure drop and velocity not to exceed 4 feet per second through the unit at specified GPM. All units shall include an integral copper bundle of Spirotubes or approved equal, to act as the turbulence suppressive coalescing medium which must completely fill the fitting's internal area. Units are to remove free and entrained air during system start up and continue to eliminate dissolved air and dirt through continual circulation and the coalescing action of the Spirotubes. Each fitting is to have a separate air and venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral float actuated brass air vent. There shall be no restriction in the connection from the venting chamber to the vent. The fittings are to include a valve side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Units shall include a bottom connection for use as a blow down connection for periodic cleaning. Unit shall have the bottom of the vessel extended for dirt separation with the system connection nozzles equal distant from the top and bottom of the vessel. Air separator shall be primed and finished in rust resistant paint. Units shall be Spirovent dirt models of the size required to meet pressure drop and velocity criteria.

B. A blowdown connection and valve shall be provided to facilitate routine cleaning of the strainer and the separator. Unit shall include a removable lower head to facilitate removal of the tube assembly for cleaning.

C. A manufacturer's data report for pressure vessels, for U-1 as required by the provisions of ASME Boiler and Pressure Vessel code, shall be furnished for each air separator upon request. Manufacturer to furnish data sheet specifying air collection efficiency and pressure drop at rated flow.

D. Conventional tangential or centrifugal non-coalesing air separators shall not be acceptable.

2.9. EXPANSION TANKS

A. Furnish and install as shown on the drawings, pre-pressurized captive air bladder type

expansion tank pre-charged with air. Tank shall be suitable for a maximum working pressure of 125 psi and constructed and certified to ASME Section VII. It shall have a replaceable elastomeric bladder suitable for a maximum operating temperature of 240 degrees F (115 degrees C). Expansion tanks shall be primed and finished in rust resistant paint. It shall have an integral steel base ring for vertical mounting and saddle for horizontal mounting. Expansion tank shall be as manufactured by Taco, Bell & Gossett, Wessels, Amtrol, Armstrong or as approved equal.

2.10. VERTICAL CABINET UNIT HEATERS (SURFACE MOUNTED)

A. Furnish and install vertical sloped top cabinet unit heaters of the size, capacity, and electrical characteristics shown on the contract drawings. Units shall be Trane, Model J, Dunham Bush, Modine, Rittling, or approved equal.

B. Front panels shall be fabricated of 16 gauge galvanized steel. All other panel parts shall be fabricated of 18 gauge galvanized steel. All panels shall be made by channel forming. Hanged access door shall be constructed of 20 gauge steel and shall be flush with top panel. All cabinet parts shall be finished in a baked on enamel finish in color as selected by Architect.

C. Water coils to be 5/8 inch OD seamless copper tubes mechanically bonded to configured aluminum fins with continuous fin collars and sleeved coil end supports. Maximum working pressure 300 psig, factory test pressure 450 psig (air). Supply and return connections on same side of units.

D. Fans shall be centrifugal, forward curved, double width of non-corrosive, molded, fiberglass-reinforced thermo-plastic materials. The fan board assembly shall include a quick disconnect motor plug.

E. Motor shall have integral thermal overload protection and start at 78 percent of rated voltage. Motor to be factory installed and tested prior to shipping.

F. Filters to be accessed by pivoting hinged bottom panel. Filters shall be 1 inch woven glass filters.

G. Provide each unit with factory furnished and insulated electrical disconnect toggle switch.

H. Provide each unit with a sloped top and extended end pocket (to conceal piping). Unit shall be provided with front bar grille inlet and top bar grille outlet.

I. Provide 18 gauge steel flanges (factory furnished) for recessing unit heater into ceiling.

J. Unit shall be U.L. listed.

2.11. HORIZONTAL HOT WATER UNIT HEATERS

A. Provide and install horizontal hot water unit heaters of the size, capacity and electrical characteristics as indicated on the contract drawings. Horizontal unit heaters shall be Trane Model S, Dunham Bush, Modine, or approved equal.

B. Casing shall be two-piece with "picture frame" front formed into wrap around sides, top and bottom. Furnish each unit with louvered fin diffuser for versatility in lateral diffusion. Casing shall be 18 gauge back panel with deep-drain fan orifice for extreme rigidity. Steel supply and return pipe top connectors bolted to back. Casings phosphatized to prevent corrosion and finished with a green baked enamel finish.

C. Fan shall be high efficiency Model A with aluminum blades, factory balanced and sturdy for standard applications.

D. Coils shall be hot water, single tube single serpentine design. Fins shall be aluminum sigma-flow, mechanically bonded to seamless copper tubing. All coils one-row deep in air flow direction. Coils shall be tested at 300 psig air under water. Coils shall be suitable for operation at 200 psig or 325 degrees F.

E. Motors shall be totally enclosed, class "B" insulated shaded pole and permanent split capacitor. All motors shall have built-in overload protection. Sleeve bearing motors can be oiled. Ball bearing motors are permanently lubricated. Units shall be U.L. listed.

2.12. AIR MONITORING STATIONS

A. General: Provide complete air monitoring station for ERV units and single zone VAV units, as indicated on drawings. The air monitoring station shall include airflow measuring stations, static pressure probes and electronic velocity pressure transmitter. All components shall be of the same manufacturer. The manufacturer shall be Air Monitor, Gold Series Ebtron Thermistar, or as approved equal. An air monitor station shall be provided for each supply duct main, outside air and exhaust duct main, as indicated on contract drawings. All air flow monitoring stations shall be fully externally insulated to prevent condensation.

B. Air Monitor Airflow Measuring Stations

1. Provide where indicated, airflow measuring stations capable of continuously monitoring the fan or duct capacities (air volumes) they serve.

2. Each airflow measuring station shall contain multiple total and static pressure sensors positioned at the center of equal area of the station cross-section and interconnected by their respective averaging manifolds. For stations of 4 square feet or less, one total and one static pressure sensor shall be present for every 16 square inches of station area respectively. For stations of larger area, one total and one static pressure sensor shall be present for every 36 square inches of station area respectively.

3. The airflow measuring station shall be fabricated of a minimum of 14 ga. galvanized steel, welded casing in 8-inch depth with 90 degree connecting flanges in a configuration and size equal to that of the duct it is to be mounted into. Each station shall be complete with an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to the casing, total and static pressure sensors located on an equal area basis and connected to symmetrical averaging manifolds, internal piping, and external pressure transmitter ports. An identification label shall be placed on each station casing listing model number, size, area, and

specified airflow capacity.

4. Cell construction shall be 3/8-inch .003-inch, type 3003 aluminum, expanded.

5. The maximum allowable pressure loss through the station shall not exceed .015-inch wc at 1000 fpm, or .085-inch wc at 2000 fpm. Each station shall be capable of measuring the airflow rate within an accuracy of 2 percent as determined by U.S.G.S.A. certification tests. The stations shall have a self-generated sound rating of less than NC 40, and the sound level within the duct shall not be amplified, nor shall additional sound be generated.

6. Stations shall be Fan-E type as manufactured by Air Monitor Corporation, Paragon or as approved equal.

C. Air Monitor Duct Static Pressure Traverse Probes

1. Provide where indicated duct static traverse probe capable of continuously monitoring the duct or system static pressure it serves.

2. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Said sensors shall not protrude beyond the surface of the probe.

3. The duct static traverse probe shall be of extruded aluminum construction and (except for ¾-inch diameter probes with lengths of 24-inches or less) be complete with threaded end support rod, sealing washer and nut and mounting plate with gasket and static pressure signal fitting.

4. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressure, without need for correction factors, with an instrument accuracy of 0.5 percent.

5. The duct static pressure traverse probe shall be the STAT-probe/1 as manufactured by the Air Monitor Corporation, Paragon or as approved equal.

D. Air Monitor Electronic Velocity Pressure Transmitters

1. The electronic control-instrument components shall be of industrial process control quality with operating features described herein and capable of producing the outlined performances. Commercial grade control-instruments, devices, are not acceptable.

2. The electronic differential pressure transmitter shall include an automatic zeroing circuit capable of automatically readjusting the transmitter zero at predetermined (adjustable) time intervals while retaining (locking in) the output signal. The electronic differential pressure transmitter shall be capable of receiving signals of duct total and static pressures, and of amplifying and scaling the sensed differential pressure into a 4-20 mADC or 0-5 (0-10) VDC output signal linear to differential pressure, within the following minimum performance criteria:

Zeroing	Automatic, within 0.1 percent of operating span, on 4 to 256 minute intervals (selectable)
Spans	Factory custom spanned, coordinated with system, ranges from 0 to .01-inch to 0 to 10.0-inches. Field adjustment +20 percent of span.
Accuracy	+ 0.25 percent of span
DeadBand and Hysteresis (Combined):	Less than 0.2 percent of span
Linearity:	+ 0.2 percent of span
Repeatability:	0.15 percent of span
Response:	0.5 second for 98 percent full span input
Power Supply:	24 VAC, 20 to 40 VDC, selectable; 4 wire

3. Coordinate requirements with the buildings direct digital control system to perform the required sequence of operation.

4. The pressure transmitter shall be the VELTRON series 5000AZ as manufactured by the Air Monitor Corporation, Paragon, Greenheck, Johnson Controls, or as approved equal.

2.13. WATER TREATMENT SERVICES:

A. Complete chemical water treatment service shall be provided by an organization regularly engaged in water treatment, ARC, Inc., RCCO Corp., Aquatel Ind., Inc., Mogul Corp., Oilin, Inc., HVAC Services, Inc., Feedwater Treatment Systems, Inc., Eco-Lab, or approved equal. The service shall provide all equipment, chemicals and labor necessary to prevent corrosion, inhibit scale build-up and minimize organic growth for a period of 2 years starting from building acceptance. Water Treatment shall be conducted for each phase prior to substantial completion of each phase. Service visits for the purpose of adding chemicals to feeding equipment, regulating bleed-off, inspecting and adjusting water treatment equipment, and obtaining samples of laboratory analysis shall be performed at monthly intervals for closed systems and every two weeks for open systems during the entire guarantee period. Chemicals shall not be injurious to water side equipment and construction materials. Records of all injurious to water side equipment and construction materials. Records of all service visits, chemical additions, laboratory tests, etc., shall be maintained and shall be provided to owner after each visit during guarantee period. Instruct mechanical contractor in field on piping and wiring of chemical feeding equipment.

B. Systems to be protected shall include chilled water system, and hot water heating system. Services shall include flushing and cleaning of piping systems specified under Division 23 Section, "HVAC Piping, Fittings, and Valves" section, furnishing and installing all

chemical treatment equipment and accessories to perform the water treatment specified below. Maintain complete records of the treatment program for each system.

C. Contractor shall perform an analysis of the building water supply as a basis of the chemical treatment. Contractor shall provide the Owner with written instructions for chemical feeding bleed-off, blowdown control and testing procedures, provide all required chemicals during the guarantee period, and provide all required test kits.

D. Contractor shall maintain the following conditions in each system:

SYSTEMS	Chiller Water System	Hot Water System
ph	8.0 to 10.5	7.0 to 10.0
Inhibitor for Scale & Corrosion Cycles	---	---
Cycles*	---	---
Organic	---	---
Buffered Nitrate	550 ppm	1000 ppm to 180 degrees F 2000 ppm to 180 degrees F
Chromate (Low)		
Molybdate	30 to 50 ppm	50 to 100 ppm
Sulfite	---	---
Sodium Nitrite	500 to 1000 PPM	1000 to 1500 PPM
Corrosion Inhibitor	100 to 150 PPM (as Molybdate) or 1000 to 1500 PPm sodium Nitrite	
*Actual cycles of concentration to be determined from analysis of make-up water.		

E. Chemical Feeding Equipment: Provide chemical feeding equipment, as specified below, to introduce chemicals into each system only when the system is operating.

1. Closed Recirculating Systems

a. Five (5) gallon steel by-pass feeder installed across circulating pump

suction and discharge lines, with tank and piping insulated using the same thickness and type of insulation as provided for the piping system. Provide filter. Unit shall contain quick opening cap and shall be suitable for working pressure of 175 psig. Tank shall be primed and finished in baked enamel paint.

2. Replace bypass feeder filter monthly during the entire 2-year warranty period.

F. Boilers shall be boiled cut with an alkaline type boiling out compound to remove grease, oil, mill scale and other foreign matter. The compound should be used at the rate of 1-1/2 pounds per 20 boiler horsepower. After boiling out period, the boilers should be completely drained, flushed, refilled with fresh water and vented. All water treatment chemicals shall comply with Delaware Water Resources laws and regulations.

G. Closed Recirculating Systems shall be filled and sufficient detergent and dispersant added to remove all dirt, oil, and grease. System shall be circulated for at least 48 hours after which a drain valve at the lowest point shall be opened and allowed to bleed while the system continues to circulate. The automatic make-up valve shall be checked to be sure it is operating. Bleeding shall continue until water runs clear and all detergent is removed. A sample of water shall be tested and if PH exceeds the PH of the make-up water, flushing shall be resumed.

2.14. ENERGY RECOVERY VENTILATORS

A. Provide and install ERV's (Energy Recovery Ventilators) as shown on contract drawings. ERV's shall be Model ERT as manufactured by Greenheck, Venmar or approved equal.

1. Energy Recovery Ventilator shall be as manufactured by Greenheck or approved equal provided all specifications are met. Greenheck Model ERT equipment is used as the basis of design. Venmar is also acceptable contingent upon meeting all specified requirements. Units shall be listed per UL 1812 and bear the UL label. Energy transfer ratings shall be in accordance with ASHRAE Standard 84 and ARI 1060. Performance to be as scheduled on plans. Exhaust discharge and outside air intake shall not be located on the same side.

2. Unit shall be of internal frame type construction of galvanized steel. All frame and panels shall be G90 galvanized steel. Where top panels are joined there shall be a standing seam to insure positive weather protection. Permatector exterior finish is available for outdoor units. All metal-to-metal surfaces exposed to the weather shall be sealed, requiring no caulking at job site. Unit base to be designed for indoor mounting.

3. Unit casing to be insulated with 1 in - 3 lb. fiber-glass with Foil-Scrim-Kraft facing. Insulation in accordance with NFPA 90A and tested to meet UL 181 erosion requirements and secured to unit with water proof adhesive and permanent mechanical fasteners.

4. Wheel shall be of the enthalpy type for both sensible and latent heat recovery and be designed to insure laminar flow. Efficiency ratings shall be based on tests conducted in accordance with ASHRAE 84 and laminar flow. Efficiency ratings

shall be based on tests conducted in accordance with ASHRAE 84 and ARI 1060 standards. Desiccant shall be silica gel for maximum latent energy transfer. Wheel shall be constructed of light weight polymer or aluminum media to minimize shaft and bearing loads. Polymer or aluminum media shall be mounted in a stainless steel rotor for corrosion resistance. Wheel design shall consist of removable segments for ease of service and/or cleaning. Segments shall be removable without the use of tools. Silica gel desiccant shall be permanently bonded to wheel media to retain latent heat capability after cleaning. Energy recovery device shall transfer moisture entirely in the vapor phase.

5. All components shall be easily accessible through removable hinged doors for both exhaust supply, filter and damper compartments. Energy recovery wheels (smaller than 54 in.) shall be mounted in a slide-out track for ease of inspection, removal and cleaning.

B. Energy Recovery Ventilators

1. Centrifugal blowers shall be backward inclined and housed in a scroll to maximize fan efficiency. Fans shall be AMCA certified for air performance. All blower wheels shall be statically and dynamically balanced. Ground and polished steel fan shafts shall be mounted in permanently sealed ball bearing pillow blocks. Bearings shall be selected for a minimum (L10) life in excess of 100,000 hours at maximum cataloged operating speeds. Blowers shall enable independent balancing of exhaust and supply airflow with adjustable sheaves for motors 10 horsepower and below. Fans shall be located in draw-through position in reference to the energy recovery wheel.

2. Motors shall be energy efficient, complying with EPACT standards, for single speed ODP and TE enclosures. Motors shall be permanently lubricated, heavy duty type, matched to the fan load and furnished at the specified voltage, phase and enclosure. Drives shall be sized for a minimum of 150 percent of driven horsepower. Pulleys shall be fully machined cast. Energy wheel motors shall have integral overload protection.

3. All internal electrical components shall be prewired for single point power connection. Units with electric reheat will be wired with independent power supply. All electrical components shall be UL listed, approved or classified where applicable and wired in compliance with the National Electrical Code. The control center shall include a weatherproof disconnect switch, motor starters, control circuit fusing and control transformer for 24 VAC circuit. Motor starters shall consist of a contactor and Class 20 adjustable overload protection and shall be provided for all motors in the unit.

4. Dehumidifier heat pipe shall precool the air leaving the wheel and reheat the air leaving the cooling coil in a wraparound configuration. Both heat exchangers shall be inside and integral to the equipment cabinet. Coils shall have copper tubes with permanently expanded aluminum fins, 12 fins per inch or less. Heat transfer fluid shall be classified as Safety Group A1 in BDR/ASHRAE Std. 15-1989R.

5. Chilled water coils shall be factory tested and rated in accordance with ARI

410. Coils shall have copper tubes with permanently expanded aluminum fins, 12 fpi or less.

6. Hot water coil shall be factory tested and rated in accordance with ARI 410. Coils shall have copper tubes with permanently expanded aluminum fins, 12 fpi or less.

7. Energy recovery ventilator housings shall be factory primed and painted in color as selected by Architect.

8. Both the supply and exhaust air streams shall be filtered to protect the enthalpy wheel. Furnish and install 30 percent pleated filters (Farr 30/30 or approved equal), filter racks and access panels. Provide one (1) set of additional filter media to Owner for each unit.

9. The exhaust and fresh air intake openings shall be furnished with aluminum birdscreens. In addition, the fresh air intake hood shall be factory furnished with 2-inch thick aluminum mesh filters.

C. Extra Materials:

1. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

2. Filters: Furnish one set of each type of filter.

3. Fan Belts: Furnish one set of belts for each belt drive fan in energy recovery ventilator.

4. Wheel Belts: Furnish one set of belts for each belt driven energy wheel.

2.15. SINGLE ZONE VAV UNITS

A. Provide and install single zone VAV unit with integral energy recovery wheels as shown on contract drawings. Single zone VAV unit with integral energy recovery wheels shall be Aaon Model H3, Venmar, or approved equal.

1. Performance to be as scheduled on plans.

2. Unit shall be of internal frame type construction of galvanized steel. All frame and panel shall be G90 galvanized steel. Where top panels are joined there shall be a standing seam to insure positive weather protection. All metal-to-metal surfaces shall be sealed, requiring no caulking at job site. Unit base to be designed for mounting or an interior concrete housekeeping pad.

3. Unit casing to be insulated with minimum thermal resistance R-value of 13. Foam insulation shall have minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929 for minimum flash ignition temperature of 610 degrees Fahrenheit. Insulation in accordance with NFPA 90A and tested to meet UL 181 erosion requirements and secured to unit with water proof adhesive and

permanent mechanical fasteners.

4. All components shall be easily accessible through removable hinged doors for both return fan, supply fan, filter, refrigerant components, enthalpy wheel, cooling coil, heating coil, and damper compartments.

5. All piping within the unit enclosure shall be insulated with insulation type, thickness and jacketing as specified in Division 23 Section, “HVAC Insulation”.

6. Furnish and install motor bearing protective rings at all variable frequency drive motors. Refer to Division 23 Section, “Common Work Results for HVAC”.

B. Fans

1. Fans shall be direct drive unhoused, backward curved plenum fans. All blower wheels shall be statically and dynamically balanced. Ground and polished steel fan shafts shall be mounted in permanently sealed ball bearing pillow blocks. Bearings shall be selected for a minimum life in excess of 200,000 hours at maximum cataloged operating speeds. Blowers shall enable independent balancing of exhaust and supply airflow with adjustable sheaves for motors 10 horse power and below. Fans shall be located in draw-through position in referenced to the energy recovery wheel. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be inverter duty premium efficiency. Furnish units with extended lube lines with grease plugs.

2. All internal electrical components shall be pre-wired for single point power connection. All electrical components shall be UL listed, approved or classified where applicable and wired in compliance with the National Electrical Code. The control center shall include a disconnect switch, motor starters, variable frequency drives, control circuit fusing, control transformer for 24 VAC circuit and motor starters. Motor starters shall consist of a contactor and Class 20 adjustable overload protection and shall be provided for all motors in the unit.

3. Housings shall be factory primed and painted in color as selected by Architect.

4. Return air stream shall be filtered prior to cooling coil. Furnish and install MERV-8 pleated filters, filter racks and access panels. Provide one (1) set of additional filter media to Owner for each unit.

5. Furnish and install filter housings with 2-inch thick filters on both air streams of the energy recovery wheel.

6. Unit shall include 2 inch thick, pleated panel outside air and return air filters with MERV rating of 8, upstream of the wheels.

7. Furnish relief air outlet and outside air inlet with flanged duct connections and field installed flexible duct connections.

C. Chilled Water Cooling Coil

1. Coil shall be certified in accordance with AHRI Standard 410 and be hydrogen or helium leak tested.

2. Coil shall be designed and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.

3. Coil shall have single serpentine circuitry, 8 rows, and 12 fins per inch.

4. Coil shall have right hand external piping connections. Supply and return connections shall be sweat connection. Coil connections shall be labeled, extend beyond the unit casing, and be factory sealed on both the interior and exterior of the unit casing to minimize air leakage.

D. Heating Water Heating Coil

1. Furnish each unit with an insulated, stainless steel IAQ drain pan under the coil extending past the coil to ensure condensate retention.

2. Coil shall be certified in accordance with AHRI Standard 410 and be hydrogen or helium leak tested.

3. Coil shall be designed and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.

4. Coil shall have half serpentine circuitry, 1 row and 12 fins per inch.

5. Coil shall have right hand external piping connections. Supply and return connections shall be sweat connection. Coil connections shall be labeled, extend beyond the unit casing, and be factory sealed on both the interior and exterior of the unit casing to minimize air leakage.

6. Control valves shall be field supplied and field installed.

7. Coils shall be located as indicated on Contract Documents.

E. Outside Air/Economizer

1. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 15 CFM of leakage per sq. ft. of damper area when subjected to 2 inches w.g. air pressure differential across the damper. Damper assembly shall be controlled by spring return sensible temperature activated fully modulating actuator.

2. Economizer shall be furnished with return air CO2 override.

3. During economizer mode the energy recovery wheel shall be bypassed.

F. Energy Recovery Section:

1. Unit shall contain a factory mounted and tested energy recovery wheel(s). The energy recovery wheel(s) shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.

3. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.

4. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.

6. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.

7. Energy recovery wheel cassette shall carry a 5 year non-prorated warranty.

8. Hinged service access door shall allow access to the wheel(s).

9. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

10. Energy recovery wheel rotation detection sensors shall be provided under Division

23 Section, “Instrumentation and Controls of HVAC and Plumbing Systems”.

G. Extra Materials:

1. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

   a. Filters: Furnish one set of each type of filter.
   b. Belts: Furnish one set of belts for each belt drive including energy recovery wheel in unit.
   c. During flush out operation prior to opening, install a minimum MERV-8 filter in outside air and exhaust air filter housing.

H. Demand Control Ventilation Components:

1. Unit shall be equipped with demand control ventilation capabilities that enable the varying of outdoor air and return air volumes based on building occupancy. A sensor shall be located in the spaces to monitor average CO2 levels of the occupied spaces. A variable frequency drive shall receive a 0-10 volt signal from the CO2 sensors and control the outdoor air volume to maintain a maximum of 1,000 ppm of CO2 in the occupied space. Supply air and return air fans shall be controlled simultaneously. Variable frequency drive shall be pre-programmed at the factory and shall assure that minimum outdoor air and return air volumes are always maintained. The variable frequency drive shall be factory mounted and wired. CO2 sensors (space and outside air) shall be provided and interlocked by Division 23 Section, “Instrumentation and Controls of HVAC and Plumbing Systems”.

2. Furnish each unit with the following:

   a. Supply air fan variable frequency drive.
   b. Return air fan variable frequency drive.
   c. Space temperature sensor shall be provided under Division 23 Section, “Instrumentation and Controls of HVAC and Plumbing Systems”
   d. Space humidity sensor shall be provided under Division 23 Section, “Instrumentation and Controls of HVAC and Plumbing Systems”
   e. All controls necessary for economizer operation.
   f. All motor operated dampers (outside air, relief air, economizer, and return).
   g. Outside air flow monitoring station and exhaust air flow monitoring station shall be furnished and installed by the contractor in the ductwork.

I. Air Flow Monitoring Station (Field Installed in Ductwork)

1. Install air flow monitoring station in outside air duct and exhaust duct to control O.A. damper and exhaust fan speed to match outside air flow rate with exhaust air flow rate.

J. Air Controller

1. Controller shall be furnished and installed by the ATC subcontractor.

2. Controller

   a. Controller shall be capable of independent stand-alone operation and have the ability to communicate and integrate with widely-used building automation systems. Controller shall be IP addressable and be able to reside on a TCP/IP network. Controller shall have 2 RJ-45 Ethernet ports, 1 RS-232 port, and 1 RS-485 port. Coordinate with ATC subcontractor.
   b. Controller shall require a PC with the configuration tool software for configuration and programming. Furnish with graphical user interface over IP option controller so the unit can be configured through a browser over the internet.
   c. Controller shall have a full calendar schedule for occupied, unoccupied, and holiday scheduling.
   d. Controller shall retain all programmed values in non-volatile memory in the event of a power failure.
   e. Configuration tool software, when connected to unit controller, shall indicate unit status, set points, and faults.
   f. All inputs and outputs on the controller shall be viewable via the interface.
   g. All setpoints and schedules shall be editable via the interface by the Building Automation System.
   h. In addition to standard inputs/outputs provide additional inputs/outputs as required to accomplish sequence of operation and items listed on point list.
   i. The manufacturer shall be responsible for assisting and participating in the integration of this equipment into the Building Automation System and shall provide programming, testing, verification and on site personnel as required.

K. Electrical

1. Unit shall be provided with standard power block for connecting power to the unit.

2. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.

3. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on the voltage, the voltage is more than 10% under design voltage, or on phase reversal.

4. Unit shall be provided with manual reset low temperature limit controls which shut off the unit when the discharge temperature reaches a field adjustable setpoint.

L. Sequence of Operation

1. Refer to Division 23 Section, “Instrumentation and Controls of HVAC and Plumbing Systems” for sequences of operation.

2.16. BOILER BUFFER TANK

A. Provide and install a heating hot water storage buffer tank for use with existing boilers of the size, dimensions, and capacity as indicated on the contract drawings.

B. The storage tank shall be a vertical Lochinvar Lock-Temp "Energy Saver", A.O. Smith, Reco or approved equal tank having a storage capacity as indicated on the contract drawings. The tank shall be constructed with an inner chamber designed to receive all circulation to and from the boilers to eliminate turbulence in the tank. The baffled tank shall supply 80 percent of tank capacity without a drop in outlet temperature, regardless of rate of draw.

C. The storage tank shall be constructed in accordance with ASME Boiler and Pressure Vessel Code requirements, ASME - stamped and registered with the National Board of Boiler and Pressure Vessel Inspectors. The storage tank shall have a working pressure of (125 psig). The storage tank shall be glass lined and fired to 1600 degrees F to insure a molecular fusing of glass and steel furnished with magnesium anodes and carry a five (5) year limited warranty.

D. The storage tank shall be furnished with a factory installed jacket of 16GA steel, galvanized inside and out and finished with three coats of acrylic enamel. The jacket and tank base shall be a water tight construction with a built-in drain pain, complete with a 3/4-inch drain connection to assist in protecting against damage in the event of a tank or component leakage. The storage tank shall be completely encased in high density fiberglass insulation of sufficient thickness to meet the energy efficient requirements of the latest edition of the ASHRAE 90.1. Standard including addendums. The entire tank assembly shall be mounted on channel steel skids to facilitate handling and installation.

E. Tank shall be furnished with a manhole.

F. Tank shall be factory furnished with all inlet, outlet, thermometer, relief-valve, temperature sensor and thermostat tapings.

G. Mount tank on a 4-inch high housekeeping pad.

H. Provide factory furnished and installed A.S.M.E. pressure/ temperature relief valve. Pipe relief valve to nearest floor drain with union on discharge piping.

2.17. EXISTING BOILERS

A. The existing boilers (typical of 2) shall be re-used and repiped as indicated on Contract Documents. Refer to “Existing Boiler Modifications/Installation Requirements” in Part 3 of this specified section for additional modifications to the existing boilers.

B. The existing boilers are CleaverBrooks Model #CFC-700-1000-160HW, with the following serial numbers 01261-6 and 01261-7.

C. Furnish and install all controls as necessary to interlock existing boilers new pumps, automatic temperature control system, etc... Refer to control diagram and sequence of

operation on the Contract Documents.

D. Interlock boilers with new combustion air dampers.

E. At project completion provide factory start-up and flue gas analysis for each existing boiler.

PART 3. EXECUTION

3.1. EXAMINATION

A. Verify all dimensions by field measurements. Verify that all equipment may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.

B. Verify structure, mounting supports and membrane installations are completed to the proper point to allow installation of roof mounted equipment, where applicable.

C. Examine rough-in requirements for all piping systems to verify actual locations of piping connections prior to installation.

D. Verify that electrical work installation is in accordance with manufacture's submittal and installation requirements of Division 26 sections. Do not proceed with equipment start-up until electrical work is acceptable to equipment installer. Coordinate sizes of all thermal overloads with Division 26.

E. Do not proceed until unsatisfactory conditions have been corrected.

F. Provide wiring diagrams of all equipment as specified in Division 23 Section, Common Work Results for HVAC.

3.2. GENERAL INSTALLATION REQUIREMENTS

A. Install all equipment in accordance with manufacturer's installation instructions, in accordance with state and local code requirements, and in accordance with the contract drawings. Install all equipment plumb and level, to tolerances as required by the manufacturer of each item of equipment. Maintain manufacturer recommended clearances around and over all equipment.

B. Coordinate vibration isolation requirements with all equipment in accordance with Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment.

C. Coordinate all electrical requirements with Division 26.

D. Coordinate all indoor and outdoor equipment pad locations and sizes with approved shop drawing submittals. Provide operating weights of equipment to Structural Engineer for review. Coordinate equipment pad locations and sizes with the Concrete Contractor or General Contractor. Furnish anchor bolts which are to be inserted in concrete pads to concrete installer.

E. Verify piping arrangements of all equipment with the contract drawings. Piping details shall be strictly adhered to concerning valves, fittings, components, etc. At coils, where a rebuildable and repairable autoflow valve is installed in the line without the need for draining or shutting of the water, the same may be utilized as the isolation valve and additional shut-off valve is not required.

F. Connect all equipment, devices and components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening requirements specified in UL 486A.

G. Testing: After installing HVAC equipment, devices and components and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

H. Remove and replace malfunctioning units with new units and retest.

I. All mechanical penetrations or terminations in exterior walls shall be flashed and caulked watertight.

J. Arrange for equipment such as energy recovery units and single zone VAV units to be shipped to project in modules where space constraints require the same. Field erect components as required.

3.3. FIELD QUALITY CONTROL

A. Where indicated provide the services of a factory authorized service representative to examine the field assembly of components, installation, piping, electrical connections, controls, and clearances. Submit factory start-up check list to Engineer for information purposes. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer, and forwarded to Testing and Balancing Agency.

B. Where factory start-up of equipment is not specified, provide field start-up by qualified technician to examine the field assembly of components, installation, piping, electrical connections, controls and clearances. Record equipment manufacturer’s standard start-up information and submit to Engineer for review. Testing and balancing work shall not commence until start-up reports have been completed, reviewed by Engineer, and forwarded to Testing and Balancing Agency.

C. Charge all refrigerant systems with refrigerant and oil and test for leaks. Repair leaks and replace lost refrigerant and oil.

D. Fill all hydronic systems with water, repair leaks and replace lost water. Coordinate with water treatment contractor.

E. Submit to Engineer a written table of all relief valve and make-up water valve settings for each system. Provide an additional copy in the Operations and Maintenance Manuals.

F. Verify proper motor sizes, voltages, thermal overloads, nameplate data, etc. All equipment voltages and current shall be recorded to insure that motors are operating below their service factors. Test and Balance Engineer shall record electrical data before continuous or permanent operation.

3.4. DEMONSTRATION

A. Provide the services of a factory authorized service representative to provide start-up and to demonstrate and train the Owner's maintenance personnel.

B. Place equipment into operation and adjust controls and safeties. Replace damaged or malfunctioning components and controls.

C. Training:

1. Train the Owner's maintenance personnel on start-up and shut-down procedures, trouble shooting procedures, lubrication, servicing procedures and preventative maintenance schedules/procedures. Review with the Owner's personnel, the contents of the operation and maintenance data specified in Division 23 Section, Common Work Results for HVAC.

2. Submit operation and maintenance data as soon as possible prior to project close-out. Operations and maintenance data shall be submitted to the Owner for review and comment prior to submission to the Engineer.

3. Schedule training with the Owner through the Architect and/or Engineer with at least seven (7) days prior notice.

D. Contractor shall demonstrate removal and replacement of filters at all pieces of equipment with filters in the prescence of the Owners representative.

3.5. CLEANING

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Clean fan and equipment interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering air face.

3.6. DUCTLESS UNITS EQUIPMENT INSTALLATION REQUIREMENTS

A. Mount indoor and outdoor units as detailed on contract drawings.

B. Supply initial charge of refrigerant and oil as required.

C. Install all interlock and control wiring between indoor units, outdoor units thermostats, and condensate pumps.

D. Install indoor ceiling cassette on vibration isolators.

E. Install outdoor units on concrete pads, wall brackets or on roof curbs as indicated on

drawings.

F. Comb out fins on condensing unit where deformed or bent. Replace or repair broken fins.

G. Install condensate lift pumps, float switches, alarm, unit shut down wiring and detection block units per manufacturer's recommendations.

H. For wall mounted units, locate condensate pumps above ceiling. Install all piping, tubing between indoor unit, adapter, detection block, and condensate pump.

I. For wall mounted units field wire power wiring, alarm circuits, control cable, safety circuit connection, alarm, and condensate pump. Condensate pump shall be powered from indoor unit power wiring. Coordinate condensate pump electrical characteristics with indoor unit electrical characteristics.

J. Install wind baffles for low ambient operation. Locate wind baffles facing the predominant wind direction in winter.

3.7. FAN INSTALLATION REQUIREMENTS.

A. Install fans with resilient mounting and flexible electrical leads.

B. Install flexible connections and vibration isolators as specified in Division 23 Section, Common Work Results for HVAC and Division 23 Section Vibration Controls for HVAC, Plumbing and Fire Protection Equipment. Ensure metal band of connectors are parallel with minimum one inch flex between ductwork and fan while running.

C. Provide safety screens/guards on all fans and permanently mount after final testing and balancing.

D. Do not operate fans for any purpose until ductwork is clean, filters in place, bearings lubricated, and fans have been test run under operation.

E. Provide sheave required for final air balance.

F. Install fans according to manufacturer's written instructions.

G. Adjust damper linkages for proper damper operation.

H. Adjust belt tension.

I. Lubricate bearings.

J. Replace fan and motor pulleys and belts as required to achieve design conditions.

K. Where specified, mount, install, and wire speed controllers for direct drive fans. Speed controllers for direct drive fans shall be mounted adjacent to fan and wired in accordance with the NEC.

3.8. HVAC PUMP INSTALLATION REQUIREMENTS

A. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

B. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches (102 mm) and over.

C. Provide air cock and drain connection on horizontal pump casings.

D. Provide drains for bases and seals, piped to and discharging into floor drains.

E. Check, align, and certify alignment of base mounted pumps prior to start-up. Prior to starting pumps, the alignment of the pumps and their motors or other drivers shall be carefully checked. Alignment should be checked for both offset and angularity. Alignment by means of an Ames dial, Laser or equivalent shall be accomplished for all pumps. Alignment by straight edge across the pump couplings shall not be acceptable.

F. Install close coupled and base mounted pumps on concrete housekeeping pads, with anchor bolts, set and level, and grout in place. See Division 23 Section, Vibration Controls for HVAC, Plumbing and Fire Protection Equipment for inertia pad requirements. After alignment is correct, tighten foundation bolts evenly but not too firmly, completely fill baseplate with non-shrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

G. Lubricate pumps before start-up.

H. Provide side-stream filtration system for base mounted pumps. Install across pump with flow from pump discharge to pump suction from pump tappings. Install flow indicator, filter housing with cartridge filter, shut-off valves, and flow control valves. Install 30 micron filter for start-up and 5 micron filter for system operation.

I. Install pumps according to manufacturer's written instructions.

1. Install pumps according to HI 1.1 1.5, Centrifugal Pumps for Nomenclature, Definitions, Application and Operation.

J. Install pumps to provide access for periodic maintenance, including removing motors, impellers, couplings, and accessories.

K. Suspend in line pumps using continuous thread hanger rod and vibration isolation hangers.

L. Set base mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.

1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1 1/2 inches between pump base and foundation for grouting.

2. Adjust metal supports or wedges until pump and driver shafts are level. Check

coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

3.9. HYDRONIC EQUIPMENT AND SPECIALITIES INSTALLATION REQUIREMENTS

A. Where large air quantities can accumulate, provide enlarged air collection standpipes.

B. Provide manual air vents at system high points and as indicated.

C. For automatic air vents provide vent tubing to nearest drain.

D. Provide air separator on suction side of system circulation pump and connect to expansion tank.

E. Provide valved drain and hose connection on strainer blow down connection.

F. Provide pump suction fitting on suction side of base mounted centrifugal pumps. Remove temporary strainers after cleaning systems.

G. Support pump fittings with floor mounted pipe and flange supports.

H. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment and in accordance with ASME requirements.

I. Pipe all relief valve outlets to nearest floor drain.

J. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

K. Perform test determining strength of antifreeze and water solution and submit written test results.

L. Install equipment exposed to finished area after walls and ceiling are finished and painted. Avoid damage.

M. Protection: Provide finished cabinet units with protective covers during balance of construction.

N. Unit heaters: hang from building structure, with pipe hangers anchored to building, not from piping. Mount as high as possible to maintain greatest headroom unless otherwise indicated.

O. Cabinet Unit Heaters: Install as indicated. Coordinate to assure correct recess size for recessed units.

P. Testing: After installing and connecting units, demonstrate product capability and compliance with requirements.

Q. Remove and replace malfunctioning units with new units and retest.

3.10. WATER TREATMENT INSTALLATION REQUIREMENTS

A. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.

B. Place terminal control valves in open position during cleaning. Open bypass valves on coils and close isolation valves on coils during initial flushing.

C. Verify that electric power is available and of the correct characteristics.

D. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect.

E. Flush open systems and closed systems with clean water for one hour minimum. Drain completely and refill.

F. Remove, clean, and replace strainer screens.

G. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.11. ENERGY RECOVERY VENTILATOR INSTALLATION REQUIREMENTS

A. Examine areas to receive energy recovery units for compliance with requirements for installation tolerances and other conditions affecting performance of energy recovery units. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Install energy recovery units as indicated, according to manufacturer's written instructions.

C. Install CO2 sensor/control/interlock wiring to variable frequency drives and to ATC system. Install global CO2 sensor to monitor ambient outside air CO2 level.

D. Install and interlock space CO2 sensors.

E. Install heat wheels so supply and exhaust flow in opposite directions and rotation is from exhaust side to purge section to supply side.

1. Provide access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.

2. Provide removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.

F. Install and interlock outside air flow and exhaust monitoring station.

G. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

H. Ducts and fan installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of piping, fittings, and specialties.

I. Ground Equipment

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

J. After completing system installation, including outlet fittings and devices, inspect and clean exposed finishes. Remove dirt and construction debris and repair damaged finishes.

K. Startup Services: Engage a factory-authorized service representative to commission units as specified below.

1. Energize and verify correct rotation of heat wheels and fans.

2. Adjust seals and purge.

3. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

4. Verify sequence of operation.

5. Record fluid temperatures and flow rates.

6. Verify and record minimum and maximum air flow rates for the supply and exhaust air fan.

7. Verify and record the minimum and maximum supply/exhaust fan speeds/ hertz and incorporate into the fan tracking sequence of operation.

8. Test A/C condensate overflow safety switch.

9. Test flow switches.

10. Verify and record the minimum and maximum supply/exhaust fan speeds/hertz and incorporate into the fan tracking sequence of operation.

L. Training

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventative maintenance.

2. Review data in the operation and maintenance manuals. Refer to Division 01 Section, Demonstration and Training.

3. Schedule training with Owner, through Architect, with at least 7 days advance notice.

3.12. SINGLE ZONE VAV UNITS INSTALLATION REQUIREMENTS

A. Examine areas and conditions for compliance with requirements for installation tolerances, other specific conditions, and other conditions affecting performance of single zone VAV

units. Do not proceed with installation until unsatisfactory conditions have been corrected.

B. Examine piping and electric rough installations for single zone VAV units to verify actual locations of piping connections before installation.

C. Install single zone VAV units according to manufacturer's written instructions.

D. Install units level and plumb, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.

E. Piping Connections: Drawings indicate the general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Connect supply and return piping to coils with unions, shutoff valves, control valve, and flow meter fittings.

2. Connect drain pan to nearest indirect waste connection, air conditioning condensate pump or as indicated.

F. Duct Connections: Connect supply, return, relief and outside air ducts to single zone VAV units with flexible duct connections. Provide transitions to match unit duct-connection size. Completely seal and insulate where ductwork connects to unit and filter rack.

G. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

H. Connect low voltage safety switch wiring to heat pumps where air conditioning condensate pumps are indicated.

I. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

J. Replace filters used during construction. Seal all return air ducts to filter racks. Seal air tight all filter racks.

K. Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of piping and electrical connections. Report results in writing.

1. Test and adjust controls and safeties.

2. Replace damaged and malfunctioning controls and equipment.

3. Test and record refrigerant pressures, air flow rates, water flow rates, electrical characteristics. Start-up Company and Test and Balance Engineer must both be present during start-up to simultaneously record the above data.

L. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

2. Review data in the maintenance manuals specified in Division 01.

3. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

M. Maintain minimum of 24 inches clear space at unit filter access. Provide manufacturer required clearances for service at ATC control panel, fan section, compressor section and electrical section. Maintain sufficient clear space below units to allow lowering and raising of units in the future.

N. All single zone VAV units shall be provided with auto-restart in the event of a power outage. Units shall automatically be enabled to re-start when power is restored.

O. Install CO2 sensor/control/interlock wiring to variable frequency drives and to ATC system. Install global CO2 sensor to monitor ambient outside air CO2 level.

P. Install and interlock space CO2 sensors.

Q. Install and interlock outside air flow monitoring station and exhaust air flow monitoring station.

R. Startup Services: Engage a factory-authorized service representative to commission units as specified below:

1. Energize and verify correct rotation of heat wheels and fans.

2. Adjust seals and purge.

3. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

4. Verify sequence of operation.

5. Record fluid temperatures and flow rates.

6. Verify and record minimum and maximum air flow rates for the supply and exhaust air fan.

7. Verify and record the minimum and maximum supply/exhaust fan speeds/ hertz and incorporate into the fan tracking sequence of operation.

S. Install CO2 sensor/control/interlock wiring to variable frequency drives and to ATC system.

T. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.13. EXISTING BOILER MODIFICATIONS/INSTALLATION REQUIREMENTS

A. Install new piping, pumps, controls, and trim on existing boilers in accordance with NFPA-54, Boiler and Pressure Vessel Safety Act including ASME CSD-1, Amendments and Addenda, latest edition, State of Delaware Requirements. Coordinate inspection of boiler by local Boiler Inspector or authority having jurisdiction. Correct any and all violations noted by Boiler Inspector at no additional cost to the Owner.

B. Existing gas valve trains shall remain, however, all gas regulators and gas pressure relief valves shall be piped to the building exterior and terminated with a gooseneck and vermin screen as required in CSD-1. Gas regulator and gas relief valve pipe material shall be in accordance with A.S.M.E. Code.

C. Provide piping connections and accessories as specified and detailed on drawings. For hot water piping all piping up to the first OS&Y gate valve on each side of the boiler shall be welded, flanged or screwed. Grooved joint piping is not acceptable until after the OS&Y gate valve on each side of the boiler. Comply with Boiler Inspector Requirements.

D. Pipe all relief valves to nearest floor drain. Support relief valve piping in accordance with A.S.M.E. requirements. Relief valve pipe material shall be in accordance with A.S.M.E. Code. Install no more than one (1) elbow on safety relief valve discharge pipe located close to the valve outlet downstream of the union. Furnish and install new 50 psig relief valves on each boiler.

E. Provide for connection to electrical services. Install and wire all safeties, new flow switches, new low water cut-offs, new flame failure alarms to boiler burners and ATC system.

F. Assemble boiler trim according to manufacturer's written installation instructions.

G. Install electrical devices as required. Mount, install, and wire low water cutoffs. Low water cut offs shall be installed per manufacturers' recommendations and wired in accordance with the National Electric Code.

H. Interlock new motor operated combustion air dampers with existing boiler burners.

I. Electrical: Comply with applicable requirements in Division 26.

J. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

K. Manufacturer's Field Service: Engage a factory authorized service representative to supervise the field assembly of components and installation of boilers, including piping and electrical connections. Report results in writing.

1. Test and adjust controls and safeties. Replace damaged and malfunctioning

controls and equipment.

2. Submit flue gas and combustion analysis reports to Engineer.

3. Record design and actual draft available at appliance vent connection.

L. Hydrostatically test assembled boiler and piping, according to applicable sections of the ASME Boiler and Pressure Vessel Code.

M. Flush and clean boilers on completion of modifications/installation, according to manufacturer's written instructions.

N. After completing boiler installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes including chips, scratches, and abrasions with manufacturer's touch up paint.

O. Furnish and install condensate neutralizers with lime chips and pipe discharge as indicated. Connect condensate neutralizers to boilers and flue pipes.

P. Equipment Mounting:

1. Mount valves and devices at heights required by the Boiler Inspector.

Q. Assemble and install boiler trim.

R. Install control wiring to field-mounted electrical devices.

S. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. All boiler relief valve and drain piping shall be Type L copper piping.

T. Install piping adjacent to boiler to allow service and maintenance.

U. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve. Drain valves shall be brass, ball type and not less than 1-inch. Pipe ends shall be cut at 45 degree angle to prevent a cap or plug from being installed.

V. All relief valve discharge piping shall be fully supported to prevent undue stress or strain.

W. Finish and install new relief valves on each boiler.

X. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection. Connect boilers to new boiler buffer tank as indicated on Contract Documents.

Y. Connect new flow switch(es) to hot water piping at each boiler and interlock with boilers

and ATC system.

Z. Install piping from safety relief valves to nearest floor drain.

AA. Ground equipment according to Division 26, Section "Grounding and Bonding."

BB. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

CC. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.

2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.

3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

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

EE. Prepare test and inspection reports.

FF. Occupancy Adjustments: When requested within 24 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

GG. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.

2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.

3. Perform field performance tests to determine efficiency of boilers.

a. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.

5. Provide analysis equipment required to determine performance.

6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.

7. Notify Architect in advance of test dates.

8. Document test results in a report and submit to Architect.

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

END OF SECTION

DIVISION 23 SECTION 230701
HVAC INSULATION
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SECTION 230701 – HVAC INSULATION

PART 1. GENERAL

1.1. REFERENCE

A. The Conditions of the Contract and other General Requirements apply to the work specified in this Section. All work under this Section shall be subject to the requirements of Division 23 Section, Common Work Results for HVAC.

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

1.2. DESCRIPTION

A. All piping, ductwork, and equipment installed under this Contract shall be covered as specified.

1.3. SCOPE

A. The work covered by this specification consists of furnishing all labor, equipment, materials and accessories, and performing all operations required, for the correct fabrication and installation of thermal insulation applied to all piping, equipment, and duct systems, in accordance with applicable project specifications and drawings, subject to the terms and conditions of the contract.

1.4. STANDARDS

A. Thermal insulation materials shall meet the property requirements of one or more of the following specifications as applicable to the specific product or use:

1. American Society for Testing of Materials Specifications:

    a. ASTM C 547, "Standard Specification for Mineral Fiber Preformed Pipe Insulation".
    b. ASTM C 533, "Standard Specification for Calcium Silicate Pipe & Block Insulation".
    c. ASTM C 55, "Standard Specification for Mineral Fiber Blanket and Felt Insulation".
    d. ASTM E 96, “Standard Test Methods for Water Vapor Transmission of Material”.
    e. ASTM C 585, "Recommended Practice for Inner and Outer Diameters of Rigid Pipe Insulation for Nominal Sizes of Pipe and Tubing (NPS System)".
    f. ASTM C 612, "Standard Specification for Mineral Fiber Block and Board Thermal Insulation".
    g. ASTM C 1136, "Standard Specification for Barrier Material, Vapor, "Type 1 or 2 (Jacket only).

2. ASHRAE 90.1 "Energy efficient design of new buildings except low-rise

residential buildings", latest edition.

3. International Energy Conservation Code, latest edition.

B. Insulation materials, including all weather and vapor barrier materials, closures, hangers, supports, fitting covers, and other accessories, shall be furnished and installed in strict accordance with project drawings, plans, and specifications.

1.5. SYSTEM PERFORMANCE

A. Insulation materials furnished and installed hereunder should meet the minimum economic insulation thickness requirements of the North American Insulation Manufacturers' Association (NAIMA) (formerly known as TIMA), to ensure cost-effective energy conservation performance. Alternatively, materials should meet the minimum thickness requirements of National Voluntary Consensus Standard 90.1, (latest edition) and "Energy Efficient Design of New Buildings," of the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), latest edition. However, if other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor. As minimum, all insulation thicknesses shall be as hereinafter specified.

B. Insulation materials furnished and installed hereunder shall meet the fire hazard requirements of any one of the following specifications:

1. American Society for Testing of Materials ASTM E 84

2. Underwriters' Laboratories, Inc. UL 723

3. National Fire Protection Association NFPA 255

4. ASTM E 96, “Standard Test Methods for Water Vapor Transmission of Materials”.

C. Calcium silicate products shall include a visual identification system to permit positive field determination of their asbestos-free characteristics.

1.6. QUALITY ASSURANCE

A. Insulation materials and accessories furnished and installed hereunder shall, where required, be accompanied by manufacturers' current submittal or data sheets showing compliance with applicable specifications listed in Section 1.4 above.

B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.

C. Mockups:

D. Provide at project site a sample of each type of insulation hereinafter specified. Display insulation in an "installed" condition, showing typical completed pipe, covers, fittings, ductwork and equipment insulation. No insulation shall be applied until these samples

have been accepted by the Engineer. Any insulation work which does not conform to the accepted samples will not be acceptable, and shall be removed and re-installed in a manner acceptable to the Engineer at no additional cost to the Owner. Build mockups according to the following requirements, using materials indicated for the completed work.

1. Include the following pipe insulation mockups:

    a. Exterior aluminum jacketing
    b. One 10-foot section of NPS 2 inch straight pipe.
    c. One 90-degree elbow.
    d. One tee fitting.
    e. One NPS 2 inch valve.
    f. Four support hangers, including hanger shield and insert.
    g. One strainer with removable portion of insulation.
    h. One reducer.

2. Include the following equipment insulation mockups:

    a. One chilled-water centrifugal pump.
    b. One small tank or vessel.
    c. One plumbing pump/circulator.
    d. One freeze protection pump.

3. Include the following duct insulation mockups:

    a. One 10 foot section of rectangular straight duct.
    b. One 90 degree square elbow and one 90 degree radius elbow.
    c. One branch takeoff.
    d. One transition fitting.
    e. Four support hangers.
    f. Exterior duct insulation.

4. Mockups shall include samples of both concealed insulation and exposed insulation.

5. Build mockups with cutaway sections to allow observation of application details for insulation materials, mastics, attachments, and jackets.

6. Build mockups in the location indicated or, if not indicated, as directed by Engineer.

7. Notify Engineer seven days in advance of dates and times when mockups will be constructed.

8. Obtain Engineer approval of mockups before starting insulation application.

9. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed work.

10. Demolish and remove mockups when directed.

11. Approved mockups may become part of the completed work if undisturbed at time of substantial completion.

1.7. DELIVERY AND STORAGE OF MATERIALS

A. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.

B. The Contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The Contractor shall also use all means necessary to protect work and materials installed by other trades.

C. If any insulation material has become wet because of transit or job site exposure to moisture or water, the Contractor shall not install such material, and shall remove it from the job site. An exception may be allowed in cases where the Contractor is able to demonstrate that wet insulation when fully dried out (either before installation, or afterward following exposure to system operating temperatures) will provide installed performance that is equivalent in all respects to new, completely dry insulation. In such cases, consult the insulation manufacturer in writing for technical assistance.

D. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements. Protect all insulation from water, construction traffic, dirt, chemical and mechanical damage.

1.8. ALTERNATES

A. Refer to Division 01 Section, “Alternates” for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. GENERAL

A. All materials to be insulated shall be thoroughly cleaned, after completion of successful tests, and shall be covered as specified below. Fiberglass insulation shall be Owens-Corning, Manville, Armstrong, or P.P.G, or as approved equal.

2.2. PIPE INSULATION MATERIALS

A. Unless otherwise noted, insulation shall be one piece or half sectional molded fibrous glass with "K" rating of .23 at 75 degrees Fahrenheit mean temperature, for service temperatures between -60 degrees Fahrenheit and +450 degrees Fahrenheit with all service poly-encapsulated jacket. Pipe insulation shall be fiberglass ASJMax SSL II with double closure system as manufactured by Owens Corning, Johns Manville, Knauf or approved equal.

B. Exterior refrigerant pipe insulation shall be Armacell, or approved equal, foam insulation with exterior field applied aluminum jacketing. Interior refrigerant piping shall be Armacell or approved equal foam insulation. Where interior refrigerant piping is exposed also install field applied PVC jacketing.

C. Unless otherwise noted, pipe insulation jacket shall be factory-applied vinyl coated, embossed and reinforced vapor barrier laminate, with a perm rating of not more than 0.02 perms. All hot and cold, concealed and exposed butt strips shall be of the same material as the jacket. Jacket and butt strips shall be sealed with field-applied Foster 85-20/85-60 or Childers CP-82 (5 gal cans only) adhesive. Jacket and butt strips shall be off-white color and shall be equivalent to Owens-Corning Fiberglass 25-ASJ.

D. Indoor chilled water pipe insulation shall be ASJ Max with SSL-II closure system pipe insulation as manufactured by Owens Corning or approved equal. Pipe insulation shall be composed of heavy density fiberglass insulation with an organic binder. The insulation shall include a white, factory jacketed, resilient, tough, soil resistant polymer facing that matches standard PVC fitting covers. Furnish all accessories and matching butt joints sealing tape for system closure. Insulation shall be suitable for operating temperatures between 32 degrees Fahrenheit and 220 degrees Fahrenheit. Flame spread rating of 25 or less, and smoke development rating of 50 or less to comply with building codes for installation in return air plenums. The maximum thermal conductivity (K-value) at a mean temperature of 50 shall be .22 BTU-in/hr-Ft2-degrees Fahrenheit.

E. Exterior and exposed interior chilled water requiring jacketing and/or painting shall be standard non-wicking pipe insulation as here-in-before specified with specified covering.

F. For fittings on all piping, valves and flanges, apply fiberglass molded or segmented insulation equal in thickness to the adjoining insulation and securely fasten in place using wire. Cold piping: Apply a tack coat of vapor barrier coating and reinforcing mesh. After ½ hour, apply second coat of same vapor barrier coating, UL labeled, Type C, for cold water piping, Hot piping Type H for hot water piping: Apply tack of breather mastic. Wrap fitting with fiberglass reinforcing cloth overlapping adjoining sections of pipe insulation by 2-inches. Apply a second coat of breather mastic over the reinforcing cloth, working it to a smooth finish.

1. Vapor Barrier Coating: Foster 30-65; Childers CP-34 or Vimasco 749. Permeanie shall be 0.03 perms or less at 45 mils dry as test by ASTM E96.

2. Breather mastic: Foster 46-50; Childers CP-10/11 or Vimasco WC-5

3. Reinforcing Mesh: Foster Mast a Fab; Childers Chil Glas #10 or Vimasco Elastafab

G. All pipe insulation, jackets, or facings, and adhesives used to adhere jacket or facing to the insulation, including fittings and butt strips, shall have non-combustible fire and smoke hazard system rating and label as tested by ASTM E-84, NFPA 225, and UL 73, not exceeding Flame Spread 25, Fuel Contributed 50, Smoke Developed 50. Accessories such as adhesives, mastic cements, tapes and cloth for fittings shall have the same ratings as listed above. All products or their shipping cartons shall bear the Underwriter's label indicating that flame and smoke ratings do not exceed the above criteria.

H. For piping having a vapor barrier insulation and for all insulated piping requiring supports, hangers and supports shall be installed outside the insulation. Wherever hangers and supports are installed outside the insulation, pipe insulation protecting shields shall be provided. Where insulation is a load bearing material, of sufficient strength to support the weight of the piping, pipe shields one-third the circumference of the insulation and of a length not less than three times the diameter of the insulation (maximum length 24-inches) shall be provided. Insulation of 7-1/4 pound or greater density will be considered as load bearing for pipe sizes up to and including 2-inches. Where insulation is not of sufficient strength to support the weight of the piping, a half section of high density fiberglass or foam inserts, shall be provided. Vapor barrier and finish shall be applied as required to match adjoining insulation. In addition, shields shall be furnished as specified above.

I. For piping located outside of the building, a corrugated aluminum weatherproof jacketing system shall be provided. This system shall be Micro-Lot ML as manufactured by Manville, Polyweld by Pabco Metals Corp., Childers, or as approved equal, and installed per the manufacturer's recommendations. Where outdoor piping is receiving electric heat tape, the insulation shall be oversized so that the heat tape is not compressed tightly to the pipe. Pipe jacketing shall be corrugated (3/16-inch) deep aluminum, .016-inch thickness of H-14 temper with aluminum strapping of .75-inch width and .020 inch thickness with moisture barrier. Aluminum jacketing elbows shall be smooth, .016-inch thickness and 1100 alloy. All jacketing shall have an integrally bonded moisture barrier over the entire surface in contact with the insulation. Longitudinal joints shall be applied so they will shed water and shall be sealed completely with metal jacketing sealant. Sealant shall be Foster 95-44 or Childers CP-76. Circumferential joints shall be closed using preformed butt strips following manufacturer's recommendations for securement. Jacket seams shall be located on the bottom side of the horizontal piping.

J. All disturbed piping insulation in existing areas shall be re-insulated with insulation type, density, and thickness as specified for new piping. Insulation damaged due to new work and demolition only shall be replaced unless otherwise noted.

K. On cold systems such as refrigerant piping chilled water piping, and cooling coil drain piping, vapor barrier performance is extremely important. All penetrations and seams of the ASJ and exposed ends of insulation must be sealed with vapor barrier coating. The ASJ must be protected with either a coating or a suitable vapor retarding outer jacket. Vapor seals at butt joints shall be applied at every fourth pipe section joint and at each fitting to provide isolation of water incursion. Vapor Barrier Coating: Foster 30-65; Childers CP-34 or Vimasco 749. Permeance shall be 0.03 perms or less at 45 mils dry as test by ASTM E96.

L. Fittings and valves shall be insulated with pre-formed fiberglass fittings, fabricated sections of fiberglass pipe insulation, Fiberglass pipe and tank insulation, Fiberglass blanket insulation, or insulating cement. Thickness shall be equal to adjacent pipe insulation. Finish shall be with pre-formed PVC fitting covers or as otherwise specified on contract drawings. Where applicable, Victaulic PVC fitting valve and coupling covers shall be utilized. Victaulic PVC covers shall be installed with matching pipe insulation jacketing material, vinyl tape solvent weld adhesive and appropriate fasteners.

1. Flanges, couplings and valve bonnets shall be covered with an oversized pipe

insulation section sized to provide the same insulation thickness as on the main pipe section. An oversized insulation section shall be used to form a collar between the two insulation sections with low density blanket insulation being used to fill gaps. Jacketing shall match that used on straight pipe sections. Rough cut ends shall be coated with a suitable weather or vapor-resistant mastic as dictated by the system location and service. Finish valve installation with a Tyvac jacket with ends that secure to adjacent piping.

2. On hot systems where fittings are to be left exposed, insulation ends should be beveled away from bolts for easy access.

3. On cold systems, particular care must be given to vapor sealing the fitting cover or finish to the pipe insulation vapor barrier. All valve stems must be sealed with caulking which allows free movement of the stem but provides a seal against moisture incursion. All gauge and thermometer penetrations and extensions shall be correctly sealed and insulated to prevent surface condensation. Install oversized hangers to prevent penetrations of pipe insulation vapor barrier.

M. All piping shall be supported in such a manner that neither the insulation or the vapor/weather barrier is compromised by the hanger or the effects of the hanger. In all cases, hanger spacing must be such that the circumferential joint may be made outside the hanger. On cold systems, vapor barrier must be continuous, including material covered by the hanger saddle.

1. Piping systems 3-inches (7.5cm) in diameter or less, insulated with Fiberglass insulation, may be supported by placing saddles of the proper length and spacing, as designated in Owens-Corning Pub. 1-IN-12534, under the insulation. Hangers saddles shall be minimum 16 gauge with a saddle arc of 120 degrees minimum.

2. For hot or cold piping systems larger than 3-inches (7.5 cm) in diameter, operating at temperatures less than +200 degrees F (93 degrees C) and insulated with fiber glass, high density inserts such as foam or wood blocks with sufficient compressive strength shall be used to support the weight of the piping system. At temperatures exceeding +_200 degrees F (93 degrees C), Owens-Corning Pink Calcium Silicate, IIG, or approved equal pipe insulation shall be used for high density inserts.

3. Owens-Corning Pink Calcium Silicate pipe insulation may be used to support the entire weight of the piping system provided the hanger saddle is designed so the maximum compressive load does not exceed 100 psi (7kg/cm).

4. Where pipe shoes and roller supports are required, insulation shall be inserted in the pipe shoe to minimize pipe heat loss. Where possible, the pipe shoe shall be sized to be flush with the outer pipe insulation diameter.

5. Thermal expansion and contraction of the piping and insulation system shall generally be taken care of by utilizing double layers of insulation and staggering both longitudinal and circumferential joints. Where long runs are encountered, expansion joints may be required where single layers of insulation are being used and should be so noted on the contract drawings.

6. On vertical runs, insulation support rings shall be used.

2.3. PIPING INSULATION THICKNESSES SCHEDULE

A. All piping shall be insulated with pipe insulation of the thicknesses indicted below:

PIPING INSULATION THICKNESS SCHEDULE SERVICES	THICKNESS
Chilled Water Piping 2 ½-inches & Larger	2-inch thickness
Chilled Water Piping 2-inches & Smaller	2-inch thickness
All Branch Runouts to Unit Heaters	½-inch thickness
Heating Hot Water Piping 2-inches & Larger	2 –inch thickness
Heating Hot Water Piping 1-½ -inches & Smaller	1 ½ -inch thickness
All Drain Piping from Cooling Coils/Evaporators	1-inch thickness
All Above Grade Floor Drain Piping Serving AHU Condensate Drains include Drain Sumps and Auxiliary Drain Pipes from Auxiliary Pans	1-inch thickness
All Refrigerant Piping	1-inch thickness

2.4. EQUIPMENT INSULATION MATERIALS AND THICKNESSES

A. The following equipment shall be insulated with Fiberglass Rigid Board Insulation or Foam Plastic Insulation:

1. Chilled Water Pump and Hot Water Pump Bodies.

2. Air Separators.

3. Expansion Tanks.

4. Chemical Feed Tanks.

5. Hot Water Storage Tanks.

6. Freeze Protection Pump Bodies.

7. All Pump Volutes and Strainers.

B. Insulation for cold surfaces shall be 1-1/2-inch thickness, 6 lb. density, 705 FRK with a "K" rating of .23 at 75 degrees F mean temperature. Insulation for hot surfaces except as otherwise noted shall be 1-1/2-inch thickness, 6 lb. density, 705 with a "K" rating of .23 at 75 degrees F mean temperature. Insulation shall be applied with staggered joints firmly butted and joined. The insulation shall be held in place by steel bands. Bands shall be 1-inch by 25 gauge galvanized steel spaced on not over 12-inch centers. All joints and voids shall be filled with Owens-Corning #110 cement, well troweled into openings. For 705 FRK insulation, all joints and voids shall be FRK taped and vapor sealed. There shall be applied over the insulation surface 1-inch galvanized wire netting laced together at all edges and wired to the steel bands with 16 gauge soft annealed wire. Over this shall be applied 2-inch thick layer of Owens-Corning #110 cement applied in two layers. Install metal corner beads at all corners and edges in order to provide a

permanent installation. Onto the dry cement surface apply a brush coat of Foster Sealfas 30-36 or Childers CP-50AMV1 lagging adhesive at the rate of 60-70 square feet per gallon. Embed into wet coating a layer of 8 ounce canvas or fiberglass lattice mesh smoothed out to avoid wrinkles and lap all seams a minimum of 2-inches. Apply a second brush coat of Sealfas 30-36 or Childers CP-50AMV1 lagging adhesive to the entire surface at the rate of 60-70 square feet per gallon. Cleanouts, nameplates, and manholes shall not be insulated, and the insulation on surrounding surfaces shall be neatly beveled off at such openings.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.

2. Fabricate boxes from aluminum at least 0.040 inch (1.0 mm) thick.

3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

D. Boards shall be scored to allow them to conform to curved or irregular surfaces.

E. Mechanical fasteners shall be utilized to hold insulation to surface with bands as required to hold the curvature of the material.

F. Support rings shall be provided to support the top head insulation where required.

G. Outdoor installations require a weather barrier for protection of the insulation jacketing.

H. Insulation types materials shall be suitable for temperatures encountered by each item of equipment.

2.5. DUCTWORK INSULATION MATERIALS AND THICKNESSES

A. Insulate all supply, return, relief, combustion air, plenums, exhaust, and outside air intake ductwork with fiberglass exterior duct insulation with factory-applied foil facing. All exposed fiberglass duct insulation shall be 2-inch rigid or non-flexible board type 3.0 pcf minimum density, 0.23 max. "K" factor at 75 degrees F mean temperature, with white vinyl A.S.J. max, polymer coating vapor barrier facing. All concealed fiberglass duct insulation shall be 2-inch flexible blanket type, 1.0 pcf minimum density. All concealed insulation shall be 0.27 max. "K" factor at 75 degrees F mean temperature with reinforced foil-scrim Kraft vapor barrier facing. Unless otherwise noted, the minimum installed R-value shall be 6.0 HR x ft2 x ºF/btu.

B. Refer to Division 23 Section, HVAC Air Distribution System and contract drawings for location of all sound-lined ductwork. Sound-lined ductwork from the discharge or supply side of all energy recovery units, heat pumps, and single zone VAV unit shall require

external insulation in addition to internal lining specified hereinafter. All other ducts indicated to be provided with interior lining shall not require additional exterior insulation.

C. Where a vapor barrier is required, all joints, seams, tears, punctures, and other penetrations shall be closed with 3-inch (7.5cm) pressure-sensitive tape matching the facing or with vapor barrier coating reinforced with 3-inch (7.5cm) glass scrim tape.

D. Contractor-applied internal linings shall be as specified and installed as hereinafter specified.

E. For exposed Fiberglass duct insulation, tightly butt all edges and seams. Secure insulation with flush mechanical fasteners spaced not less than one per square foot. Insulation may be secured with 100 percent coverage of adhesive with mechanical fasteners on the underside of the duct only, in addition to adhesive. Adhesive shall be water based Foster 85-60 or Childers CP-127. Cover all seams, joints and fasteners with not less than 3-inch wide tape matching the insulation facing. Pre-finished white fastener caps may be left exposed if the spacing and pattern is uniform in appearance. Staples will not be permitted.

F. All new and existing supply air diffusers and supply air registers shall be fully insulated on the rear exposed surface to prevent condensation. Insulation shall be 1 ½" inch flexible blanket type 1 ½ pcf minimum density with reinforced foil-scrim-Kraft vapor barrier facing, .25 max "k" factor.

G. All airflow monitoring stations shall be externally insulated similar to adjacent ductwork as hereinbefore specified.

2.6. ACCESSORY MATERIALS

A. Accessory materials installed as part of insulation work under this section shall include, but not be limited to:

1. Closure Materials - Butt strips, bands, wires, staples, mastics, adhesives; pressure-sensitive tapes.

2. Field-applied jacketing materials - sheet metal, plastic, canvas, fiber glass cloth, insulating cement; PVC fitting covers, PVC jacketing.

3. Support Materials - Hanger straps, hanger rods, saddles.

4. Fasteners, weld pins/studs, speed clips, insulation washers.

5. Metal mesh or expanded metal lagging.

B. All accessory materials shall be installed in accordance with project drawings and specifications, manufacturer's instructions, and/or in conformance with the current edition of the Midwest Insulation Contractors Association (MICA) "Commercial & Industrial Insulation Standards."

2.7. FIELD-APPLIED JACKET

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   a. Johns Manville; Zeston.
   b. P.I.C. Plastics, Inc.; FG Series.
   c. Proto PVC Corporation; LoSmoke.
   d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.

3. Color: High gloss white.

4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

2.8. HANGER BLOCKS

A. For all pipes larger than 3 inches in diameter the hanger blocks shall be high compressive strength foam or wood blocks. Wood blocks shall be precision cut thickness to match specified insulation and shall include flared edge hanger saddle as manufactured by Buckaroo.

B. The wood blocks shall be suitable for temperatures from -120 degrees Fahrenheit to 200 degrees Fahrenheit. Do not utilize the wood blocks for piping systems operating outside of the indicated temperature range.

C. Wood blocks are not acceptable for use at refrigerant pipe hangers.

PART 3. EXECUTION

3.1. WORKMANSHIP

A. The Contractor shall take special care to prevent soiling equipment below or adjacent to areas being insulated. He shall be completely responsible for removing insulation cement splashes and smears and all surfaces that he mars or otherwise soils or defaces, and he will be totally responsible for restoring these damaged surfaces to their like-new

condition when delivered to the site.

3.2. SITE INSPECTION

A. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.

B. Verify that all materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.

C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all materials and accessories to be installed on the project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.3. PREPARATION

A. Ensure that all pipe and equipment surfaces over which insulation is to be installed are clean and dry.

B. Ensure that insulation is clean, dry, and in good mechanical condition with all factory-applied vapor or weather barriers intact and undamaged. Wet, dirty, or damaged insulation shall not be acceptable for installation.

C. Ensure that pressure testing of piping or duct systems has been completed prior to installing insulation.

3.4. INSTALLATION

A. Piping Systems

1. General:

a. Install all insulation materials and accessories in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
b. Install insulation on piping subsequent to installation of heat tracing, painting, testing, and acceptance tests.
c. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other. Butt insulation joints firmly to ensure complete, tight fit over all piping surfaces.
d. Maintain the integrity of factory-applied vapor barrier jacketing on all pipe insulation, protecting it against puncture, tear or other damage. Seal all tears, punctures and other penetrations of the pipe insulation vapor barrier coating.
e. On exposed piping, locate insulation and cover seams in least visible location.

2. Fittings: Cover valves, fittings, unions, flanges, strainers, flexible connections, expansion joints, pump bodies, strainers, blowdowns, backflow preventers, autoflow valves and similar items in each piping system using one of the following:

   a. Mitered sections of insulation equivalent in thickness and composition to that installed on straight pipe runs.
   b. Cold pipe fittings: Apply a tack coat of vapor barrier coating and reinforcing mesh to produce a smooth surface. After ½ hour, apply a second coat of same vapor barrier coating, UL labeled, Type C, for cold water piping.
   c. Hot pipe fittings and Type H for hot water piping: Apply tack of breather mastic. Wrap fitting with fiberglass reinforcing cloth overlapping adjoining sections of pipe insulation by 2-inches. Apply a second coat of Type C or Type H breather mastic over the reinforcing cloth, working it to a smooth finish.
   d. Insulation cement equal in thickness to the adjoining insulation.
   e. PVC fitting covers insulated with material equal in thickness and composition to adjoining insulation.

3. Penetrations: Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise specified.

4. Joints:

   a. Butt pipe insulation against hanger inserts. For hot pipes, apply 3-inch (7.5cm) wide vapor barrier tape or bank over butt joints. For cold piping, apply wet coat of vapor barrier lap cement on butt joints, and seal joints with 3-inch (7.5cm) wide vapor barrier tape or band.
   b. All pipe insulation ends shall be tapered and sealed, regardless of service.

5. All existing floor drain piping and floor drain sumps that are indicated to receive A/C condensate shall be fully insulated to prevent condensation.

B. Equipment Insulation:

1. General:

   a. Install insulation in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
   b. Install insulation on equipment after installation of heat tracing, painting, testing, and acceptance tests.
   c. Install insulation materials with smooth, even surfaces. Rework poorly fitted joints. Do not use joint sealer or mastic as filler for joint gaps and excessive voids resulting from poor workmanship. Apply insulation using staggered joint method for both single and double layer installation, applying each layer of insulation separately.
   d. Coat insulated surfaces where specified on contract drawings with layer

of insulating cement, troweled in a workmanlike manner, leaving a smooth and continuous surface. Fill in seams, broken edges, and depressions. Cover over wire mesh and joints with cement sufficiently thick to remove surface irregularities.

e. Maintain the integrity of factory-applied vapor barrier jacketing on all insulation, protecting it against puncture, tears or other damage. Seal all tears, punctures and other penetrations of equipment insulation facing.

f. Where specification calls for field-applied all-service vapor barrier jacketing, it shall be neatly fitted and tightly secured. Lap seams 2-inches (5cm) (min.). Seal all joints with adhesive. Tape with 3-inches (7.5cm) matching pressure-sensitive tape or 3-inch (7.5cm) glass fabric and vapor barrier coating.

g. On exposed equipment, locate insulation and cover seams in least visible location.

2. Removable Insulation: Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance, such as vessel covers, fasteners, flanges, frames accessories, manholes, handholes, cleanouts ASME stamp, and manufacturer nameplates.

3. Areas Left Uninsulated: Items such as boiler manholes, handholes, clean-outs, ASME stamp, and manufacturers' nameplates should be left uninsulated unless omitting insulation would cause a condensation problem. When such is the case, provide removable insulation and appropriate tagging to identify the presence of these items. Provide neatly beveled edges at interruptions of insulation.

4. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of weather barrier mastic protective finish or jacketing as recommended by the jacketing manufacturer.

C. Ductwork Insulation:

1. General:

a. Before installing insulation, ensure that all seams and joints in ductwork have been sealed and leak tested by the contractor responsible for the duct system. Before applying duct insulation, air ducts shall be clean and dry.

b. Install insulation in accordance with manufacturer's published instructions and recognized industry practice to ensure that it will serve its intended purpose.

c. Install insulation materials with smooth and even surfaces. Butt joints firmly together to ensure complete and tight fit over surfaces to be covered.

d. Maintain the integrity of factory-applied vapor barrier jacketing on all insulation, protecting it against puncture, tears or other damage. All staples used on ductwork insulation shall be coated with suitable sealant to maintain vapor barrier integrity and covered with pressure sensitive vapor barrier tape and vapor barrier coating as specified.

e. Insulate entire system including fittings, joints, flanges, fire dampers,

flexible connections, and exposed joints. All portions of duct designated to receive duct wrap shall be completely covered with duct wrap.

f. To ensure installed thermal performance, duct wrap insulation shall be cut to "stretch-out" dimensions. Maintain specified duct insulation thickness and vapor barrier at all fittings, obstructions, and duct flanges.

g. A 2-inch (50mm) piece of insulation shall be removed from the facing at the end of the piece of duct wrap to form an overlapping stapling and taping flap.

h. Install duct wrap insulation with facing outside so that the tape flap overlaps the insulation and facing at the other end of the piece of duct wrap. Adjacent sections of duct wrap insulation shall be tightly butted with the 2-inch (50mm) stapling and taping flap overlapping. If ducts are rectangular or square, install so insulation is not excessively compressed at corners. Seams shall be stapled approximately 6-inches (150mm) on center with 2-inch (13mm) (min) steel outward clinching staples.

i. Seams, joints and staples shall be sealed with pressure-sensitive tape matching the insulation facing (either plain foil or FRK backing stock) and glass fabric and vapor barrier coating. Cloth duct tape of any color or finish using reclaimed rubber adhesives shall not be utilized on duct wrap insulation. Adjacent sections of duct wrap shall be tightly butted with the 2-inch (50mm) tape flap overlapping.

j. Where rectangular ducts are 24-inch (600mm) in width or greater, duct wrap insulation shall be additionally secured to the bottom of the duct with mechanical fasteners such as pins and speed clip washers, spaced on 18-inch (425mm) centers (maximum) to prevent sagging of insulation.

k. Seal all tears, punctures and other penetrations of the duct wrap facing using one of the above methods to provide a vapor tight system.

l. Upon completion of installation of duct wrap and before operation is to commence, visually inspect the system and verify that it has been correctly installed.

m. Open all system dampers and turn on fans to blow all scraps and other loose pieces of material out of the duct system. Allow for a means for removal of such material.

n. Check the duct system to ensure that there are no air leaks through joints.

o. No ductwork insulation shall be supported utilizing tie wire or bailing wire. Penetrations of ductwork insulation vapor barrier are prohibited.

p. Bevel and terminate insulation at access doors. Paint edges with vapor barrier mastic.

q. Install insulation board between volume dampers and sheet metal standoffs.

r. Provide removable insulation section at all pitot tube traverse points. Insulation section shall contain tether that attaches to adjacent ductwork.

2. Penetrations: Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise specified.

3. Ductwork Exposed to Weather: Protect outdoor insulation from weather by installing outdoor weather barrier mastic or jacketing as recommended by the insulation manufacturer.

4. Rigid Insulation:

   a. Rigid duct insulation may be impaled over welded pins and secured with insulation caps and washers matching the color of the vapor barrier facing. All seams shall be firmly butted and sealed with pressure-sensitive vapor barrier tape matching the facing and vapor barrier coating.
   b. Corner angles shall be installed on all external corners of rigid duct insulation in exposed finished areas before jacketing, except oven and hood exhaust duct insulation, which shall have no corner angles.

5. Duct Wrap Insulation: Duct wrap insulation shall be applied with all joints butted firmly together. All joints in the insulation covering shall be sealed with adhesive. Duct wrap insulation shall be secured to bottom of rectangular or oval ducts over 24inches (60cm) wide with mechanical fasteners on 16-inch (40 cm) (approx.) centers to prevent sagging.

6. Duct Lining Insulation: Duct liner insulation shall be applied with all joints tightly butted using 90 percent coverage of adhesive meeting the requirements of ASTM C 916 plus mechanical fasteners spaced according to the liner manufacturer's schedule for the interior width of the plenum, housing, or air shaft. (Also refer to Division 23 Section, HVAC Air Distribution System.)

3.5. FIELD QUALITY ASSURANCE

A. Upon completion of all insulation work covered by this specification, visually inspect the work and verify that it has been correctly installed. This may be done while work is in progress, to assure compliance with requirements herein to cover and protect insulation materials during installation.

3.6. PROTECTION

A. Replace damaged insulation which cannot be satisfactorily repaired, including insulation with vapor barrier damage and moisture-saturated insulation.

B. The insulation contractor shall advise the general and/or the mechanical contractor as to requirements for protection of the insulation work during the remainder of the construction period, to avoid damage and deterioration of the finished insulation work.

3.7. SAFETY PRECAUTIONS

A. Insulation contractor's employees shall be properly protected during installation of all insulation. Protection shall include proper attire when handling and applying insulation materials, and shall include (but not be limited to) disposable dust respirators, gloves, hard hats, and eye protection.

B. The insulation contractor shall conduct all job site operations in compliance with applicable provisions of the Occupational Safety and Health Act, as well as with all state and/or local safety and health codes and regulations that may apply to the work.

3.8. INSULATION COVERING

A. Unless otherwise noted, all exposed duct and equipment insulation shall have a field applied PVC jacket cover neatly cut and pasted over ductwork and equipment insulation. PVC shall be high gloss white and shall be 20 mils thick.

B. Unless otherwise noted, all exposed pipe insulation required to be insulated shall be jacketed with a PVC Jacketing with fitting covers. PVC jacket shall be color fade resistant, white high gloss, U.S.D.A. authorized as manufactured by Proto Corporation or approved equal. PVC jacketing shall be high impact, ultraviolet resistant PVC. Minimum thickness shall be 20 mils, roll stock ready for shop or field cutting and forming.

C. Exposed areas include, but are not limited to, all mechanical equipment rooms/fan rooms, mezzanines, penthouses, boiler rooms, electric rooms, piping and ductwork exposed in an occupied space.

D. Where PVC jackets are indicated, install with 1 inch overlap at longitudinal seams and end joints, for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

E. Exterior exposed pipe insulation required to be insulated shall be jacketed with a corrugated aluminum jacketing system as previously described. Seal all laps with 1/8” bead metal jacketing sealant.

END OF SECTION

DIVISION 23 SECTION 230900
INSTRUMENTATION AND CONTROLS OF HVAC AND PLUMBING SYSTEMS (DDC SYSTEM)
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END OF SECTION 59

SECTION 230900 - INSTRUMENTATION AND CONTROLS OF HVAC AND PLUMBING SYSTEMS

PART 1. GENERAL

1.1. SUMMARY

A. For General Mechanical Requirements, see Division 23 Section, Common Work Results for HVAC, and Division 01 Sections.

B. Comply with all code requirements and fire safety requirements as specified in Division 23 Section, Common Work Results for HVAC.

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

D. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory wired controls.

E. The automatic temperature control system ATC and central control and monitoring system (CCMS) shall be electric/electronic direct digital control (DDC), Johnson Controls (Metasys), Johnson Controls FX as installed by Modern Controls, Siemens, Automated Logic Corporation, Reliable Controls, Schneider Electric, Advanced Power, Trane, and TAC Controls by Schneider Electric installed by Automation and Control Concepts or Niagara. All work associated with the automatic temperature control system shall be performed by personnel regularly and directly employed by the Automatic Temperature Controls Contractor. Control System shall be web based, allowing the client access via a standard web browser.

F. Coordinate controls with controlled equipment. Upon completion of the work, calibrate and adjust all controls for proper function. Electric wiring, including interlock wiring for equipment such as fans, boilers, boiler buffer tank, switches, heat pumps, ERV's, pumps, variable refrigerant volume systems, single zone VAV units, unit heaters, ductless units, etc., shall be furnished and installed under this section. All electrical work shall conform to the applicable requirements of Division 26.

G. All automatic temperature control dampers, valves and separable wells for immersion elements furnished by the Control Manufacturer shall be installed by the Mechanical Contractor or his sheet metal subcontractor under the Control Manufacturer's supervision.

H. Reference is hereby made for this contractor to become familiar with Division 26 of these specifications. Familiarization is for coordination purposes only. The control contractor shall provide all necessary relays, contacts, interlock wiring etc. not provided under Division 26 for the automation of the ATC and CCMS systems as required by the sequence of operation and input/output schedule. The control contractor shall coordinate all requirements with the building Fire Alarm System. The control contractor shall provide all additional devices and interlock wiring required for the automation of the ATC system and monitoring of the CCMS system.

I. Furnish all labor, materials, software, equipment and services necessary for and incidental to furnishing and installing a complete direct digital control, automatic temperature control system to meet the requirements of the sequence of operation described on the Drawings.

J. Unless the necessary items are specified to be provided with mechanical equipment by Division 23, the ATC contractor shall coordinate with Division 23, Mechanical, and shall furnish and install all items necessary to meet the requirements of the Sequence of Operation and the Central Control and Monitoring System (CCMS) indicated on the drawings and as required in this specification.

K. The control system shall include all necessary and specified control equipment properly installed in accordance with the specifications and drawings and shall include, but not be limited to the automatic temperature control and energy management system of the following:

1. Airflow Monitoring Stations
2. Building Facilities
3. Carbon Dioxide Sensors
4. Chilled Water Systems
5. Condensing Units
6. Combustion Air
7. Ductless Units
8. Duct Detector Fan Interlocks
9. Energy Recovery Ventilators
10. Boiler Buffer Tank
11. Existing Boilers
12. Flow Measuring Stations
13. Flow Switches
14. Heating System
15. High Temperature Alarms
16. Mechanical Room Heat and Ventilation Control
17. Pumps
18. Single Zone VAV Units

19. Static Pressure Controllers

20. Variable Speed Drives

21. Ventilation Systems

22. Variable Refrigerant Volume Systems

L. All labor, material, equipment and software to meet the functional intent of the system, as specified herein and as shown on the drawings, shall be included. Drawings are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans, that are required to meet the functional intent, shall be provided without additional cost to the owner.

M. Where equipment is specified to be provided by equipment manufacturer or where packaged controls are specified map out all points provided by the manufacturer so the same can be viewed by ATC system. As a minimum all points indicated in the point list and control diagram must be viewable and adjustable from the ATC system. Coordinate with equipment manufacturer.

1.2. DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

H. UPS: Uninterruptible Power Supply.

I. NAE: Network Automated Engine.

1.3. SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

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

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

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

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

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

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

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

   a. Water Temperature: Plus or minus 1 deg F (0.5 deg C).
   b. Water Flow: Plus or minus 5 percent of full scale.
   c. Water Pressure: Plus or minus 2 percent of full scale.
   d. Space Temperature: Plus or minus 1 deg F (0.5 deg C).
   e. Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
   f. Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
   g. Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
   h. Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
   i. Relative Humidity: Plus or minus 5 percent.
   j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
   k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
   l. Airflow (Terminal): Plus or minus 10 percent of full scale.
   m. Air Pressure (Space): Plus or minus 0.01-inch wg (2.5 Pa).
   n. Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa).
   o. Carbon Dioxide: Plus or minus 50 ppm.
   p. Electrical: Plus or minus 5 percent of reading.

1.4. DELIVERY, STORAGE, AND HANDLING

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

B. System Software: Update to latest version of software at Project completion.

1.5. COORDINATION

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

B. Coordinate equipment with Division 28 Section, “Fire Alarm System” to achieve compatibility with equipment that interfaces with that system.

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

D. Coordinate equipment with Division 26 Section, Electricity Metering to achieve compatibility of communication interfaces.

E. Coordinate equipment with Division 26 Section, Panelboards to achieve compatibility with starter coils and annunciation devices.

1. Coordinate equipment with Division 26 Section, Motor-Controllers to achieve compatibility with motor starters and annunciation devices.

F. Coordinate with the Owners IT Department for fully functional and secure system.

1.6. WORK BY OTHERS

A. Automatic temperature control valves, air flow stations, pipe taps, flow meters, and separable wells for immersion elements furnished by the control manufacturer shall be installed by the mechanical contractor under the control manufacturer's supervision. The control contractor shall deliver to the mechanical contractor valves and wells for installation within the various systems.

B. All automatic dampers furnished by the control manufacturer shall be installed by the mechanical contractor under the control manufacturer's supervision.

1.7. QUALITY ASSURANCE

A. The automatic temperature control (ATC) system and the central control and monitoring system (CCMS) shall be as manufactured by Johnson Controls, Siebe, Siemens, Automated Logic Corporation, Reliable Controls, Schneider Electric, Advanced Power, and Trane shall be an acceptable installer of the ATC system.

B. Supplier shall have an in-place support facility with technical staff, spare parts inventory and all necessary test and diagnostic equipment. The fully staffed and equipped office shall be within a 60 mile radius of the job site.

C. The systems shall be complete in all respects, and shall be installed by skilled personnel. The Control Contractor shall have a successful history in the installation and maintenance of automatic temperature control systems similar in size and performance to that specified herein.

D. All electrical wiring in connection with the Automatic Temperature Control System shall be furnished and installed by the ATC Contractor. This shall include all interlock wiring between the fans, pumps, heating systems, boilers, switches, dampers, energy recovery ventilators, ductless units, condensing units, static pressure controllers, variable refrigerant volume systems, single zone VAV units, etc.

E. Bids by wholesalers, contractors or franchised dealers or any other firm whose principal business is not that of manufacturing or installing automatic temperature control systems, shall not be acceptable. Bid documents that are not complete in their response to these documents or take exception to any of the capabilities defined within these documents shall not be acceptable.

F. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

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

H. Comply with ASHRAE 135 for DDC system components.

1.8. GUARANTEE AND INSTRUCTION

A. The control system including all components, system software, parts and assemblies herein specified shall be free from defects in workmanship and materials under normal use and service. After completion of the installation, the Control Manufacturer shall regulate and adjust all thermostats, control valves, control motors, and other equipment provided under this contract. If within two (2) years from the date of acceptance by Owner any of the equipment herein described is proved to be defective in workmanship or materials, it will be replaced or repaired at no additional cost to the Owner. The Control Manufacturer shall, after completion, provide any service incidental to the proper performance of the Control System under guarantees outlined above for a period of two (2) years. Normal maintenance of the system is not to be considered part of the guarantee. All corrective modifications made during warranty service periods shall be updated on all user documentation including "as-built" shop drawings and on user and manufacturer archived software disks.

B. The control contractor shall completely check out, calibrate and test all connected hardware to insure that the system performs in accordance with the approved specifications and sequences of operation submitted.

C. Upon completion of the work, the control drawings encased in heavy plastic shall be provided where directed. Layout shall show all control equipment and the function of each item indicated.

D. The temperature control contractor's office shall be within a 100 mile radius of the job site.

E. The contractor shall respond to the job site with qualified technicians within a 4 hour period for any emergency relating to the control system or energy management systems.

F. This agreement shall include emergency service during normal working hours.

1.9. SUBMITTALS

A. 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. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface

equipment.

2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

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. Bill of materials of equipment indicating quantity, manufacturer, and model number.

2. Schematic flow diagrams showing equipment, fans, pumps, coils, dampers, valves, and control devices.

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

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

5. Written description of sequence of operation.

6. Schedule of dampers including size, leakage, and flow characteristics.

7. Schedule of valves including flow characteristics.

8. DDC System Hardware:

a. Wiring diagrams for control units with termination numbers.
b. Schematic diagrams and floor plans for field sensors and control hardware.
c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.

10. Controlled Systems:

a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
c. Written description of sequence of operation including schematic diagram.
d. Points list.

C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks or Bacnet.

D. 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.

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

F. Qualification Data: For Installer and manufacturer.

G. Field quality-control test reports.

H. Submit screen shots of ATC system graphics at substantial completion.

I. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section, Operation and Maintenance Data, and Division 23 Section, Common Work Results for HVAC 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.

J. Upon completion of the work, provide a complete set of "as-built" drawings and application software on CD, USB, or other type of electronic storage device. Drawings shall be provided in format as acceptable to the Owner’s files. Submit as-built drawings and specification to Owner's representative for review and approval prior to final project closeout.

1.10. SOFTWARE LICENSE AGREEMENT

A. The owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.

B. Software license agreement shall not apply on projects where existing ATC system is being extended.

1.11. ELECTRICAL SURGE PROTECTION

A. It is the responsibility of the ATC/FMS contractor to provide adequate surge protection for all wall mounted control panels required for this project.

1. Devices under surge protection shall be of design that loss of memory will not occur in the event of the surge protection device being activated due to surge/spike conditions.

2. Surge protection devices will be required to be hard wired, with the exception of peripheral devices that use standard 110VAC plugs for connections (i.e. Modems).

3. Surge protection devices are to be rated for 120 VAC single phase, 20 (or greater) amps capacity.

4. Surge Protection devices to include internal fuse protection, audible surge alarm & LED indicators.

5. Surge protectors to have clamping voltage of 480V peak, maximum surge current rating of 50,000 amps. Unit to have NEMA 12 enclosure with wall mounting bracket and conduit connection.

1.12. TRAINING

A. The Automatic Temperature Controls (ATC) Contractor shall include in his bid, provisions for additional computer training at the company’s regular school or training center. The ATC contractor shall include in his bid all costs associated with sending one (1) individual to the ATC contractors school for a period of not less than one (1) week. This training is in addition to the aforementioned training required under the General Provisions.

B. The training time period shall be coordinated with the school system's facility Engineer. The schedule training period shall be arranged at the owner's convenience.

C. Cost shall include all training material, instruction books, and two copies of video tape with sound DVD of training session.

D. Upon completion of the work, the Control Contractor shall have completely adjusted the entire control system. He shall arrange to instruct the Owner's representative on the operation of the control system for a period of not less than two (2) eight (8) hour days. All training shall be by the control contractor and shall utilize specified manuals and as-built documentation.

E. 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. Include a minimum of 40 hours' dedicated instructor time on-site.

3. Review data in maintenance manuals. Refer to Division 01 Section, Contract Closeout.

4. Review data in maintenance manuals. Refer to Division 01 Section, Operation and Maintenance Data.

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

1.13. ALTERNATES

A. Refer to Division 01 Section, Alternates for description of work under this section affected by alternates.

1.14. DELAWARE TECHNICAL COMMUNITY COLLEGE SPECIFIC REQUIREMENTS

A. The ATC Subcontractor shall include in his bid all costs associated with incorporating the following specific requirements:

1. All holiday schedules shall incorporate a 12 month block. Coordinate exact holidays, schedules, calendars, occupied, and unoccupied periods with the Owner prior to writing software. All schedules shall be reviewed and approved by the Owner.

2. Relays for ATC equipment shall not be located in ceilings. All relays shall be located in equipment control panels and/or mechanical rooms.

3. All exhaust fans shall be assigned a designated point. Utilizing relays to provide digital point for exhaust fans shall not be acceptable.

4. Graphics on ATC computer shall in addition to basic requirements indicate the percentage open or closed on all valves and dampers.

5. The ATC Computer Graphics shall incorporate the final room numbers actually utilized in the building. All room names utilized in the graphic display shall be reviewed and approved by the Owner.

6. The ATC Computer Graphics shall indicate for each item of equipment the “on” or “off” status and command shall be “run” or “stop”.

7. The ATC Computer Graphic shall indicate for each duct smoke detector the “on” or “off” status and command.

8. All Temperature Sensors, equipment, humidity sensors, current sensors, CO2 sensors, differential pressure sensors, etc. indicated on ATC Control Diagrams and point list shall be displayed on the ATC Computer Graphic. Measured value or status shall be displayed.

9. For any multi-stage HVAC units, the quantity of compressor stages and the quantity of electric heat stages shall be displayed on the Computer Graphics.

10. The exact space temperature set points, humidity set points, changeover set points. etc., shall be coordinated with Owner prior to final data entry. All items indicated in sequences of Operation as “adjustable” shall be reviewed and approved by Owner prior to implementation of the same.

11. The outside air humidity and outside air temperature shall be monitored on ATC system and reported on ATC Computer Graphics. See Floor plans for exact locations.

12. Provide a graphic of all floor plans indicating location of all equipment interlocked with ATC System including all control panels.

13. Graphic shall also indicate area of building served by each item of equipment. Graphics shall indicate all global sensor readings.

14. All equipment shall be labeled with name of equipment, area served, and area location (room name/number).

1.15. GLOBAL SENSORS

A. General

1. Furnish and install global sensors and report the same on the automatic temperature control system.

2. Global sensors shall monitor and trend the following conditions:

   a. Outside air temperature.
   b. Outside air humidity.
   c. Chilled supply water temperature.
   d. Chilled return water temperature.
   e. All ventilation fan speeds where variable frequency drives are specified.
   f. Outside air carbon dioxide level.
   g. All ventilation fan amperage where variable frequency drives are specified.
   h. All pump or fan speeds where variable frequency drives are specified.
   i. All pump amperage's where variable frequency drives are specified.
   j. All fan amperages where variable speed fans are indicated. Graphic shall also indicate area of building served by each item of equipment.

k. Main Distribution Frame (MDF), and I.T. server room space temperature sensor.

l. Global holiday schedules:

i. Provide all interlock wiring and programming to allow a global holiday schedule for all equipment except the administration equipment. Global holiday schedule shall allow the Owner to shut down the entire school's HVAC systems if an unscheduled event occurs when school is cancelled.

ii. System shall also be capable of individual scheduling of equipment as specified or all can be globally modified at once.

m. All equipment interlocked with ATC system shall be able to be turned on/off via ATC system as specified. Changing temperature set point alone is not acceptable method for turning equipment on/off.

n. Where valve or damper position is indicated ATC graphic shall indicate percentage open or percentage closed.

PART 2. PRODUCTS

2.1. BUILDING MANAGEMENT SYSTEM

A. The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.

B. The Building Management System shall consist of the following:

1. Standalone Network Automation Engine(s)

2. Field Equipment Controller(s)

3. Input/Output Module(s)

4. Local Display Device(s)

5. Portable Operator's Terminal(s)

6. Distributed User Interface(s)

7. Network processing, data storage and communications equipment

8. Other components required for a complete and working BMS

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.

D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network

connection shall not interrupt the execution of control strategies at other operational devices.

E. Acceptable Manufacturers

1. Johnson Controls, Reliable, Siemens, Honeywell, Automated Logic Cooperation, Schneider Electric, Advanced Power, Trane, Alerton, Niagara, or TAC Controls by Schneider Electric.

F. Automation Network

1. The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels.

2. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.

3. Network Automation Engines (NAE) and/or system controllers shall reside on the automation network.

4. The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

G. Control Network

1. Network Automation Engines and/or system controllers shall provide supervisory control over the control network and shall support all three (3) of the following communication protocols:

   a. BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.
   b. LonWorks enabled devices using the Free Topology Transceiver (FTT-10a).
   c. The Johnson Controls N2 Field Bus or equivalent.
   d. Tridium FX-40
   e. Honeywell Webs
   f. TAC Controls by Schneider Electric
   g. Siemens P1/P2 Serial

2. Control networks shall provide either "Peer-to-Peer," Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.

3. DDC Controllers shall reside on the control network.

4. Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.

5. A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.

6. The Conformance Statements shall be submitted 10 day prior to bidding.

H. Integration

1. Hardwired

   a. Analog and digital signal values shall be passed from one system to another via hardwired connections.
   b. There will be one separate physical point on each system for each point to be integrated between the systems.

2. BACnet Protocol Integration – BACnet

   a. The neutral protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-2003.
   b. A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.
   c. The ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems shall be provided.

I. Dedicated Web Based User Interface

1. Where required by the Owner, the BMS Contractor shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. All real-time control functions, including scheduling, history collection and alarming, shall be resident in the BMS Network Automation Engines to facilitate greater fault tolerance and reliability. Coordinate with Owner to determine computer type (i.e. PC (Windows based) or Macintosh (Apple)).

2. Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BMS Contractor and by other third party applications suppliers, including but not limited to Microsoft Office Applications. Specifically it must be implemented to conform to the following interface standards.

   a. Microsoft Internet Explorer for user interface functions
   b. Microsoft Office Professional for creation, modification and maintenance of reports, sequences other necessary building management functions
   c. Microsoft Outlook or other e-mail program for supplemental alarm functionality and communication of system events, and reports
   d. Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries.

3. Computer Hardware – The personal computer(s) shall be configured as follows:

   a. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.
   b. Performance Requirements:
      i. Performance requirements may dictate equipment exceeding minimum requirements indicated.
      ii. Energy Star compliant.
   c. Personal Computer:
      i. Minimum Processor Speed: 3 gigahertz (GHz).
   d. RAM:
      i. Capacity: 8GB.
      ii. Speed and Type: 1333 MHz, SDRAM.
   e. Hard Drive:
      i. Media: Solid state.
      ii. Number of Hard Drives: One.
      iii. Capacity: 250GB.
   f. Optical Read and Write Drive:
      i. Include with at least 2 MB of data buffer.
      ii. Type: SCS1 CD-ROM Drive with Read/Write Capability.
      iii. Average access time of 150 ms or less.
   g. At least four expansion slots.
   h. Video Card:
      i. Resolution: 1920 by 1200 pixels.
      ii. RAM: 4 GB.
      iii. Controller Speed: 4GHz.
   i. Sound Card:
      i. At least 128 voice wavetable synthesis.
      ii. Capable of delivering three-dimensional sound effects.
      iii. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.
   j. Network Interface Card: Include card with connection, as applicable.
      i. 10-100-1000 base TX Ethernet with RJ45 connector port.
      ii. 100 base FX Ethernet with SC or ST port.
   k. Wireless Ethernet, 802.11 a/b/g/n.
   l. Optical Modem: Full duplex link for connection to optical fiber cable provided.
   m. I/O Ports:
      i. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
      ii. One serial port.
      iii. One parallel port.
      iv. Two PS/2 ports.
      v. One RJ-45.
      vi. One stereo line-in and headphone/line-out on back panel.
      vii. One microphone and headphone connector on front panel.
      viii. One IEEE 1394 on front and back panel with PCI-e card.
      ix. One ESATA port on back panel.
   n. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

o. Keyboard:
   i. 101 enhanced keyboard.
   ii. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
   iii. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

p. Pointing Device:
   i. Either a two- or three-button mouse.
   ii. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

q. Flat Panel Display Monitor:
   i. Display:
      1. Color display with 21 inches diagonal viewable area.
      2. Digital input signal.
      3. Aspect Ratio: 16 to 9.
      4. Antiglare display.
      5. Tilt adjustable base.
      6. Energy Star compliant.
      7. Resolution: 1920 by 1200 pixels at 60 Hz.
      8. Number of Displays: One.

r. Speakers:
   i. Two, with individual controls for volume, bass and treble.
   ii. Signal to Noise Ratio: At least 65 dB.
   iii. Power: At least 4 W per speaker/channel.
   iv. Magnetic shielding to prevent distortion on the video monitor.

s. I/O Cabling: Include applicable cabling to connect I/O devices.

J. User Interface Application Components

1. Operator Interface

a. An integrated browser based client application shall be used as the user operator interface program.

b. All Inputs, Outputs, Setpoints, and all other parameters as defined within Part 3 or on the drawings, shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software.

c. The user interface software shall provide help menus and instructions for each operation and/or application.

d. All controller software operating parameters shall be displayed for the operator to view/modify from the user interface. These include: setpoints, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, and so forth.

e. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:
   i. User access for selective information retrieval and control command execution
   ii. Monitoring and reporting
   iii. Alarm, non-normal, and return to normal condition annunciation

iv. Selective operator override and other control actions
v. Information archiving, manipulation, formatting, display and reporting
vi. FMS internal performance supervision and diagnostics
vii. On-line access to user HELP menus
viii. On-line access to current FMS as-built records and documentation
ix. Means for the controlled re-programming, re-configuration of FMS operation and for the manipulation of FMS database information in compliance with the prevailing codes, approvals and regulations for individual FMS applications.
x. The operation of the control system shall be independent of the user interface, which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications shall not be acceptable.

2. Navigation Trees

a. The system will have the capability to display multiple navigation trees that will aid the operator in navigating throughout all systems and points connected. At minimum provide a tree that identifies all systems on the networks.
b. Provide the ability for the operator to add custom trees. The operator will be able to define any logical grouping of systems or points and arrange them on the tree in any order. It shall be possible to nest groups within other groups. Provide at minimum 5 levels of nesting.
c. The navigation trees shall be "dockable" to other displays in the user interface such as graphics. This means that the trees will appear as part of the display, but can be detached and then minimized to the Windows task bar or closed altogether. A simple keystroke will reattach the navigation to the primary display of the user interface.

3. Alarms

a. Alarms shall be routed directly from Network Automation Engines to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the user interface shall, at the minimum, provide the following functions:
i. Log date and time of alarm occurrence.
ii. Generate a "Pop-Up" window, with audible alarm, informing a user that an alarm has been received.
iii. Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.
iv. Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.
v. Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop up window described above. Systems that use e-mail and pagers

as the exclusive means of annunciating alarms are not acceptable.

vi. Any attribute of any object in the system may be designated to report an alarm.

b. The FMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions

c. The FMS shall annunciate application alarms as required.

4. Reports and Summaries

a. Reports and Summaries shall be generated and directed to the user interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:

i. All points in the BMS

ii. All points in each BMS application

iii. All points in a specific controller

iv. All points in a user-defined group of points

v. All points currently in alarm

vi. All points locked out

vii. All BMS schedules

viii. All user defined and adjustable variables, schedules, interlocks and the like.

b. Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.

c. Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.

d. The system shall allow for the creation of custom reports and queries via a standard web services XML interface and commercial off-the-shelf software such as Microsoft Access, Microsoft Excel, or Crystal Reports.

5. Schedules

a. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:

i. Weekly schedules

ii. Exception Schedules

iii. Monthly calendars

b. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.

c. It shall be possible to define one or more exception schedules for each schedule including references to calendars

d. Monthly calendars shall be provided that allow for simplified scheduling of holidays and special days for a minimum of five years in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the exception schedules.

e. Changes to schedules made from the User Interface shall directly modify the Network Automation Engine schedule database.

f. Schedules and Calendars shall comply with ASHRAE SP135/2003

BACnet Standard.

g. Selection of a single menu item or tool bar button shall print any displayed schedule on the system printer for use as a building management and diagnostics tool.

6. Password

a. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, based on an assigned password.
b. Each user shall have the following: a user name (24 characters minimum), a password (12 characters minimum), and access levels.
c. The system shall allow each user to change his or her password at will.
d. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
e. A minimum of five levels of access shall be supported individually or in any combination as follows:
   i. Level 1 = View Data
   ii. Level 2 = Command
   iii. Level 3 = Operator Overrides
   iv. Level 4 = Database Modification
   v. Level 5 = Database Configuration
   vi. Level 6 = All privileges, including Password Add/Modify
f. A minimum of 100 unique passwords shall be supported.
g. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
h. The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including: modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.

7. Screen Manager - The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.

8. Dynamic Color Graphics

a. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.
b. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.
c. The graphics shall be able to display and provide animation based on real-

time data that is acquired, derived, or entered.

d. Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:
   i. All graphics shall be fully scalable
   ii. The graphics shall support a maintained aspect ratio.
   iii. Multiple fonts shall be supported.
   iv. Unique background shall be assignable on a per graphic basis.
   v. The color of all animations and values on displays shall indicate the status of the object attribute.

e. Operation from graphics – It shall be possible to change values (setpoints) and states in system controlled equipment by using drop-down windows accessible via the pointing device

f. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, and defining all runtime binding.
   i. The graphic editing tool shall in general provide for the creation and positioning of point objects by dragging from tool bars or drop-downs and positioning where required.
   ii. In addition, the graphic editing tool shall be able to add additional content to any graphic by importing backgrounds in the SVG, BMP or JPG file formats.

g. Aliasing – Many graphic displays representing part of a building and various building components are exact duplicates, with the exception that the various variables are bound to different field values. Consequently, it shall be possible to bind the value of a graphic display to aliases, as opposed to the physical field tags.

9. Historical trending and data collection

a. Each Automation Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:
   i. Any point, physical or calculated, may be designated for trending. Two (2) methods of collection shall be allowed:
      1. Defined time interval
      2. Upon a change of value.
   ii. Each Automation Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.

b. Trend and change of value data shall be stored within the engine and uploaded to a dedicated trend database or exported in a selectable data format via a provided data export utility. Uploads to a dedicated database shall occur based upon one of the following: user-defined interval, manual command, or when the trend buffers are full. Exports shall be as requested by the user or on a time scheduled basis.

10. Trend data viewing and analysis

    a. Provide a trend viewing utility that shall have access to all database points.
    b. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.
    c. The trend viewing utility shall have the capability to define trend study displays to include multiple trends
    d. Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.
    e. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.
    f. Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.
    g. Trend studies shall be capable of calculating and displaying calculated variables including highest value, lowest value and time based accumulation.

K. Network Automation Engine (NAE)/ System Controllers

1. The Network Automation Engine (NAE)/ System Controllers or approved equal shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Automation Engines.

2. Automation network – The NAE shall reside on the automation network and shall support a subnet of system controllers.

3. User Interface – Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.

    a. The web based UI software shall be imbedded in the NAE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.
    b. The NAE shall support up four (4) concurrent users.
    c. The web based user shall have the capability to access all system data through one NAE.
    d. Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access through one NAE.
    e. Systems that require the user to address more than one NAE to access all system information are not acceptable.
    f. The NAE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NAE.
    g. Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.
    h. The web based UI shall support the following functions using a standard

version of Microsoft Internet Explorer:
i. Configuration
ii. Commissioning
iii. Data Archiving
iv. Monitoring
v. Commanding
vi. System Diagnostics

i. Systems that require workstation software or modified web browsers are not acceptable.

j. The NAE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.

4. Processor – The NAE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NAE size and capability shall be sufficient to fully meet the requirements of this Specification.

5. Memory – Each NAE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.

6. Hardware Real Time Clock – The NAE shall include an integrated, hardware-based, real-time clock.

7. The NAE shall include troubleshooting LED indicators to identify the following conditions:

a. Power - On/Off
b. Ethernet Traffic – Ethernet Traffic/No Ethernet Traffic
c. Ethernet Connection Speed – 10 Mbps/100 Mbps
d. FC Bus – Normal Communications/No Field Communications
e. Peer Communication – Data Traffic Between NAE Devices
f. Run – NAE Running/NAE In Startup/NAE Shutting Down/Software Not Running
g. Bat Fault – Battery Defective, Data Protection Battery Not Installed
h. Fault – General Fault
i. Modem RX – NAE Modem Receiving Data
j. Modem TX – NAE Modem Transmitting Data

8. Communications Ports – The NAE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.

a. Up to two (2) USB port
b. Up to two (2) URS-232 serial data communication port
c. Up to two (2) RS-485 port
d. One (1) Ethernet port

9. Diagnostics – The NAE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network

Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.

10. Power Failure – In the event of the loss of normal power, The NAE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.

    a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
    b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

11. Certification – The NAE shall be listed by Underwriters Laboratories (UL).

12. Controller network – The NAE shall support the following communication protocols on the controller network:

    a. The NAE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
        i. A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.
        ii. The Conformance Statements shall be submitted 10 day prior to bidding.
        iii. The NAE shall support a minimum of 100 control devices.
    b. The NAE shall support the Johnson Controls N2, Tridium FX-40, or Honeywell Webs or approved equal Field Bus.
        i. The NAE shall support a minimum of 100 N2 control devices.
        ii. The Bus shall conform to Electronic Industry Alliance (EIA) Standard RS-485.
        iii. The Bus shall employ a master/slave protocol where the NAE is the master.
        iv. The Bus shall employ a four (4) level priority system for pollng frequency.
        v. The Bus shall be optically isolated from the NAE.
        vi. The Bus shall support the Metasys Integrator System.

2.2. WIRING

A. The multi-conductor cable for field wiring of electronic analog sensors shall be minimum No. 22 AWG, 300 volt, thermoplastic with stranded copper wire and 100 percent shield coverage. The number of conductors in each sensor cable shall be as determined by the Contractor. 2/c #22 shielded cables shall be Belden Cat. #8451 3/c #20 shielded cables shall be Belden Cat. #9770 or approved equal.

B. Conductors for digital sensors or contact control shall be the same as for the analog sensors,

except the grounded shield is not required.

C. Individual conductors shall be color coded and in addition shall be numbered in the field to identify the particular terminal to which attached. Field numbering shall be performed with Brady or approved equal markers wrapped around the wire near the terminal connection. All wires shall be terminated with pressure type connectors suitable for wire size, material and terminal connection.

D. All exposed wiring or wiring concealed in partitions shall be installed in a designated conduit raceway. The conduit shall conform to Division 26 of the specification. Where wiring is installed in an air plenum the same shall be plenum rated cable.

E. All junction boxes shall have covers painted safety green, and be rigid steel.

F. All wiring between differential pressure transmitters and variable frequency drive pump controllers shall be shielded and grounded at the pump controller end. Directly route the variable frequency drive pump controller to the differential pressure transmitter(s).

G. All wiring between static pressure controllers and/or air flow monitoring stations and variable frequency drive fan controllers shall be shielded and grounded at the fan controller end. Directly route the variable frequency drive fan controller to the static pressure controller(s) and/or air flow monitoring stations.

H. All control wiring between VRV compressor units, branch selector boxes, and indoor VRV units shall be shielded and grounded per VRV manufacturer requirements.

2.3. CONTROLLERS

A. Temperature, humidity, and CO2 sensor covers shall be stainless steel wire guard type with vandal proof screws. All room humidity, CO2, and temperature sensors shall be mounted 4'-0 inches above the finished floor, except in stairways, corridors and toilets, which shall be 7'-0 inches. Provide insulating bases where temperature sensors are located on exterior or unconditioned walls. Each temperature sensor shall have adjustable limit stops and adjustable sensitivity. User adjustment shall be 2 degrees F above and below set points or as determined by the Owner. Room temperature sensors shall include range of 55 degrees F to 85 degrees F set point adjustment. Temperature sensors shall include set-point adjustors, U.L. approved for mounting base in air plenums, and RJ-11 jack for communications. Room temperature sensors shall be fully adjustable and shall display set point and actual temperature.

B. Space sensor wiring shall be installed concealed where possible. Should the Division 23 Contractor be unable to do so then surface metal raceway shall be utilized as specified in Division 26.

C. Low Limit Thermostats: Freezestats shall have a minimum 20 foot (averaging sensing element) capillary tube sized to the basis of one linear foot of capillary tube for each square foot of coil surface. Thermostat sensitivity shall be adjustable. Freezestats shall stop supply and return fans and close the outside air damper if mixed air temperature drops below 35 degrees F and open hot water heating valves. Additional requirements are indicated in Sequence of Operation.

D. Room temperature sensors shall be accessible to ADA occupants.

2.4. DAMPERS

A. Control Dampers

1. The temperature control contractor shall provide all automatic control dampers of the types indicated on the plans and not specified to be integral with other equipment. Frames shall be not less than 16 gauge galvanized steel. Blades shall not be over 6 inches wide airfoil shaped double skin construction of 14 gauge equivalent thickness. Bearings shall be stainless steel sleeves with 2 inch shafts. Blade edge seals shall be vinyl blade with flexible metal compressible jamb seals of the tight-seal spring type. Dampers and seals shall be suitable for temperature ranges of -40 to 250 degrees F.

2. All proportional control dampers shall be opposed blade type and all two-position dampers shall be parallel blade type.

3. Dampers shall be sized to meet flow requirements of the application. The sheet metal contractor shall furnish and install baffles to fit the damper to duct size. Baffles shall not exceed 6 inches.

4. Dampers shall be minimum leakage type to conserve energy and the temperature control manufacturer shall submit leakage and flow characteristic data for all control dampers with the temperature control submittal. Maximum leakage shall be 3 CFM/Sq. Ft. at static pressure of 1 inch W.C. for a damper width of 48 inches.

5. Ultra-low leakage dampers shall have blade edges shall to be fitted with replaceable, snap-on, inflatable seals to limit damper leakage to 2 percent at applied static pressure.

6. Medium and low pressure rectangular control dampers shall be Type CD60 airfoil low leakage damper as manufactured by Ruskin or as approved equal of American Warming and Ventilating, Air Balance and Arrow.

7. Round control dampers shall be Type CERS25 with blade edge seals as manufactured by Ruskin or as approved equal.

8. Provide damper end switch for all control dampers where indicated. Damper end switch shall be independent of the damper actuator and shall provide “proof of open” prior to allowing fan to energize. Damper end switch shall be Model TS-475 Mechanical Damper Arm Switch (no-mercury) as manufactured by MDI, Inc. or approved equal. Install per manufacturer’s recommendations on control damper. End switch shall have the following features:

   a. Housing Material: Glass filled PBT (polybutylene terephthalate).
   b. Bracket Material: Plated steel.
   c. Operation: Steel ball actuated sub-miniature snap action switch.
   d. Operating angle: 15 degrees. (Contact closes at 10 degrees above horizontal and contact opens at 5 degrees below horizontal).

B. Smoke Detectors

1. Smoke detectors shall be provided by the Electrical Contractor and installed by the Mechanical Contractor. All wiring, interlocks, etc., to be provided by Electrical Contractor. Wiring from duct smoke detectors to fans shall be by ATC Contractor. Duct smoke detectors shall be tested by the Test and Balance Engineer as specified in Division 23 Section, Testing Adjusting & Balancing for HVAC and Plumbing.

C. Damper Operators

1. Electric damper actuators shall be properly sized to provide sufficient torque to position the damper throughout its operating range.

2. Use devices which are quiet in operation and which in the event of power failure, will "fail safe" by spring action in either the normally open or normally closed position as required for freeze, moisture, smoke, or fire protection.

3. Electric actuators requiring a 24 VAC power supply will be utilized. Motors shall be specifically designed and sized with proper torque according to requirements of the device it is to be used on (i.e.: valve, damper). Each actuator will accept the proper control input as the system is designed, (i.e,: floating, 0-10VDC, 4-20Ma etc.) without the need for any additional interface devices.

4. For all exterior damper operators provide NEMA 4X stainless steel corrosion resistant enclosure. Damper operator enclosure shall be model ZS-300 as manufactured by Belimo or approved equal.

2.5. PRESSURE INDEPENDENT HYDRONIC CONTROL VALVES

A. All automatic control valves 2 inches and smaller shall be screwed type, and valves 2 ½ inches and larger shall be flanged. Valves shall be factory-rated to withstand the pressures encountered. Valves shall have stainless-steel stems and spring loaded Teflon packing with replaceable seats and discs. All control valves must be capable of withstanding the shut-off head of the pumps, they are connected to without the valve seat lifting. Valves shall have stainless steel stems and spring loaded Teflon packing with replaceable seats and discs.

1. All modulating straight-through water valves shall be provided with equal-percentage contoured throttling plugs and shall be pressure independent type. All three-way valves shall be provided with linear throttling plugs such that the total flow through the valve shall remain constant regardless of the valve's position modulating. Valves shall be sized for a pressure drop equal to the coil they serve but not to exceed 5 psi. Valves shall have replaceable seats and discs. Pressure independent control valves shall be as manufactured by Griswold, Delta P, Warren Controls, Danfos, Bray, or approved equal.

2. Pressure Independent Actuated Ball Valves (PIC-V) for Flows up to 85 GPM

a. The modulating control valves shall be pressure independent.
b. Valves shall accurately control flow within +/-5% (including

manufacturing tolerance) independent of system pressure fluctuation by maintaining a constant pressure differential across the control valve so that the valve only repositions on a change in load demand.

c. The pressure independent modulating control valve shall include a Pressure Compensating Cartridge, Actuated Ball Valve, 2 PT's, Manual Air Vent, Union, and Manual Isolation Ball in a single valve housing.

d. The valve shall have an accuracy of +/- 5% including manufacturing tolerances and pressure variations.

e. Valve housing shall consist of forged brass, rated at no less than 360 psi at 250°F.

f. Valve shall include a venturi metering station so that the flow rate can be read by means of differential pressure. Venturi metering station shall not require any straight runs of piping before or after meter.

g. Both the ATC and shutoff valve shall have stems that are field repairable with the valve in the line. The body design shall allow inspection or repair of the stem without disturbing piping connections or draining water. The repairable stem shall include two Teflon seals and one EPDM O-ring for protection against chemicals and modulating temperature.

h. Valve shall have a union end connection with factory installed air vent to allow for venting of the coil or heat pump.

i. The control valve shall accurately control the flow from 0 to 100% full rated flow.

j. The ATC portion of the valve shall use the full 90 degrees of the stroke for control. Stroke limiting of the valve shall not be acceptable.

k. A flow tag shall be furnished with each valve.

l. A universal mounting plate shall allow installation of actuators meeting the system electrical requirements and valve torque requirements as provided by Honeywell, Invensys, Johnson Controls, KMC, Schneider, Neptronic, or Siemens.

m. The actuator and plate can be rotated after mounting.

n. The actuator mounting assembly shall accommodate no less than 1 ½" of insulation.

o. Pressure Compensating Cartridge (PCC)

   i. PCC shall automatically compensate for pressure changes in valve and shall maintain a constant pressure drop across the flow limiting actuated ball.

   ii. The operating pressure range shall be available with the minimum range requiring 3 PSID to actuate the cartridge and the maximum 8 psid to actuate the cartridge

   iii. Valve internal control mechanism includes a diaphragm and full travel linear coil spring.

   iv. Valves shall include an accessible/ replaceable cartridge.

   v. Dual pressure/temperature test valves for verifying the pressure differential across the cartridge and flow limiting ball shall be standard.

p. Actuated Ball Valve

   i. Valve ball shall consist of chemically plated nickel brass or stainless steel.

   ii. Actuator stem shall be removable/ replaceable without removing valve from line.

iii. Manufacturer shall be able to provide ball insert to limit flow to maximum flow rate with ±5% accuracy. Insert shall be constructed of a Glass-Filled Polymer. The insert shall be press fit to the inside of the ball. Clipping the insert onto the exiting side of the ball shall not be acceptable.

iv. Each maximum flow rate selected shall use a different characterizing disc so that stroke limiting is not required.

v. Valve shall have a minimum rangeability as follows: ½”-40:1, ¾”-160:1, 1” to 3”-400:1

vi. Valve shall have EPDM O-rings behind Reinforced Teflon (PTFE) ball seals.

vii. The valve shall have a minimum close-off pressure differential rating of 100 psi with 35 in-lbs of torque for 1/2" to 2" sizes.

viii. Actuator shall provide minimum torque required for full valve shutoff position.

q. Isolation Ball Valve

i. Valve shall include a 600 WOG manual isolation ball valve.

ii. Stem shall be removable/replaceable with the valve in the line.

r. The control valve actuator will be furnished by the controls contractor under Section 230900.

s. Pressure independent valves shall come as one complete assembly from Griswold Controls or approved equal and shall include a supply side combination shutoff/ strainer valve.

3. MVP Pressure Independent Control Valves for Flows above 85 GPM.

a. Pressure Independent Flow Control Valve 2.5” and Larger

i. The modulating control valves shall be pressure independent.

ii. Valve shall accurately control flow within +/-5% (including manufacturing tolerance) independent of system pressure fluctuation by maintaining a constant pressure differential across the control valve so that the valve only repositions on a change in load demand.

iii. Contactor shall install pressure independent flow control valves where indicated in drawings.

iv. Valve shall be electronic, pressure independent, modulating 2-way control device.

v. Balancing valves shall not be required where pressure-independent valves are installed.

vi. Install flow measuring station and shut-off valve on return pipe to measure flow rate in gallons per minute.

b. Valve Actuator

i. Valve actuator housing shall be rated to IP44 insulation.

ii. Actuator shall be driven by a 24Vdc motor, and shall accept 2-10 Vdc, 4-20mA, 3-point floating or pulse width modulation electric signal and shall include resistor to facilitate any of these signals.

iii. Actuator shall be capable of providing 4-20mA or 2-10 Vdc feedback signal to the control system so that the gpm can be determined.

iv. External LED readout of current valve position and maximum

valve position setting shall be standard.

v. Maximum flow setting shall be adjustable to 51 different settings within the range of the valve size by changing the settings electronically on the actuator.

vi. Optional fail safe system to power valve to either open or closed position from any position in case of power failure shall be provided per the sequence of operations and the automatic temperature control diagrams.

c. Valve Housing

i. 2.5"–6": Housing shall be constructed of Ductile Iron ASTM A536-65T, Class 60-45-18 rated at no less than 580 psi static pressure and 248°C.

d. Pressure Regulation Unit

i. Pressure regulation unit shall consist of 304 Stainless Steel and hydrogenated acrylonitrile butadiene rubber (1/2"–1-1/2") or 316 Stainless Steel and EPDM (2"–6").

ii. Flow regulation unit shall be accessible for maintenance without disturbing the piping.

iii. Valve shall have a maximum of 8.6 psid to actuate the pressure regulating cartridge.

iv. Dual pressure/temperature test valves for verifying accuracy of flow performance shall be available for all valve sizes.

4. Where applicable, all two (2) position control valves may be furnished with hose kits at Contractor's option. Coordinate actuator and pressure drop requirements with hose kit supplier. Maximum allowable pressure drop for two (2) position modulating control valves shall be 12 feet at scheduled flow rate.

5. Optional accessories shall include a stem packing lubricator for factory or field assembly. Valve stem packing shall be low friction, tight sealing Teflon.

6. Unitary valves shall be straight-through or three way type as specified in the sequence of operation with high-pressure connections suitable for copper pipe and rated for 250 psig. Stems shall be polished stainless-steel and packing shall be ethylene-propylene suitable for both chilled water and 250 degree hot water service. Straight-through valves shall have back-seating feature, to allow packing to be replaced without draining system.

7. All valves shall use guided valve plugs for good seating and reliable operation. Valves ½ inch to 1 inch shall be ANSI Class 125 brass body with screwed ends. Valves 1-1/4 inches to 2 inches shall be ANSI Class 150 brass body with screwed ends. Valves 2-1/2 inches to 4 inches shall be Class 125 cast iron body with bronze trim and flanged ends. Valves 6 inches and larger shall be Class 125 steel body with bronze trim and flanged ends. Butterfly valves shall be DeZurick HIGH performance or Keystone Keylock, Lug style as specified in Division 23 Section, HVAC Piping, Fittings, and Valves.

8. All heating coil valves shall be normally open to the coil.

B. Control Valve Operators

1. Electric valve actuators shall be properly sized to provide sufficient torque to position valves throughout its operating range.

2. Use devices which are quiet in operation and which in the event of power failure, will "fail safe" by spring action in either the normally open or normally closed position as required for freeze, moisture, smoke, or fire protection. Spring return valves are required for all control valves where coils are exposed to outside air conditions.

3. Electric actuators requiring a 24VAC power supply will be utilized. Motors shall be specifically designed and sized with proper torque according to requirements of the device it is to be used on (i.e: valve, damper). Each actuator will accept the proper control input as the system is designed, (i.e.: floating, 0-10VDC, 4-10Ma etc.) without the need for any additional interface devices.

2.6. CONTROL PANELS

A. Furnish and install local panels for ATC devices. Control panels shall be fully enclosed cabinets, all steel construction and shall meet the requirements of NEMA 1 enclosures. Cabinet shall have piano hinged door with a locking latch. All cabinet locks shall use common key. Provide means of storing control system instructions and drawings inside cabinet for future reference. Panel shall be wall mounted or free standing and located where directed by the Contract Drawings or Engineer.

1. Each panel shall have all internal devices factory wired to a numbered terminal strip. Controllers and associated devices shall be mounted within the panel, accessible through a hinged door.

2. All ATC panels shall be provided with integral disconnect, wiring, and control transformers.

3. Any ATC control panel that is serving equipment on the emergency generator must be powered by an emergency generator fed circuit/electrical panel. Refer to electrical contract documents for all emergency powered equipment.

2.7. MISCELLANEOUS ELECTRICAL DEVICES

A. Electric Actuators. All automatically controlled devices, unless specified otherwise elsewhere, shall be provided with electric actuators which shall be sized to operate their appropriate loads with sufficient reserve power to provide smooth modulating action or two-position action and tight close off as specified.

2.8. UNINTERRUPTIBLE POWER SUPPLY

A. Furnish, size and install uninterruptible power supplies (UPS's) at all ATC panels.

B. Provide all interlock and power wiring from U.P.S. to control panels as required such that all components are powered via the UPS. For hard-wired equipment furnished with pigtails/wire leads, e.g. control power transformers, splice pigtails/wire leads in junction box to a flexible cord with NEMA 5-15P Plug, which shall be plugged into the UPS.

C. UPS's shall be sized for the ATC panel load and shall provide at least 2 minutes of full load power in the event of a power outage.

2.9. DESKTOP WORKSTATIONS

A. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.

B. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.

2. Energy Star compliant.

C. Personal Computer:

1. Minimum Processor Speed: 3 gigahertz (GHz).

2. RAM:

a. Capacity: 8GB.
b. Speed and Type: 1333 MHz, SDRAM.

3. Hard Drive:

a. Media: Solid state.
b. Number of Hard Drives: One.
c. Capacity: 250GB.

4. Optical Read and Write Drive:

a. Include with at least 2 MB of data buffer.
b. Type: SCS1 CD-ROM Drive with Read/Write Capability.
c. Average access time of 150 ms or less.

5. At least four expansion slots.

6. Video Card:

a. Resolution: 1920 by 1200 pixels.
b. RAM: 4 GB.
c. Controller Speed: 4GHz.

7. Sound Card:

a. At least 128 voice wavetable synthesis.
b. Capable of delivering three-dimensional sound effects.
c. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.

8. Network Interface Card: Include card with connection, as applicable.

    a. 10-100-1000 base TX Ethernet with RJ45 connector port.
    b. 100 base FX Ethernet with SC or ST port.

D. Wireless Ethernet, 802.11 a/b/g/n.

1. Optical Modem: Full duplex link for connection to optical fiber cable provided.

2. I/O Ports:

    a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
    b. One serial port.
    c. One parallel port.
    d. Two PS/2 ports.
    e. One RJ-45.
    f. One stereo line-in and headphone/line-out on back panel.
    g. One microphone and headphone connector on front panel.
    h. One IEEE 1394 on front and back panel with PCI-e card.
    i. One ESATA port on back panel.

3. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

E. Keyboard:

1. 101 enhanced keyboard.

2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.

3. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

F. Pointing Device:

1. Either a two- or three-button mouse.

2. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

G. Flat Panel Display Monitor:

1. Display:

    a. Color display with 21 inches diagonal viewable area.
    b. Digital input signal.
    c. Aspect Ratio: 16 to 9.
    d. Antiglare display.
    e. Tilt adjustable base.
    f. Energy Star compliant.

g. Resolution: 1920 by 1200 pixels at 60 Hz.
h. Number of Displays: One.

H. Speakers:

1. Two, with individual controls for volume, bass and treble.

2. Signal to Noise Ratio: At least 65 dB.

3. Power: At least 4 W per speaker/channel.

4. Magnetic shielding to prevent distortion on the video monitor.

I. I/O Cabling: Include applicable cabling to connect I/O devices.

2.10. CENTRAL CONTROL AND MONITORING SYSTEM (CCMS) (HARDWARE DESCRIPTION)

A. General

1. The Facilities Management Control System (FMCS) shall be comprised of a network of various independent, Stand-alone Digital Controllers (SDC'S), Mechanical System Digital Controllers (MSDC's), Air Handler Digital Controllers (AHDC's), Unitary Digital Controllers (UDC's), together with Centralized Control Stations (CCS), and Centralized Host Stations (CHS) as specified, to provide centralized access and facility wide control functions. The SDC's, MSDC's, AHDC's, and UDC's shall be interconnected in a communicating network to provide facility wide access and sharing of information. A Gateway Digital Controller (GDC's) shall be provided to allow interface with third party microprocessor based control systems that are specified for integration within specification. A Local Area Network (LAN) shall be provided to interconnect SDC's for high-speed data transmission.

2. Specification Nomenclature

a.	FMCS	Facility Management Control System
b.	SDC	Stand-alone Digital Controller
c.	MSDC	Mechanical System Digital Controller
d.	AHDC	Air Handler Digital Controller
e.	UDC	Unitary Digital Controller
f.	HHOT	Hand Held Operator Terminal
g.	GDC	Gateway Digital Controller
h.	GP	Graphical Programmer
i.	CHS	Central Host Station
j.	CCS	Central Control Station
k.	RPTR	Communications Repeater

B. Centralized Host Stations (CHS)

1. The FMCS shall include Centralized Host Stations. CHS's shall, in conjunction

with the full compliment of Digital Controllers, provide the performance requirements within this specification. Each CHS shall include all hardware and software components to serve as a centralized facility operator station, providing color graphics, facility wide access, operator initiation of global control strategies, and centralized documentation.

The CHS shall be capable of simultaneously interfacing with the following:

a. -mouse pointing device
b. -two parallel printers
c. -high resolution VGA color graphics monitor
d. -seven auto answer/auto dial modems
e. -color inkjet printer
f. -two serial printers
g. -three FMCS LAN interface
h. -Alarm Graphic and Report FAX dial out service interface
i. -Mass storage tape system

As a minimum, the temperature control contractor shall provide the types and quantities of CHS, CCS, SDC, MSDC, AHDC, GDC, UDC, as required.

2. Operator Workstation: One PC-based microcomputer with minimum configuration as follows:

a. Uninterruptible Power Supply: 2 kVa.
b. Operating System: Microsoft Windows – Latest Version.
   i. ASHRAE 135 Compliance: Workstation shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
   ii. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
c. Printer: Color, ink-jet type as follows:
   i. Print Head: 4800 x 1200 dpi optimized color resolution.
   ii. Paper Handling: Minimum of 100 sheets.
   iii. Print Speed: Minimum of 17 ppm in black and 12 ppm in color.

C. Centralized Control Stations (CCS)

1. The FMCS shall include Centralized Control Stations, as required. CCS's shall, in conjunction with the network of SDC's and additional CCS components as required, provide the performance requirements within this section of the specification. Each CCS shall include all hardware and software components to serve as a centralized facility operator station, providing facility wide access, for review and modification of global control strategies, real time system monitoring, controller database editing or creation, and centralized documentation.

D. Local Area Networks

1. The LAN shall utilize packetized transmissions, CRC 16 error checking, and

distributed error recovery. Single or multiple SDC failures shall not cause loss of communication between other LAN-connected SDC's.

2. LAN connected SDC's shall be provided with a communications watchdog to assure that an individual SDC cannot permanently occupy the LAN. If an SDC is determined to be monopolizing communications, it shall be automatically shut down and an exception reported to annunciate this fact.

3. The LAN shall employ a token passing, peer-to-peer convention, same as or similar to the industry standard format IEEE 802.4. The content of messages shall be the manufacturer's standard. The Local Area Network components shall be manufacturer's standard or available from third party vendors which utilize the same chip implementation as used by the manufacturer.

4. Industry standard ANSI, RS-485 Network Communication System, Lon, or Bacnet, or Equivalent shall be utilized.

5. Trunk Wiring Practices - General

   a. The distributed communication network system shall consist of a multi-drop RS-485 bus architecture connecting SDC's, MSDC's, AHDC's, GDC's, and UDC's. The trunk shall consist of:
      i. A twisted pair of wires (24 awg) completely encased in continuous metallic conduit.
      ii. A twisted shielded pair of wires (24awg) with the shield grounded in accordance with the manufacturer's wiring practices.
      iii. Or a dual channel, 62.5 micron fiber cabling system with ST type connectors.

      There shall be no power wiring, in excess of 30 VAC rms voltage, run in conduit with communications trunk wiring. In cases where power or signal wiring is run in conduit with trunk wiring, all communications trunk wiring and power wiring shall be run using separate twisted shielded pairs (24awg) with the shields grounded in accordance with the manufacturer's wiring practices.

   b. Communication Transient Protection
      i. The manufacturer's catalog data sheet shall provide evidence that all FMCS products offered by the manufacturer are tested and comply with the standard for Transient Surge withstand capabilities for electrical devices ANSI C62.41, IEEE-587-1980, Categories A and B. Such testing shall have included power and communication trunk wiring. Compliance with IEEE-587 shall imply conformance with IEEE-472 transient standards based on the stated position of ANSI and IEEE regarding applicability of the rated standards.
      ii. In addition, at each building entry and exit point, the wire communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection specifications of the General semiconductor, Model #422E device. Transient surge protection is not necessary if the communication trunk, external to the building, is fiber optic in

nature.

iii. The communications circuitry and input/output circuitry, of the SDC's, MSDC's, and AHDC's shall provide protection against a 1000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations. The manufacturer's catalog data sheet shall provide evidence of conformance with this requirement. Systems not complying with this requirement shall provide equivalent protection external to the FMCS controller. Protection shall be provided for the individual communications and input/output terminations for each FMCS controller. Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.

c. RS-485 Trunk Distance and Topology

The manufacturer's RS-485 trunk shall provide operation over end to end linear distances of 4000 feet for wire connections and 6,500 feet for fiber optic connections, without repeaters, at communication data rates of up to 64 kbps. The trunk may be extended up to 20,000 feet through the use of wire repeaters or 80,000 feet through the use of fiber optic repeaters.

At data rates of up to 19.2 kbps, the trunk distance shall be extendible to distances of up to 20,000 feet using RS-485 communication wire or fiber optic repeaters. A repeater shall be used each 4,000 feet of linear distance for wire or every 6,500 feet for fiber optics. Repeating devices shall contain separate LED indication for each communication interface trunk to indicate proper operation of the repeater as well as the communications trunks.

Contractors shall provide devices which are of FMCS control system manufacturer's design.

d. It shall be possible for the trunk to be "T" eed or "starred", at any location using a repeater, to facilitate the installation. Systems which do not provide this capability shall provide a trunk riser diagram showing end to end distances and locations of system topology necessary to meet the trunk diagram shown on the plans.

e. Fiber Optic Communication Trunk

The temperature control contractor shall provide a dual channel fiber optic data link, as required, to minimize the effects of transient surges caused by lightning or external EMI generating equipment. The data link shall be comprised of a single duplex cable containing two fibers (transmit and receive), of 62.5 micron construction, to accommodate data rates of up to 64 kbps.

The fiber optic trunk shall be connected to SDC devices using manufacturer's standard RS-485 to fiber optic data link modem. Repeating devices shall contain separate LED indication for each communication interface and the fiber modem, to indicate proper operation of all aspects of the device. Fiber modem devices shall be tested and conform with transient surge withstand tests for electrical devices, ANSI C62.41 IEEE-587 Categories A and B. Manufacturer's data sheet shall provide evidence of compliance with this requirement. Manufacturer's products which do not meet this minimum performance requirement shall not be acceptable.

Systems which require a special gateway controller to accommodate the

fiber optic trunks, shall provide such a controller per point where the fiber optic cable enters and leaves the building. Gateway controllers shall not inhibit transfer of point data values between SDC controllers throughout the LAN. Such inhibitive systems shall not be acceptable.
In lieu of the above two options, the contractor may provide a fiber optic link to each SDC controller within the LAN. All controllers shall have access to the fiber optic link for LAN.
Fiber optic cable shall be fully tested and terminated by the temperature control contractor.

E. Standalone Digital Controllers (SDC)

1. General

Standalone Digital Controllers (SDC) shall be 16 bit microcomputer based, utilizing a multi-tasking, multi-user operating system.

The SDC controllers shall permit the simultaneous operation of all control, communication facilities management and operator interface software, as programmed by the Contractor or User. Modification of the on-board SDC controller database shall be performed on-line using the built-in or HHOT interface. Systems which require the SDC to be removed from service while DDC control sequences are modified shall not be acceptable.

SDC controllers shall utilize true floating point arithmetic capabilities. To accommodate totalization of large totalized values, SDC's with reporting capability shall support the calculation, accumulation and display of values within the range of +/-10 to the 10th power.

2. Database and Memory Back-up

All programming defining the functions to be performed by the SDC, including but not limited to application programs and point database within each SDC, shall be protected from loss due to power failure for a minimum of six months. Systems providing non-volatile memory for these functions are preferred. Systems not providing non-volatile memory shall provide a system rechargeable battery backup system sufficient to provide protection for the specified 6 month period. Systems not in compliance shall provide for uninterrupted power to each SDC.

3. Service Ports

SDC controllers shall be equipped with a minimum of one operator service port for the connection of a HHOT. The service port shall be either a built-in RS-232 data terminal port or an RJ-11 type jack which connects to the manufacturer's standard HHOT.

Connection of a service device, to a service port, shall not cause the SDC controller to lose communications with its peers or other networked device controllers.

The service port shall allow utilization of the same HHOT from any location. The

same HHOT shall be utilized for any SDC, MSDC, AHDC, or UDC Systems which utilize more than one variety of HHOT shall not be acceptable.

4. Display and Readout Capability

The SDC controller shall provide manufacturer's standard display and readout capability.

5. Manual/Auto Control and Notification

The SDC controller shall provide commanded override capability from the HHOT or the built-in operator interface. Such overrides shall be annunciated to the CHS's. Such overrides shall be valid as long as power is applied to the controller.

Manual service overrides, such as Hand/Off/Auto switches, shall be provided as indicated on the drawings. Such overrides shall be located at the controlled device location and conform with OSHA Manual lockout regulations, as appropriate, for safety reasons. SDC indication of such manual override actions shall be provided as feedback status indication points shown on the drawings, in conjunction with the application programs within the SDC. Systems which provide built-in H/O/A switching devices with integral feedback shall provide external manual service overrides, as indicated, to comply with OSHA manual lockout regulations. H/O/A switches remotely located at the SDC controller are not acceptable.

6. Adjustments

Every control panel shall provide adjustments for the functions specified. In general, adjustments shall be provided for all set points used by controllers within each control panel. In addition, adjustments shall be provided for throttling ranges, mixed air damper minimum positions, or other items as specified. Adjustments shall be integral to each individual SDC. The built-in operator interfaces shall allow the easy execution of the adjustment through named identifiers within the SDC. From a single SDC user interface, any other SDC shall be accessible and full adjustment capabilities shall be provided.

7. Sensing and Control Outputs Requirements

a. Sensing

i. All sensing inputs shall be provided via industry standard signals. Temperatures, humidities, differential pressure signals, and other signal inputs shall be one of the following types:

1. 0-20 mA
2. 4-20 mA
3. 0-5 VDC
4. 0-12 VDC

ii. 1000 ohm platinum (at O{SYMBOL 176\f"Symbol"}C,2.62 ohms/C)

iii. 1000 ohm Balco (2.2 ohms/{SYMBOL 176\f"Symbol"}F)

iv. 10 k ohm Thermistor (at 25{SYMBOL 176\f"Symbol"}C/77{SYMBOL 176\f "SYMBOL"}F)

Custom, definable input signals (accept sensor inputs from RTD devices, other than those of the manufacturer).

All signal inputs shall be compatible with the controllers used, and with the requirements for readout of variables in true scaled engineering units as specified.

b. Control Outputs

i. On/Off Outputs

Control panel shall internally provide test points for the circuit driving the equipment contactor, for the purpose of troubleshooting the 120 VAC or 240 VAC circuit to the contactor. All such relays or digital output modules shall provide a pilot light or LED display of the same status. On/Off output modules shall be of the modular construction that can be easily and quickly replaced, on an individual basis, if the module were to be damaged.

ii. Modulating Outputs

Modulating outputs shall be industry standard 0-5 VDC, or 0-12 VDC with definable output spans, to adapt to industry available control products. Milliamp outputs of 0-20 mA or 4-20 mA are also acceptable. Drive open/Drive closed type modulating outputs are acceptable provided that they also comply with the following requirements.

All modulating outputs shall provide within the control panel, a meter gauge, or display indication via on board display or HHOT, the commanded position signal for the actuating device. This meter, gauge, or display must provide either a 0-100 percent position indication, or read out directly in the engineering unit of the signal being used. Drive open/Drive closed type controllers shall include sufficient components and control algorithms to comply with this requirement. In the case of Drive open/closed technology, position feedback shall be provided to insure positive indication that the control device is at the commanded position.

F. Mechanical System Digital Controllers (Msdc's)

1. General

a. Controls shall be microprocessor based, Mechanical System Direct Digital Controllers (MSDC's). MSDC's shall be provided for air handling units, central pump systems and other applications as required. MSDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the MSDC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates sensor signals. All input/output signal conversion shall be performed through a minimum of a 12 Bit A to D converter. All input/output points shall be universal in nature allowing their individual function definition to be assigned through the application software. All unused input/output points must be available as universally definable at the owner discretion. If input/output points are not fully universal in nature, unused points must be equal in quantity between Analog Input, Digital Input, Analog Output, Digital Output.

Contractor shall provide a minimum of one MSDC controller per mechanical system, as shown on the drawings.

The BAS contractor shall provide and field install al MSDC's specified

under this section. Mechanical Equipment manufacturers desiring to provide MSDC type controls as factory mounted equipment, shall provide a separate bid for their product less all controls, BAS/Temperature Control Contractor.

b. All input/output signals shall be directly hardwired to the MSDC. Trouble shooting of input/output signals shall be easily executed with a volt-ohm-milli-amp meter (VOMA). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be used.

c. MSDC shall be in continuous direct communication with the network which forms the facility-wide Building Automation System (BAS). The MSDC's shall communicate with the SDC at a baud rate of not less than 19,200 baud.

2. Non-Volatile Memory

a. All control sequences programmed into the MSDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained. Power failures shall not cause the MSDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The MSDC shall allow for the creation of unique application control strategies. Systems that allow selection of sequences from the library or table are not acceptable.

b. All control sequences shall be fully field programmable at the MSDC controller, allowing for the creation or editing of an application sequence of operations.

c. Each MSDC shall be provided with manufacturer’s standard built-in Operator Interface.

d. The MSDC shall allow for internal processing and reporting of user defined Time of Day Schedules, Alarms, Trend Reports, Run Time Totalization, Energy Utilization Reports, Application Program Documentation and interface with a peripheral device such as an autodial/autoanswer modem, a VT-100 Display Terminal, or a serial printer.

i. Systems not providing the above functionality at the MSDC are not acceptable and shall utilize an SDC in place of the MSDC.

e. The MSDC shall provide LED indication of transmit/receive communications performance as well as for the proper/improper operation of the controller itself.

f. The MSDC shall be provided with a battery backed time clock that is capable of maintaining the time of day and calendar for up to thirty days without loss of setting. The battery for the time clock shall be field replaceable by the customer. Integral daily, weekly, holiday and special event scheduling shall be provided, such that all schedules can be custom tailored to the facility. Predefined schedules, with set quantities of on/off cycles are not acceptable.

3. Controller Location

a. To simplify controls, mechanical service and troubleshooting, the MSDC

shall be mounted directly in or on the control compartment of the mechanical system. The MSDC shall be provided in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The MSDC shall be constructed in a modular orientation such that service of the failed components can be performed quickly and easily. The modular construction should limit the quantities of printed circuit boards to a maximum of three. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. The MSDC shall allow for the creation of, unique, application control strategies. Systems that allow selection of sequences from a library or table are not acceptable. This shall allow all controls maintenance and troubleshooting to be made while at the unit location. MSDC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

b. For compatibility to the environment of the mechanical systems, MSDC shall have wide ambient ratings. MSDC shall be rated for service from -40 Deg F (Degrees Fahrenheit) to 140 Deg F.

c. Contractor shall submit description of location for the MSDC's on all mechanical equipment.

G. Energy Recovery Unit, Single Zone VAV Unit Digital Controller (AHDC)

1. General

a. Controls shall be microprocessor based, Air Handler Digital Controllers (AHDC's). AHDC's shall be provided for energy recovery ventilators, single zone VAV unit, and other applications as required. AHDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the AHDC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter. All input points shall be universal in nature allowing their individual function definition to be assigned through the application software. All unused input points must be available as universally definable at the discretion of the owner. If the input points are not fully universal in nature, unused points must be equal in quantity between Analog Inputs and Digital Inputs.

Contractor shall provide a minimum of one AHDC controller per air handling system as shown on the drawings.

The BAS contractor shall provide and field install all AHDC's specified under this section. Mechanical equipment manufacturers desiring to provide AHDC type controls as factory mounted equipment, shall provide a separate bid for their products less all controls, actuators, valve assemblies and sensors, which are specified to be provided by the BAS/Temperature control contractor.

b. All input/output signals shall be directly hardwired to the AHDC. Troubleshooting of input/output signals shall be easily executed with a volt-ohm meter (VOM). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.

c. AHDC's shall be in continuous direct communication with the network which forms the facility wide Building Automation System. The AHDC's shall communicate with the SDC at a baud rate of not less than 19,200 baud.

2. Non-Volatile Memory

a. All control sequences programmed into the AHDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the AHDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The AHDC shall allow for the creation of unique application control sequences. Systems that only allow selection of sequences from a library or table, are not acceptable.

b. All control sequences shall be fully programmable at the AHDC, allowing for the creation and editing of an application control sequence, while at the unit.

c. The AHDC shall be provided with an interface port for the HHOT. The interface port shall allow the HHOT to have full functionality as described. From the interface port, the HHOT shall be able to directly access any AHDC, UDC or VAVDC in the network.

d. The AHDC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples, per Input/Output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken. The samples shall be protected against loss due to power interruptions through a battery or capacitor backup method for a minimum of 30 days.

Systems unable to provide the above capability shall provide for the individual Input/Output point trending at the SDC. Specifics as to how each AHDC point will be trended, at the SDC, shall be provided in the submittal documents. Included in the explanation shall be the sample intervals, the memory allocation in the SDC and the number of AHDC's per SDC that can be expected.

e. The AHDC shall provide LED indication of transmit/receive communications performance, as well as for the proper/improper operation of the controller itself.

f. The AHDC shall be provided with a battery backed time clock that is capable of maintaining the time of day and calendar for up to thirty days, upon loss of power to the AHDC, without loss of setting. The battery for the time clock shall be replaceable by the customer. The AHDC shall be provided with integral time schedules; as a minimum, two seven day schedules with eight on/off periods per day shall be provided. Holiday override of weekly schedules shall be provided for pre-scheduling of holidays, for the year in advance.

3. Controller Location

a. To simplify controls and mechanical service troubleshooting, the AHDC shall be mounted directly in or on the controls compartment of the air handling system. The AHDC shall be provided in a NEMA 1 enclosure to accommodate direct mounting on the equipment to be controlled. The AHDC shall be constructed in a modular orientation such that service of the failed components can be done quickly and easily. The modular construction should limit the quantities of printed circuit boards to a maximum of two. All logic, control system, power supply and input/output circuitry shall be contained on a single plug-in circuit board. When required to replace a printed circuit board, it shall not be necessary to disconnect any field wiring. This shall allow all controls maintenance and troubleshooting to be made while at the air handling unit. The AHDC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

b. For compatibility to the environment of the air handling unit, AHDC's shall have wide ambient ratings. AHDC's shall be rated for service from -40 Deg F (Degrees Fahrenheit) to 140 Deg F.

c. Contractor shall submit description of location of AHDC's on all mechanical and air handling equipment.

H. Unitary Digital Controller (UDC)

1. General

a. Controls shall be microprocessor based Unitary Digital Controllers (UDC's). UDC's shall be provided for equipment as necessary. UDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the UDC. The application control program shall be resident within the same enclosure as the input/output circuitry which translates the sensor signals. All input/output signal conversion shall be performed through a minimum of a 10 bit A to D converter.

Contractor shall provide a minimum of one UDC controller per unitary system as required.

The BAS contractor shall provide and install all UDC's specified under this section. Mechanical equipment manufacturers desiring to provide UDC type controls as factory mounted equipment, shall provide a separate bid for their products less all controls, actuators, valve assemblies and sensors, which are specified to be provided by the BAS/Temperature control contractor.

b. All input/output signals shall be directly hardwired to the UDC. Troubleshooting of input/output signals shall be easily executed with a volt-ohm-milli-amp meter (VOMA). As a result of this intent, it is specified that power line carrier systems, or other systems which command multiple outputs over a single pair of wires, shall not be utilized.

c. UDC's shall be in continuous, direct communication with the network which forms the facility wide building automation system. The UDC's shall communicate with the SDC at a baud rate of not less than 9,600 baud.

2. Non-Volatile Memory

a. All control sequences programmed into the UDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the UDC memory to be lost, nor shall there be any need for batteries to be recharge or replaced to maintain the integrity of the controller database. The UDC shall allow for the creation of unique application control sequences. Systems that allow only selection of sequences from a library or table are not acceptable.

b. All control sequences shall be fully configurable at the AHDC, allowing for the creation and change of a sequence while at the unit.

c. The UDC shall be provided with the ability to interface with the HHOT. The interface port shall be provided at the wall sensor or within the unitary equipment, as specified on the plans. The interface port shall allow the HHOT to have full functionality as described hereinbefore of this specification. From the interface port, the HHOT shall be able to directly access any AHDC, or UDC in the network.

d. The UDC shall provide an input/output point trending utility that is capable of accumulating 48 analog point samples and 10 digital point samples per Input/Output point. Each sample shall be taken on a user defined interval, ranging from 1 second to 255 hours per sample. The digital readings shall be on a change of state occurrence for the digital points. All samples shall be recorded with the engineering units for the value, along with a time and date identifier for each sample taken.

Systems unable to provide the above capability shall provide for the individual input/output point trending at the SDC. Specifics as to how each UDC point will be trended, at the SDC, shall be provided in the submittal documents. Included in the explanation shall be the sample intervals, the memory allocation in the SDC and the number of UDC's per SDC that can be expected.

e. The UDC shall provide LED indication of transmit/receive communication performance, as well as for the proper/improper operation of the controller itself.

3. Controller Location

a. To simplify controls and mechanical service troubleshooting, the UDC shall be mounted directly in the controls compartment of the unitary system. The UDC shall be provided with a sheet metal or polymeric enclosure that is constructed of material allowing for the direct mounting within the primary air stream, as defined by UL-465. The direct mounting shall allow all controls maintenance and troubleshooting to be made while at the unitary equipment. The UDC shall be directly wired to sensory devices, staging relays or modulating valves for heating and cooling.

b. For compatibility to the environment of the unitary equipment, UDC's shall have wide ambient ratings. UDC's shall be rated for service from 32 Deg F (Degrees Fahrenheit) to 140 Deg F.

c. Contractor shall submit description of location of UDC's on all mechanical and unitary equipment.

I. Gateway Digital Controller (GDC)

1. General

a. Controls shall be microprocessor based, Gateway Digital Controllers (GDC's). GDC's shall be provided for the purpose of integrating microprocessor based, communicating, direct digital control systems from vendors other than the primary, selected controls manufacturer. GDC's shall be based on a minimum 16 bit microprocessor working from software program memory which is physically located in the GDC. All communications interface control programs shall be resident within the GDC.

The BAS contractor shall provide and field install all GDC's specified under this section. Any interface requirement beyond a two wire communications wire link, shall be provided by the equipment manufacturer supplying the non-primary or third party microprocessor based, communicating, direct digital controllers.

b. All GDC's shall exist at the LAN level with the SDC's. The GDC's shall possess all capabilities described under the SDC section while additionally providing the interface to the third party systems described above. The GDC's shall communicate with the third party controllers at the highest possible baud rate offered by the third party system. As a minimum, 9,600 baud communications shall be utilized.

c. All control sequences programmed into the GDC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained. Power failures shall not cause the GDC memory to be lost, nor shall there be any need for batteries to be recharged or replaced to maintain the integrity of the controller database. The GDC shall allow the standard database information from the third party system to be integrated in standard FMCS data formats, allowing for the creation of unique application control sequences. Systems that only allow selection of data and sequences from a library or table, are not acceptable.

d. Each GDC shall be provided with manufacturer's standard built-in operator interface.

The GDC shall provide Alarming, point trending and Energy report generation capabilities. Alarming points shall be uniquely definable, with multiple alarms assignable to a single point. Such alarm shall be provided with a unique 80 character message. Systems utilizing an alarm message library, shall describe the size of the library and verify how all alarming within the GDC will be guaranteed unique 80 character messages.

The quantities of trended point values shall be limited only by total controller memory space. If necessary, a GDC may be dedicated fully to a trending task, allowing all controller memory to be available for the trend storage. Each unique trend report shall contain a minimum of 4 different points and a minimum of 128 samples per point. Trending frequency for each report shall be operator definable from a sample once a second to a sample once every 24 hours. Trend reports shall be internally formatted by the GDC and shall be reportable directly to a serial printer, a VT-100 display terminal, a CCS, CHS or any other device capable of receiving a formatted ASCII data file.

e. The energy reports shall not be limited in quantities only by available memory within the GDC. Each Energy Report shall be fully formatted

and reportable to a serial printer, a VT-100 display terminal, a CCS, a CHS or any other device capable of receiving a formatted ASCII data file. As a minimum, each Energy Report shall provide a daily report and a monthly report with summary information such as outside air temperature, outside air humidity, total energy consumed and degree day calculations.

f. The GDC shall be provided with a battery backed clock that is capable of maintaining the time of day and calendar for up to thirty days, upon loss of power to the GDC, without loss of setting. The battery for the time clock shall be field replaceable by the customer.

2.11. SYSTEM SOFTWARE DESCRIPTION

A. General

1. Contractor shall provide all software for a complete and operational system as described herein. Software shall include manufacturer's standard multi-tasking, multi-user operating system for operator consoles and controllers, network communication software for dial-up and hard trunk applications, operator man-machine interface software, control application software and all other software necessary to provide the functions specified herein.

2. System software shall be as manufactured by Siebe Environmental Controls, Johnson Controls, Siemens, Reliable Controls, Schneider Electric, Advanced Power, Trane, or approved equal.

2.12. EXCEPTION REPORTING SEQUENCES

A. Alarm/COS Reports

1. For those digital points indicated on the drawings, the Contractor shall provide a unique change-of-state alarm message of up to 70 characters. The message shall report to all devices assigned to the alarm class.

2. For those points indicated on the drawings which are designated as interrupt priority, the Contractor shall provide an interrupting process display at the CHS location which displays the current conditions for the operator.

   In addition, the CHS computer shall automatically send a picture of the process graphic display to the remote locations specified on the drawings as receiving facsimile copies of interrupting alarms.

3. For those points designated in paragraph 3 above, the FMCS shall also send a history log to the system report printer of the immediate prior history of the points causing the interrupt priority. This log shall contain 1 minute samples of the previous 15 minutes of operation.

4. For those points on the drawings designed as Hard Facts points, the Contractor shall provide an alarm message to a remote facsimile location designated by the Owner. The FMCS system shall provide at the remote location, a facsimile print-out showing location, time/date of alarm and alarm message of the point. For

interrupt priority fax alarms, the remote facsimile machine shall receive a hard copy of the interrupt process screen showing on-line dynamic data values of the current conditions.

B. Off Hours Exception Reporting

1. The Owner shall specify up to five sites to which off hours exceptions shall be auto-dialed and reported. This shall allow the owner to assign off hours exception responses to various facility personnel as necessary. Selection of the site to be dialed can be programmed by the Owner, and set to change automatically per time of day and day of week.

2.13. MONITORING SYSTEM, SENSORS AND WIRING

A. Sensors and other Devices for Input/Output Summary Schedule:

1. Provide all necessary sensors, relays, panels, conduits and wire for the points indicated in the input/output summary as shown on the contract drawings.

2. Analog sensing elements for remote indication shall be independent of local sensors used for local control loops.

3. Temperature sensors shall be Resistance Temperature Detector (RTD) type of 1000 ohm balco. Space (60-90 degrees F); Duct/Well (-30-250 degrees F); Averaging Duct (-30-225 degrees F) or as required under Division 26.

   a. Space temperature sensors shall be provided with blank commercial type locking satin chrome covers.
   b. Duct temperature sensors shall be rigid stem or averaging type as specified in the sequence of operation. Water sensors shall be provided with a separable copper, monel or stainless steel well. Outside air wall mounted sensors shall be provided with a sun shield.
   c. The dew point sensor shall employ a non-reactive organic bobbin material to give precise dew point readings with accuracy of not more than + 1.5 degrees F. The dew point sensor shall incorporate an integral draft shield as part of the instrument for air velocities in excess of 50 feet per minute. The dew point sensor shall operate over a minimum dew point temperature range suitable to application.

4. Relative humidity sensors shall be capacitance type with 10 percent to 90 percent range. Duct mounted humidity sensors shall be provided with a sampling chamber. Wall mounted sensors shall be provided with covers identical to temperature sensors. Space 10 percent -90 percent RH; Duct 10 percent - 90 percent RH.

5. All wall mounted temperature sensors, humidity sensors, and CO2 sensors shall be installed with stainless steel wire guard. Set point adjustment shall be achievable without removing the wire guard.

6. Differential and Static Pressure Sensors and Switches

Fan proof-of-flow switches shall be U.L. listed adjustable set point and differential pressure type. Switches shall be piped to fan discharge except where fans operate at less than one inch WG, they shall be piped across the fan. For fractional horsepower and non-ducted fans, relays or auxiliary contacts may be used. Maximum pressure rating shall be at least 10 inches WG. with .05-12 inch W.C. range.

a. Pump proof-of-flow switches shall be U.L. listed adjustable differential pressure or flow type as specified in the sequence of operation or data point summary. Devices shall be 150 psi rated except chilled water flow switches shall be provided with totally sealed vapor tight switch enclosure on 300 psi body. Differential pressure switches shall have valved manifold for servicing, and a range of 3 psi-150 psi.

b. Air flow and static pressure analog sensors shall be high accuracy suitable for the low velocity pressures to be encountered, be selected for approximately 50 percent overrange, and have a 4 to 20 ma output. These differential pressure sensors shall be connected to the air flow measuring station with valved lines for testing and calibration, and shall have adjustments for zero and span. 5 inch W.C. range.

c. Water flow analog sensors shall be provided complete with flow element and shall be an all solid state precision industrial type with stainless steel meter body, maximum error of no more than .5 percent or span, and 4 to 20 ma output. Sensor shall be rated for 250 psi minimum and installed in strict accordance to the manufacturer's instructions complete with three-valve manifold for calibration and maintenance.

7. Overall system accuracy, including electronic analog sensing elements, shall be as follows:

a. Air: Plus or minus 1.0 degrees F temperature, plus or minus 2.5 percent r.h., plus or minus 2.0 percent static pressure.

b. Water: Plus or minus 0.7 degrees F over full scale range for water points, plus or minus 1.0 degree F for others.

c. Proof of fan or pumps operating status, or alarm conditions shall be through positive feedback from differential pressure switches across fan or pump. Auxiliary dry contacts may be used for proof of fans or pumps if the motors are fractional H.P., and other non-ducted fans.

8. Digital inputs from devices with isolated, dry type contacts (no grounds, no voltage) of either normally open (N.O.) or normally closed (N.C.) configuration shall be provided. Live contact inputs, those that have voltage present, shall be provided with isolating devices to meet dry contact requirements.

9. Liquid flow data shall be received and transmitted by commercial grade instrument similar in quality to Honeywell 411, Rosemount, Foxboro, MAMAC Systems or approved equal, type differential pressure transmitter. Pulse type data sensors shall not be acceptable. Speed response of differential pressure transmitters shall be at least 500 milliseconds. Maximum error signal shall be +/- 1 foot.

10. Start-stop relay module shall contain relays for start-stop function at the remote point, with relays mounted and factory wired to numbered terminal strips.

11. Outage Devices:

    a. Control Relays: Control relay contacts shall be rated for the application, with a minimum of two sets of Form C contacts, enclosed in a dustproof enclosure. Relays shall have silver-cadmium contacts with a minimum life-span rating of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression limiting transients to nondamaging levels.
    b. Time Delay Relays: Time delay relay contacts shall be rated for the application with a minimum of two sets of Form C contacts enclosed in a dustproof enclosure. Relays shall have silver-cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices to limit transients to nondamaging levels. Delays contact opening or closing shall be adjustable from one to 60 seconds with a minimum accuracy of plus or minus 2 percent of setting.
    c. Latching Relays: Latching relay contacts shall be rated for the application with a minimum of two sets of Form C contacts enclosed in a dustproof enclosure. Relays shall have silver-cadmium contacts with a minimum life-span rating of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to nondamaging levels.
    d. Reed Relays: Reed relays shall be encapsulated in a glass-type container housed in a plastic or epoxy case. Contacts shall be rated for the application. Operating and release times shall be one millisecond or less. Reed relays shall have a minimum life span rating of 10 million operations.
    e. Contactors: Contactors shall be of the single-coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semi-permanent magnets. Contacts shall be double-break silver-to-silver type protected by arcing contacts. Number of contacts and ratings shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices to limit transients to nondamaging levels.
    f. Solid-State Relays: Input-output isolation shall be greater than 1000 megohms with a breakdown voltage of 1500 V rms or greater at 60 Hz. The contact life shall be 10 million operations or greater. The ambient temperature range shall be minus 20 degrees to plus 140 degrees F. Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release times shall be one millisecond or less. Transient suppression shall be provided as an integral part of the relay to limit transients to nondamaging levels.

12. Audible Alarm:

    a. All alarms shall annunciate on the ATC system front end computer and via pagers.

2.14. MAKE-UP WATER FLOW METER/ALARM

A. In-line T-mounted Flowmeter: Made for installation between pipe flanges; measures flow directly in gallons per minute. As manufactured by Aaliant, Badger, Hersey, Kele, Data Industrial or approved equal.

1. Construction: Stainless steel body, with integral transmitter and direct - reading scale.

2. Pressure rating: 400 psig maximum.

3. Temperature Rating: 221 F maximum

4. Display: Two lines; alphanumeric characteristic each. Visual instantaneous rate of flow, with register to indicate total volume in gallons.

5. Output: Two simultaneous outputs; 4 to 20 mA, two-wire, pulse.

6. Transmitter: Universal flow transmitter with pulse output (totalization) to convert digital pulses to totalized gallons.

7. Electronic Housing: NEMA4, 3/4 NPT conduit connection, epoxy coated aluminum.

8. Accuracy: Plus or minus 1 percent of reading.

9. Key Pad: Setting of recalibration, engineering units, data logging sample time, alarms, response time.

B. Power and control wiring to be furnished and installed under this Section of Division 23.

2.15. FLOW MEASURING STATIONS

A. Furnish and install an Onicon Model F-1210, Hersey, Kobold or approved equal dual turbine insertion flow sensor complete with hot tap full port ball valve and installation hardware. The dual turbine element shall have counter rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Paddle type rotors will not be acceptable. Rotational sensing of each turbine shall be accomplished electronically by sensing impedance change and not with magnetic or photo-electric means. Each sensor shall be individually calibrated and tagged accordingly against the manufacturers primary standards which must be accurate to within 0.1 percent and traceable to the U.S. National Institute of Standards and Technology (NIST).

B. The sensor shall have a maximum operating pressure of 400 PSI, maximum operating temperature of 220 degrees F (optional 300 degrees F) and a pressure drop of less than 1 PSI at 17 feet per second flow rate. Flow sensor shall have 100:1 turndown ratio. Accuracy shall be + 2 percent of actual reading from 0.4 feet per second to 20.0 feet per second.

C. The sensor shall have integral analog outputs of 0-10 VDC and 4-20 mA current output for

connection to the Central Control System. The sensor shall also include three integral frequency outputs, (top turbine, bottom turbine, average frequency) for diagnostic purposes and for connection to peripheral equipment (local display, BTU meter, etc.). All outputs shall be linear with flow rate.

D. The turbine elements shall be made of polypropylene with sapphire jewel bearings and tungsten carbide shafts. The flow sensor shall be constructed of 316 stainless steel with an aluminum electronics enclosure and gasketed cover.

E. Install flow measuring stations with minimum straight lengths of pipe upstream and downstream from sensor as prescribed by manufacturer's written instructions.

F. Make electrical connections to power supply and interlock with ATC system.

G. Calibrate meters for manufacturer’s requirements.

2.16. FIELD INSTALLED CONDENSATE OVERFLOW SWITCHES

A. Condensate overflow switches must be tested to comply with U.L. 508.

B. Interlock condensate overflow switches to shut-down cooling equipment and alarm on ATC system where overflow condition exists.

2.17. CO2 SENSORS/TRANSMITTER

A. Furnish and install wall mount CO2 sensor/transmitters at locations indicated on floor plans. CO2 sensor/transmitter shall be model CD-W00 as manufactured by Johnson Controls or approved equal.

B. Measuring Range: 0 to 2,000 ppm CO2.

C. Response Time: 1 minute

D. Output Signal: As required by ATC system

E. Max power consumption: Less than 2 watts.

F. Listing: U.L. Listed

G. Accessories: Mounting Kit, Transformer required.

H. Where installed in toilet rooms, and corridors install heavy duty stainless steel guards.

PART 3. EXECUTION

3.1. GENERAL

A. The Automatic Temperature Control System and Central Control and Management System, shall be designed, installed, and commissioned in a turnkey fully implemented and operational manner.

3.2. BMS SPECIFIC REQUIREMENTS

A. Graphic Displays

1. Provide a color graphic system flow diagram display for each new and existing system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.

2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection.

B. Custom Reports:

1. Provide custom reports as required for this project:

3.3. WORKSTATION INSTALLATION

A. Desktop Workstations Installation:

1. Install workstation(s) at location(s) directed by Owner.

2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.

3. Install software on workstation(s) and verify software functions properly.

4. Develop Project-specific graphics, trends, reports, logs and historical database.

5. Power each workstation through a dedicated UPS unit. Locate UPS adjacent to workstation.

B. Portable Workstations Installation:

1. Turn over portable workstations to Owner at Substantial Completion.

2. Install software on workstation(s) and verify software functions properly.

C. Color Graphics Application:

1. Use system schematics indicated as starting point to create graphics.

2. Develop Project-specific library of symbols for representing system equipment and products.

3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.

4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.

5. Seek Owner input in graphics development once using graphics software.

6. Final editing shall be done on-site with Owner's and Architect's review and feedback.

7. Refine graphics as necessary for Owner acceptance.

8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.4. INSTALLATION & SUPERVISION

A. All wiring and tubing shall be properly supported and run in a neat and workmanlike manner. All wiring and tubing exposed and in equipment rooms shall run parallel to or at right angles to the building structure. All piping and wiring within enclosures shall be neatly bundled and anchored to prevent restriction to devices and terminals.

B. The control contractor shall be responsible for all electrical installation required for a fully functional control and automation system and not shown on the electrical plans or required by the electrical specifications. All wiring shall be in accordance to all local and national codes.

1. All line voltage wiring, all wiring exposed, and all wiring in equipment rooms shall be installed in conduit in accordance to the electrical specifications.

2. All electric and electronic wiring shall be minimum #20 AWG minimum THHN and shielded if required.

3. All wiring in the central control room shall be concealed in an approved manner.

C. Verify locations of temperature sensors, humidity sensors, CO2 sensors, and other exposed control sensors with plans and Owner prior to installation.

D. The installation and supervision of this project shall be carried out by factory trained personnel who are employed by the Contractor and licensed for this type of work.

E. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.

F. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation.

G. Install in accordance with manufacturer’s instructions.

H. Check and verify location of space temperature sensors, humidity sensors, CO2 sensors, and other exposed control sensors with plans and room details before installation. Align with lighting switches and humidistats.

I. Mount freeze protection thermostats using flanges and element holders.

J. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements

outdoors with sun shield.

K. Provide separable sockets for liquids and flanges for air bulb elements.

L. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.

M. Install equipment plumb and level.

N. Install all equipment to be accessible for service and maintenance.

3.5. ACCEPTANCE TESTING

A. Point Verification

To verify end-to-end operation of the system the Contractor shall provide a hard copy of an All Points Summary Listing to the Owner of each part or system to be placed in warranty by the Owner. For CHS systems, the Contractor shall additionally provide a print screen of the process display showing real time dynamic point information for all points on the subsystem(s) to be accepted.

B. Sequence Verification

1. The Contractor shall notify the Owner's representative of systems which perform all specified sequences.

2. The warranty acceptance test shall be of 5 days duration and the system shall perform as follows:

   a. During the five days, the FMCS system shall not report any system diagnostics from the subsystem under test.
   b. The subsystem shall be performance verified as operational using temporary trends of each control loop located in the SDC or MSDC.
   c. During the occupied periods, BAS control loops, under test, shall maintain control of the process variable within the following scales:
      i. Duct Static Pressure +/-0.3 inch WC
      ii. Pump Head Pressure +/-10 percent of control range
      iii. Duct Temperature Loops +/-2 degrees F
      iv. Room Temperature Loops +/-1degrees F
      v. Pipe Temperature Loops +/-2 degrees F
      vi. Duct Humidity +/-2x rated error of Humidity Transmitter
   d. The contractor shall provide a hard copy printout of the process variable, process variable set point and control loop output percent for the period of 2 hours prior to occupancy to 2 hours after occupancy with samples taken every 15 minutes.

3.6. VARIABLE AIR VOLUME AIR BALANCING

A. The air balance of the system shall be conducted by an independent AABC certified test and balance contractor.

B. The test and balance contractor shall verify that duct static pressure and scheduled VAV box flows +/-5 percent are present at each VAV terminal and supply air system. The air balance contractor shall make such adjustments as necessary to verify air flows meet design requirements.

C. The BAS contractor shall provide the air balance contractors via loan, palm top HHOT with an air balance test program. The HHOT shall plug into each wall sensor location and provide the air balancer a prompted display to properly set the minimum and maximum flow of each VAV terminal.

3.7. COORDINATE WITH TAB AGENCY

A. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water reset, freeze stats and duct smoke detectors.

B. Verify that all controlling instruments are calibrated and set for design operating conditions prior to commencement of TAB work.

C. Calibrate sensors after installation, and before the sensor control verification tests are performed. Prove the accuracy of final settings by taking temperature readings. The readings shall be in a typical conditional space for each separately controlled zone.

D. Allow sufficient time in the project to provide assistance and instruction to the balancing agency in the proper use and setting of control components such as, but not limited to, computers, static pressure controllers, or any other device that may need set points changed so that the testing and balancing work can be performed.

E. All control sequences, software, equipment, and components shall be started-up by a qualified technician. Start-up report shall be submitted to Engineer prior to the commencement of testing and balancing work. Testing and balancing shall not commence until start-up reports are completed, reviewed by Engineer and forwarded to Testing and Balancing Agency.

3.8. EXAMINATION

A. Verify existing conditions before starting work.

B. Verify that systems are ready to receive work.

C. Beginning of installation means installer accepts existing conditions.

D. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.

E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

F. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices, wiring, and tubing is installed prior to installation proceeding.

3.9. INTERLOCK REQUIREMENTS

A. The fan and equipment interlock requirements are as scheduled on the contract drawings.

B. Furnish and install all necessary relays, transformer, contactors, wiring, conduit, and accessories to perform fan, equipment, and damper interlocks.

C. Unless otherwise noted, fan interlocks shall be arranged such that dampers associated with fan shall be open when fan starts and close when fan stops.

3.10. SUBMITTALS AT PROJECT CLOSEOUT

A. Project Record Documents: Record actual locations of components and set points of controls, including changes to sequences made after submission of shop drawings.

3.11. CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to machine to allow service and maintenance.

B. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

C. Connect hand-off-auto selection switches to override automatic interlock controls when switch is in hand position.

3.12. FIELD QUALITY CONTROL

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

B. Perform the following field tests and inspections and prepare test reports:

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

2. Test and adjust controls and safeties.

3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

4. Test each point through its full operating range to verify that safety and operating control set points are as required.

5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.

6. Test each system for compliance with sequence of operation.

7. Test software and hardware interlocks.

8. Test all end switches and verify status is reported on the ATC system.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.

2. Check instruments for proper location and accessibility.

3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.

5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.

6. Check temperature instruments and material and length of sensing elements.

7. Check control valves. Verify that they are in correct direction.

8. Check DDC system as follows:

a. Verify that DDC controller power supply is from emergency power supply, if applicable.
b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
c. Verify that spare I/O capacity has been provided.
d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

E. All temperature control and interlock wiring shall be installed in conduit unless otherwise noted on the plans. Power or interlock wiring shall be run in separate conduit from sensor and communications wiring.

3.13. ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.

2. Make three-point calibration test for both linearity and accuracy for each analog instrument.

3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using volt-ohm-milli-amp meter (VOMA) at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 0, p50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers.

9. Provide diagnostic and test instruments for calibration and adjustment of system.

10. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial

Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.14. ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, 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.

3.15. SCHEDULING

A. Submit spreadsheet to Owner indicating occupied/unoccupied times for each item controlled by ATC system. Incorporate all scheduling requirements into sequence of operation.

3.16. STAGING

A. Coordinate staging requirements with equipment being controlled. Where multistage units are scheduled or specified, provide all devices, controllers, wiring to control and sequence all stages.

PART 4. SEQUENCES OF OPERATION

4.1. REFER TO CONTRACT DRAWINGS FOR SEQUENCES OF OPERATION, CONTROL DIAGRAMS, AND POINTS LIST.

END OF SECTION

DIVISION 23 SECTION 233000
HVAC AIR DISTRIBUTION
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SECTION 233000 - HVAC AIR DISTRIBUTION

PART 1. GENERAL

1.1. SUMMARY

A. For General Mechanical Requirements, see Division 23 Section, "Common Work Results for HVAC" and Division 01, "General Requirements".

B. The fabrication and installation of all ductwork, together with related equipment, shall comply with the standards of the National Fire Protection Association, as set forth in NFPA Standard No. 90A, as well as with the requirements of the Sheet Metal and Air Conditioning Contractors' National Association, Inc., and the latest edition of the ASHRAE Guide.

C. All duct sizes shown are net inside clear dimensions. Where internal duct lining is used, increase duct sizes accordingly to provide the indicated net free area. Unless otherwise indicated size runouts, drops, and connections to grilles, registers, diffusers, fans, coils, louvers, filters, and other equipment to the full size of the equipment connection.

D. Minor changes may be made in duct sizes where required to fit the available space, provided the indicated net free area and approximate aspect ratio are maintained.

E. Smoothly transition all ductwork to prevent excessive or unnecessary turbulence or pressure loss.

F. All exposed ductwork in finished areas shall be painted in color as indicated by Architect. All ductwork requiring paint shall be constructed of paint grade galvanized sheet steel with a paintable finish.

1.2. REFERENCES

A. ASTM A 36 - Structural Steel

B. ASTM A 90 - Weight of coating on Zinc-Coated (Galvanized) Iron or Steel Articles

C. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

D. ASTM C 916 Type II – Standard Specification for Adhesives for Duct Thermal Insulation

E. ASTM A 366 - Steel, Sheet, Carbon, Cold Rolled, Commercial Quality

F. ASTM A 480 - General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

G. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process

H. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality

I. ASTM A 568 - Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and

Cold-Rolled

J. ASTM A 569 - Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip, Commercial Quality

K. NFPA 90A - Installation of Air Conditioning and Ventilating Systems

L. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems

M. SMACNA - HVAC Air Duct Leakage Test Manual

N. NFPA 90A - Installation of Air Conditioning and Ventilating Systems

O. NFPA 70 - National Electrical Code

P. SMACNA - HVAC Duct Construction Standards - Metal and Flexible

Q. UL 555 - Fire Dampers

1.3. PERFORMANCE REQUIREMENTS

A. No variation of duct configuration or sizes permitted except by written permission. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE Table of Equivalent Rectangular and Round Ducts.

1.4. QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the projects specified in this section with minimum five (5) years documented experience.

B. Installer: Company specializing in performing the work of this section with minimum five (5) years' experience.

1.5. REGULATORY REQUIREMENTS

A. Construct ductwork to NFPA- 90A.

1.6. ENVIRONMENTAL REQUIREMENTS

A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturer.

B. Maintain temperatures during and after installation of duct sealants.

1.7. ALTERNATES

A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. DUCTWORK

A. Unless otherwise indicated or specified, fabricate ductwork of galvanized sheet steel, stainless steel, or aluminum conforming to Commercial Designation 3003 Temper H14

and Duct Sheet. Duct gages, jointing and reinforcement shall conform to Tables 4, 5, 6 and 7, as applicable, Chapter I of the latest ASHRAE Guide and Data Book. Construction details shall conform to Section I and Section II, as applicable, of Duct Manual and Sheet Metal Construction for Ventilation and Air Conditioning Systems as published by Sheet Metal and Air Conditioning Contractors' Association, Inc.

B. Erect sheet metal ductwork in a first-class, workmanlike manner secured in place rigidly and permanently. Provide suitable hangers, securely attached to building construction with bolts, clips or inserts. Hangers shall be structural shapes, flat bars, or formed strap hangers; use of wire will not be permitted. Hangers shall not pass through or be inside duct. Support vertical ducts passing through floors by angles riveted to duct and resting either on floor or on brackets secured to building construction. All space around ducts where they pass through any walls, floors, ceilings, or roofs shall be sealed tight with incombustible inert material. Do not arrange ducts so as to impair the effectiveness of fireproofing around structural members. Provide sheet metal flanged collars around exposed ducts passing through walls, floors, or ceilings to provide finished appearance. Seal all duct joints and seams including supply, return, outside air, combustion air, relief air, ventilation air and exhaust ductwork with Hardcast Sealing System as manufactured by Hardcast, Inc., Foster, Childers, or approved equal.

C. Flexible connections of neoprene or other NFPA approved non-inflammable fabric shall be provided in the duct system at all fan inlet and outlet connections.

D. Provide cut turning vanes in all duct turns where centerline radius is located. Turning vanes shall be air-foil type with extended trailing edges. Fabricate to comply with SMACNA Sheet Metal Construction for Ventilation and Air Conditioning Systems Manual.

E. Provide duct collars and angle iron framework for mounting of automatic dampers.

F. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.

G. Construct T’s, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide air foil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.

H. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

I. Fabricate continuously welded round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Joints shall be minimum 4-inch (100 mm) cemented slip joint, brazed or electric welded. Prime coat welded joints.

J. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.

K. Fasteners: Rivets, bolts, or sheet metal screws.

L. Hanger Rods: ASTM A36 - Galvanized steel; threaded both ends, threaded one end, or continuously threaded.

2.2. DUCT SYSTEMS

A. All supply, return, exhaust, fresh air intake, relief, ventilation, outside air and combustion air ductwork shall be constructed for low pressure service (2 inch W.G.).

2.3. DUCT CONSTRUCTION

A. Rectangular and/or Round Ductwork (Low Pressure):

1. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized steel sheet, lock-forming quality, having G-90 Zinc coating in conformance with ASTM A90.
2. Make allowance for internal duct lining where required. Sizes shown on the drawings are inside clear dimensions.
3. Determine duct gauges for the longest duct side and use for all four sides. Joints and reinforcing requirements apply to the longest duct side.
4. Reinforce all ducts to prevent buckling, vibration, or noise as recommended in the referenced construction standards, and as required to suit the installed conditions.
5. Do not cross break duct which will receive rigid insulation covering.
6. Where tap sizes of divided-flow fittings are not indicated, make branch and main/connection sizes proportional to their respective air flows and maintain uniform transverse velocities in the fitting.
7. Make radius elbows and radius tee connection with throat radius equal to or greater than the width of the duct. Use vaned elbows where shown and where radius elbows will not fit the space, and in all square bends.
8. Turning vanes shall be the air-foil type with extended trailing edges, 36-inch maximum vane length. Where longer vanes are required, use two or more sets of vanes with intermediate runners securely fastened together.
9. Bolt, screw, rivet, or spot weld reinforcing members securely to the duct on not less than 6-inch centers.
10. Where ducts are open-ended without grilles, registers, or other means of stiffening, reinforce and stiffen the open end with standing seams or an angle frame. Provide rolled edges to prevent any exposed sharp edges.
11. Paint all cut ends on galvanized angles, rods, and other uncoated surfaces with aluminum paint.
12. Where ductwork is not painted or otherwise finished, remove all exposed traces of joint sealers, manufacturer's identification and other markings.
13. Aluminum sheet shall be 3003 H14 alloy or duct sheet, 16,000 psi minimum

tensile strength, and capable of being formed to a Pittsburgh lock seam.

14. Reinforcing members for aluminum ductwork shall be galvanized steel or aluminum unless otherwise indicated. Where aluminum reinforcing is used, size the member in accordance with ASHRAE recommendations to have rigidity equivalent to listed mild steel angle sizes.

15. Where aluminum ductwork is used, make allowance for increased thermal expansion. Particularly avoid direct contact between aluminum and concrete or masonry walls subject to dampness.

16. Determine duct gauges per SMACNA based on duct size and pressure indicated.

2.4. AIR TRANSFER OPENINGS

A. Furnish and install metal sleeves or frames, of the same material as the duct or air terminals attached thereto, in all air transfer openings through walls, partitions, floors and other building construction, extending completely through the opening. Securely fasten the sleeves or frames in place and provide face flanges on both sides. Where grilles or registers are required, attach them to the sleeve or frame, or extend ductwork where shown on the drawings. If no grilles, registers or duct connections are required, furnish and install ½ inch x ½ inch removable galvanized wire mesh on one face.

2.5. AIR VOLUME CONTROLS

A. Furnish and install air volume control devices where indicated and where required to adjust and balance air flow in the systems, whether indicated or not. Volume dampers shall be provided in all branch ducts serving air outlets and inlets. For existing air devices install a new volume damper and where required for access, a new access door to allow access and adjustment.

B. Air extraction for air outlets and branch ducts shall be the gang-operated vane type, Tuttle & Bailey - Vectrol, Type VLC or VLK as appropriate, or approved equal, with suitable adjusting device and means of access.

C. Manual volume dampers in ductwork shall be factory-assembled units with rigid frame, opposed-blade action, and locking quadrant operator. Mark the extended damper shaft and align the operating handle to indicate the blade position. Dampers shall be as manufactured by Ruskin, American Warming and Ventilating, Inc., Arrow, or approved equal. Rectangular dampers shall be Type MD35, with steel channel frame, 16 gauge steel blades, 9 inch maximum blade spacing, low pressure, nylon bearings, and galvanized finish with aluminum paint touch up. Round manual balancing dampers shall be Type MDRS25 manufactured by Ruskin, Arrow, American Warming and Ventilating, Inc., or as approved equal. When external insulation is to be applied, provide sheet metal standoffs on all manual volume dampers.

D. Motor-operated dampers shall be as hereinafter specified under Division 23 Section, “Instrumentation and Controls of HVAC & Plumbing System”.

E. Duct turning vanes shall be Tuttle & Bailey Ducturns, or approved equal.

F. Furnish and install duct collars and angle iron frames for the installation of ATC

dampers.

G. Provide Type 316 stainless steel motor-operated dampers for installation in stainless steel ductwork.

H. Where volume dampers are installed in exposed finished spaces locate damper handle on top of duct.

I. Where volume dampers are installed above ceilings attach a colored piece of tape so that Test and Balance Engineer can easily locate for air flow adjustment.

2.6. INSTRUMENT TEST PORTS

A. Furnish and install instrument test ports in the ductwork to allow use of pitot tube length. Equip holes with Ventlok #699 instrument ports. Fittings shall extend beyond duct covering and insulation.

2.7. DUCT THERMOMETERS

A. Duct thermometers shall be Dresser Industries, Trerice, Weiss, Weksler, Miljoco, or approved equal direct-mounting filled system dial thermometers. Duct thermometers shall be vapor-actuated, universal-angle dial type, cast aluminum case with 4 ½ inch diameter, glass lens. Duct thermometers shall include adjustable joint with finish to match case, 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal place, with locking device. Thermal bulbs shall be copper with phosphor-bronze bourden pressure tube. Movement shall be brass, precision geared. Duct thermometer scales shall be Progressive, satin-faced non-reflective aluminum with permanently etched markings. Each stem shall be copper-plated aluminum or brass for separable socket of length to suit installation.

B. Where ductwork is installed at a height that would require duct thermometers to be installed 10 feet above finished floor or greater then remote-ready filled - system dial thermometers shall be installed. Connecting tubing shall be bronze, double-braided, armor-over-copper capillary; of length to suite installation.

C. Duct thermometers shall be furnished and installed at energy recovery ventilators, single zone VAV units and ducted heat pumps, and ducted variable refrigerant volume units as follows:

LOCATION	RANGE
Outdoor Air Duct	-40 degrees Fahrenheit to 120 degrees Fahrenheit
Return Air Duct	40 degrees Fahrenheit to 180 degrees Fahrenheit
Mixed Air Plenum	30 degrees Fahrenheit to 180 degrees Fahrenheit
Supply Air Duct	30 degrees Fahrenheit to 180 degrees Fahrenheit

Exhaust Air Duct	30 degrees Fahrenheit to 180 degrees Fahrenheit

D. Description: Flanged fitting bracket for mounting in hole of duct, with threaded end for attaching thermometer.

1. Extension Neck Length: Nominal thickness of 2 inches, but not less than thickness of exterior insulation.

2. Insertion Neck Length: Nominal thickness of 2 inches, but not less than thickness of insulation lining.

2.8. FLEXIBLE DUCT

A. Where indicated, flexible ductwork shall be Type SLR-25C as manufactured by General Flex Corporation, or as approved equal, insulated fully, UL listed as Class 1 Air Ducts, Standard 181, NFPA 90A and NFPA 90B with scuff-resistant polyethylene connector jacket and suitable for use in return air plenums.

B. Limit flexible duct runs to 5 feet maximum. Install flexible ducts, using all recommended fittings, couplings, and accessories. Support ducts with wide straps spaced so that horizontal runs do not sag more than 2-1/2 inches in 5 feet. Internally seal all joints and connections, cover with duct tape, and fasten with metal duct strap clamps. Bends of 180 degrees in flexible duct are prohibited.

2.9. FIRE DAMPERS

A. Furnish and install automatic fire dampers where indicated, in all 2-hour fire-rated partitions, shafts, slabs, etc., and where required by NFPA Standard No. 90A and by the Fire Marshal. Refer to the architectural drawings for location of all fire-rated walls, shafts and slabs. Fire Dampers shall also be provided at all transfer air devices installed in rated walls at all floor penetrations, and as shown on the contract drawings.

B. Construction of fire dampers shall conform to requirements of NFPA No. 90A, UL Standard 555 and shall bear UL label. Fire dampers shall be set in frames adequately secured to fire partitions, floors, etc., and installed in strict accordance with UL listing and manufacturer's instructions.

C. Fire damper shall be Dynamic Type for rectangular ductwork and round ductwork as manufactured by Ruskin, Air Balance, Inc., Arrow, Greenheck, Lloyd Industries, Nailor, or approved equal, multi-leaf accordion type, held open by adequate heavy gauge wires and suitably calibrated fusible links. Vertical dampers (horizontal air flow) shall close by gravity. Horizontal dampers (vertical air flow) shall be closed by suitable and positive spring closing devices.

D. Damper frames shall provide pocket which shall store the damper leaves in open position outside of the air stream and shall provide for 100 percent opening connecting to ductwork or grille face. Damper material shall match connecting ductwork.

E. Provide adequately sized hinged access doors with cam locks for access to all fusible links and for resetting fire dampers. Where applicable, access to fire dampers shall be through registers or grilles. Provide identification on access door indicating fire damper within. Letters shall be not less than ½-inch in height.

F. Submit complete information to the Engineer including installation details. Furnish and install sleeves, angles, break-away duct connections, per UL listing.

G. Furnish to the Owner in a suitable storage container not less than six (6) fusible links of each type, size, and rating used on the project. Where required, furnish Greenheck Type CR, CO, or Type C transition sleeves.

2.10. DUCT ACCESS DOORS

A. Furnish and install adequately sized duct access doors at fire dampers, air measuring devices, motor-operated dampers, duct smoke detectors, and other locations where indicated and required for duct access. Doors shall be the continuous piano-hinged type with approved latches and neoprene compression-type gaskets with 1 inch thick fiberglass double skin and shall be Ruskin Model ADH22, Air Balance, Inc., FSA-100 or as approved equal. Stiffen ductwork at door openings. Where doors are installed in insulated ductwork, provide equivalent insulation in the door assembly. Where access doors are installed in the fire-rated partitions, provide Fire Seal access doors as manufactured by Air Balance, Inc., or approved equal, UL approved, meeting the rating of the enclosure in which the access door is installed.

B. For walk-in plenums, provide insulated walk-through access doors, Ruskin Type ADW2, American Air Balance Type WA-100, or as approved equal.

C. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

2.11. SPIN-IN FITTINGS

A. Furnish and install spin-in fittings where indicated on the contract drawings, Model SM-20G, as manufactured by General Environment Corporation, or an approved equal.

2.12. DUCT LINING (LOW PRESSURE DUCTWORK)

A. All low pressure supply and return ductwork within 10 feet of energy recovery ventilation units, single zone VAV units, Ducted VRV heat pumps and as additionally shown on Contract Drawings, shall be lined on the interior for sound attenuation and thermal insulation.

B. All low pressure ductwork within 10 feet of relief, supply or exhaust air fans and as additionally shown on Contract Drawings shall be lined on the interior for sound attenuation and thermal insulation.

C. All internal duct lining for low pressure duct systems shall be provided with an interior galvanized perforated liner.

D. Provide additional exterior insulation where required and as indicated in Division 23

Section, "HVAC Insulation".

E. The lining insulation shall be 1 inch thick, 3.0 pcf density, Aeroflex plus Duct Liner Type 300, Owens Corning Quiet R Rotary Duct Liner, Manville, Knauf, or approved equal. The material shall be specifically designed for this application, shall have a black, fire-resistant coating, shall meet NFPA Standards 90A and 90B and shall have a UL Fire Hazard Classification of Flame Spread 25 or less and smoke developed of 10 or less. The black-coated surface shall face the air stream.

F. All exposed edges and the leading edge of all cross joints of the liner shall be coated with the same adhesive used to secure the duct liner to metal surface. All air stream surfaces shall be treated with EPA registered fungicide Foster 40-20. Coating shall meet ASTM D 5590 with 0 growth rating.

G. The duct liner shall be adhered to the metal with 100 percent coverage of adhesive. Adhesive shall conform to Adhesive and Sealant Council Standards for adhesives for duct liner; ASTM C916, Type II (ASC-A-7001-A-1971). Adhesive shall be Foster 85-60, Childers CP-127 or approved equal.

H. The duct liner shall be additionally secured with mechanical fasteners, which shall compress the duct liner sufficiently to hold it firmly in place. Mechanical fasteners shall conform to Mechanical Fastener Standard MF-1-1971, available from Sheet Metal and Air Conditioning Contractors National Association.

I. All duct lining shall be installed in complete accordance with the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Duct Liner Application Standard, First Edition and Green Guard Indoor Air Quality certification program requirements.

J. Dimensions on drawings indicate inside clear opening of rectangular ductwork. Increase duct dimensions 2 inches each way for accommodating insulation on all shop or field-fabricated rectangular ductwork where lining is specified.

2.13. AIR TERMINAL DEVICES

A. Furnish and install air supply, return, exhaust devices of sizes and capacities as scheduled on the drawings. Catalog numbers shown are Metalaire, Inc., products for equipment which have been found suitable for the application. Products of Tuttle & Bailey, Anemostat, Division of Hart & Cooley, Carnes, Titus, Price, Nailor, or approved equal will be considered only if performance characteristics including throw, drop, pressure loss, sound pressure level, etc., are equal to or better than the performance characteristics of the specified products. All air devices shall be ADC certified. Ductwork behind registers, grilles and diffusers shall be given two coats of flat black paint. Perimeter of all ceiling diffusers shall be caulked to provide a neat, aesthetic appearance.

B. Device Schedule:

AIR DEVICE SCHEDULE

Device	Accessories	Finish
Supply Diffusers, Lay-in Tile		
Model 5000-A, Rectangular MetalAire Ceiling Diffuser, Throw as Indicated	Integral opposed blade damper	White baked enamel finish
	Removable core	
	Louvered face	
	All aluminum construction	
	Auxiliary panel for lay-in tile installation	
	Adjustable pattern deflector	
Supply Diffuser, Gypboard, Surface Mount		
MetalAire Model 5000-A, Rectangular Ceiling Diffuser, Throw as Indicated (Surface or Duct Mount)	Integral opposed blade damper	White baked enamel finish
	Louver face	
	All aluminum construction	
	Removable core	
	Adjustable pattern deflector	
Return/Exhaust, Transfer Register, Gypboard, Surface Mount		
MetalAire, Model RHD Rectangular Registers (Surface Mount)	Integral opposed blade damper	Off-white baked enamel finish
	45 degree angled deflecting vanes	
	All aluminum construction	
Return/Exhaust Register Sidewall w/filters		
MetalAire Model SRHF Sidewall Return Register with Filter Housing	All steel construction, for auditorium spaces provide heavy duty, 16 gauge	Off white electro-deposition finish
	45 degree angled deflecting vanes	
	Opposed blade dampers	

AIR DEVICE SCHEDULE		
	Filter housing w/ 1 inch thick disposable filter	
	Hinged core	
	Provide return air filters racks and 1" thick filters where indicated.	
Return/Exhaust, Transfer Register, Lay-in Tile		
MetalAire, Model RHD Rectangular Registers	Integral opposed blade damper	Off-white baked enamel finish
	45 degree angled deflecting vanes	
	All aluminum construction	
	Auxiliary panel for lay-in tile installation	
	Provide return air filters racks and 1" thick filters where indicated.	

C. Where air terminal devices are installed in duct collars or branches, furnish and install air extractors. Furnish and install control grids, volume dampers, and/or other accessories necessary to ensure uniform air flow across the terminal devices. Accessories shall be of the same material as the terminal device. Install fixed blade terminals so that blades block the normal line of vision. Furnish three (3) of each type of removable key operators.

D. Contractor shall determine frame and mounting type as per type of ceiling as shown on Architectural drawings.

E. Noise Criteria: All air devices shall be sized and selected to limit maximum NC (noise criteria) levels to 30.

2.14. LOUVER BLANK-OFF PANELS

A. Insulated, Blank-Off Panels: Laminated panels consisting of insulating core surfaced on back and front with metal sheets and attached to back of louver

1. Thickness: 2 inches (50mm)
2. Metal Facing Sheets: Aluminum sheet, not less than .032 inch (.81mm) nominal thickness.
3. Insulating Core: Rigid, glass-fiber-board insulation or extruded-polystyrene foam
4. Edge Treatment: Trim perimeter edges of blank-off panels with louver

manufacturer's standard extruded-aluminum-channel frames, not less than .080 inch (2.03mm) nominal thickness with corners mitered and with same finish as panels.

5. Seal perimeter joints between panel faces and louver frames with gaskets or sealant.
6. Panel Finish: Same finish applied to louvers.
7. Attach blank-off panels with stainless steel sheet metal screws.
8. Cover all unused openings in louvers.

2.15. INTAKE/RELIEF HOODS

A. Furnish and install heavy gauge aluminum intake/relief hoods of size, capacity, and arrangement as shown on Contract Drawings. Intake/relief hoods shall be Greenheck Model FHI for intake or Model FHR for relief as manufactured by Greenheck, ACME Engineering, Cook, Twin City, or approved equal.

B. Gravity roof ventilators shall be constructed of heavy gauge aluminum or galvanized steel. Hoods shall be constructed of precision formed, arched panels with interlocking seams. Bases shall be constructed so that the curb cap is 8 inches larger than the throat size. Insulated roof curbs shall be furnished as specified and shall be of same manufacturer as roof hood.

C. Hood support members shall be constructed of galvanized steel and fastened so that the hood can be either removed completely from the base or hinged open. Birdscreens constructed of ½ inch galvanized steel mesh shall be mounted horizontally across the intake/discharge area of the hood. Intake units with throat widths through 42 inches shall ship assembled when throat lengths do not exceed 84 inches. Relief units with throat widths through 48 inches shall ship assembled when throat lengths do not exceed 96 inches.

D. Motor-operated dampers shall be provided by the ATC Subcontractor and installed by Mechanical Contractor.

2.16. OPEN END DUCTS (OED)

A. Whether indicated on plans or not, all open-ended ducts shall be provided with a protective screen.

B. All open-ended ducts shall be furnished with a 12 gauge ½ inch x ½ inch aluminum mesh screen. Screens shall be permanently installed in a removable frame, and the frame shall be attached to the open-ended duct in a neat, workmanship-like manner without any exposed edges or sharp surfaces.

C. Screen shall be attached to a ¾ inch x 1/8 inch continuous galvanized perimeter frame. Install duct stiffeners greater than 16 inches in any direction at open-ended ducts.

2.17. DRIP PANS

A. Furnish and install suitable watertight, aluminum drip pans where water or drain piping is routed over electrical switchgear, transformers, computers, elevator machine equipment,

dry storage rooms, etc. Each drip pan shall have a 1 inch copper type M drain piped to discharge where shown on drawings; or, if not shown, to discharge over nearest available open drain. Size and arrangement shall be as approved by Engineer. Sides shall be minimum 1.5 inches deep.

B. Drain pans shall be of 16 gauge welded construction. Provide drawings of typical drain pan construction for approval before construction. See Submittals in Division 01 Section, "Product Requirements".

2.18. DUCT SEALANTS AND ADHESIVES

A. All ductwork shall be sealed, including low pressure exhaust systems. Transverse joints and longitudinal seams in duct systems shall be sealed with a duct sealant of the type specified hereinafter in Section 1, 2, or 3, or with a tape sealing system as specified in Section 4. Spiral lockseams are not longitudinal seams and do not require duct sealant. All seams and joints shall require duct sealant suitable for the pressure rating and installation application. All sealants shall exceed 500 hours without becoming brittle under ASTM-D572 test conditions (oxygen bomb), unless specified otherwise. No surface preparation or solvent cleaning shall be necessary to remove light coatings of oil and dust before applying sealant unless specified otherwise. Flanged joints shall be sealed according to Section 5. Construction joints that are not fully welded shall be sealed according to Section 6. Adhesive to secure insulation to metal surfaces shall be that specified in Section 7.

1. Assembly joints to be installed indoors or outdoors shall be sealed with Foster 32-19, Childers CP-146, United Duct Sealer WB, or equivalent, which is a water-based sealant formulated to withstand service temperatures from 20 degrees F to +200 degrees F. Sealant shall have a UL Classification marking with a flame spread of 15 and smoke developed of 0 when applied to inorganic reinforced cement board, both at a coverage of 31 square feet per gallon. Store and apply between 40°F (4°C) and 100°F (38°C); protect from freezing.

2. Assembly joints to be installed indoors shall be sealed with Foster 32-19, childers CP-146, UNI-GRIP™ duct sealer or equivalent, which is a water-based (vinyl-acrylic polymer) sealant formulated to withstand temperatures from –20 degrees to +200 degrees Fahrenheit. Surfaces to be sealed should be clean, dry, and free from oil, grease, and dirt. Sealant shall be nonflammable (wet) and fire retardant. Sealant shall have a UL Classification marking with a flame spread of 5 and smoke developed of 5 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 0 when applied to inorganic reinforced cement board, both at a coverage of 40 square feet per gallon.

3. Assembly joints shall be sealed with UNI-CAST® tape sealing system or equivalent, which is a combination of an adhesive activator and woven-fiber tape impregnated with a gypsum mineral compound. Modified acrylic/silicone activator (MTA-20 for indoor use) reacts exothermically with the tape to form a hard, airtight seal. Sealant shall be formulated to withstand temperatures from –40 degrees F to +200 degrees Fahrenheit. Combination of tape and MTA-20 adhesive shall have a flame spread and smoke developed of 0. Do not use for outdoors.

4. Flanged joints to be installed indoors shall be sealed with UNI-GASKET™ flange sealer or equivalent, which has a synthetic elastomer base and is formulated to withstand temperatures from –20 degrees F to +150 degrees F. Sealant shall have a UL Classification marking with a flame spread of 5 and smoke developed of 5 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 5 when applied to inorganic reinforced cement board, both at a coverage of 80 square feet per gallon.

5. Where duct fittings are constructed with standing seam or spot-welded techniques, all construction joints shall be sealed with UNI-WELD™ metal cement or equivalent, which is composed of neoprene rubber, resins, and inert reinforcing material dispersed in a petroleum distillate. Sealant shall be formulated to withstand temperatures from –20 degrees F to +225 degrees F. Sealant shall have a UL Classification marking with a flame spread of 0 and smoke developed of 0 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 0 when applied to inorganic reinforced cement board, tested as applied in two 1/8 inch beads 8 inches on center.

6. Where insulation is to be secured to metal surfaces, the adhesive used shall be Foster 85-60, Childers CP-127, UNI-TACK™ duct liner adhesive or equivalent, which are water-based, vinyl-acrylic copolymer adhesives formulated to withstand temperatures from –20 degrees Fahrenheit to +200 degrees Fahrenheit. Adhesive shall have a UL Classification marking with a flame spread of 0 and smoke developed of 0 when applied to 18-gauge galvanized steel and a flame spread of 0 and smoke developed of 0 when applied to inorganic reinforced cement board, both at a coverage of 267 square feet per gallon. Adhesive shall conform to ASTM C916, Type II.

B. Manufacturers: Duct Mate, United McGill, MKT Metal Manufacturers, Semco, Elgen, Childers, Foster, or as approved equal.

2.19. AUXILIARY DRIP PANS

A. Furnish and install suitable watertight, aluminum drip pans for all suspended air handling units, heat pumps, or air handling units installed on upper floor and/or attic. Each drip pan shall have a 1" copper type "M" drain piped to discharge where shown on drawings. Drain pan shall extend 3" beyond sides of air handling unit/heat pump. Sides shall be minimum 1.5" deep.

B. Drain pans shall be of 16 gauge welded construction. Provide drawings of typical drain pan construction for approval before construction. See Submittals, Division 23 Section, “Common Work Results for HVAC” and Division 01, Section, “General Requirements”.

C. Install U.L. 580 listed condensate float switch in auxiliary drain pan and wire to shut-down unit upon sensing water. All control and interlock wiring to be furnished and installed under Division 23 Section, “Instrumentation & Controls of HVAC & Plumbing Systems”

2.20. FILTER MEDIA DURING CONSTRUCTION

A. Filter media installed during construction: Minimum MERV 8.

PART 3. EXECUTION

3.1. DUCT INSTALLATION REQUIREMENTS

A. Coordinate ductwork with other work and install ducts at proper elevations and locations to maintain indicated ceiling heights and clearances. Provide all elbows, transitions, offsets, connections, and other fittings necessary to fit the work into place or to connect to equipment or diffusers. Method of duct support connection to structure and slabs shall be approved by Structural Engineer, and Shop Drawings shall be submitted.

B. Substantially support ductwork with structural shapes, flat bars, or formed strap hangers securely attached to the building structure by means of bolts, clamps, or inserts. Support vertical ducts by angles attached to the duct and resting on the floor or supported by brackets or hangers attached to the building structure. Strap hangers shall be 16-gauge minimum galvanized steel formed under the bottom edge of duct. Use square ¼ inch thick washers tight against the bend on upper strap attachments to horizontal surfaces. Place all supports external to the ductwork and out of the air stream. Provide additional supports at coils and other concentrated loads. Arrange supports so that duct weight is not transmitted to ceilings, fans or other equipment.

C. Prevent direct contact between ductwork and building surfaces or other equipment. Where ducts pass through walls, partitions, floors, ceilings, or roofs, pack and seal the space around the duct with an approved fire-safe inert material. Provide flanged duct escutcheons at all exposed ducts that pass through walls, partitions, floors, and ceilings.

D. Use galvanized (compatible) corrosion-resistant hangers, supports, brackets, and hardware.

E. Furnish and install NFPA-approved duct connections where shown and at all connections to fans, air handling units, and similar rotating equipment. Use glass-reinforced neoprene fabric, roll-formed to sheet metal strips or flanges. Support adjacent ductwork to provide sufficient slack in the connection.

F. See NFPA 90A, and latest publication of SMACNA. Prevent direct contact between ductwork and building surfaces or other equipment. The opening in the construction around the duct shall not exceed one-inch average clearance on all sides. Where ducts pass through walls, partitions, floors, ceilings, or roofs, pack and seal the space around the duct with an approved fire-safe inert material capable of preventing the passage of flame and hot gases sufficiently to ignite cotton waste when subjected to the same NFPA 251 Time-Temperature Conditions required for fire barrier penetration. All exposed duct penetrations shall be finished with a sheet metal field erected flange escutcheon to form a neat appearance.

G. Coordinate duct installation with the requirements of Division 23 Section, “Vibration Controls for HVAC, Plumbing & Fire Protection Equipment”.

H. Install in accordance with manufacturer’s instructions.

I. Install and seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

J. Duct Sizes are inside clear dimensions. For lined ducts, maintain sizes inside lining.

K. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

L. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

M. Use crimp joints, with or without bead, for joining round duct sizes eight (8) inches and smaller with crimp in direction of air flow.

N. Use double nuts and lock washers on threaded rod supports.

O. Set plenum doors 6 to 12 inches (150 to 300 mm) above floor. Arrange door swings so that fan static pressure holds door in closed position.

P. During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork systems.

3.2. ACCESSORY INSTALLATION REQUIREMENTS

A. Install accessories in accordance with manufacturer's instruction, NFPA 90A, and SMACNA HVAC Duct Construction Standards - Metal and Flexible.

B. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, duct detectors, air flow monitoring stations, duct-mounted equipment, duct coils and elsewhere as indicated. Review locations prior to fabrication.

C. Provide duct test holes where required for testing and balancing purposes. Review locations with Test and Balance Engineer prior to installation.

D. Provide fire dampers at locations indicated, where ducts and outlets pass through fire-rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion-resistant springs, bearings, bushings and hinges.

E. Demonstrate re-setting of fire dampers to Owner's representative.

F. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment and supported by vibration isolators. Refer to Division 23 Section, "Vibration Control for HVAC and Plumbing Systems".

G. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum duct widths from duct take-off.

H. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless

of whether dampers are specified as part of the diffuser, grille, or register assembly.

I. Support duct silencers independent of ductwork

J. Install diffusers, registers, and grilles to ductwork with airtight construction.

K. Check location of all air outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangements.

L. Install duct thermometer support flanges in wall of duct. Attach to duct with screws. Locate duct mounted thermometers, minimum 10 feet downstream of mixing dampers, coils or other devices causing air turbulence.

M. Install remote - reading duct dial thermometers in control panels with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length. Mount control panel 60 inches above finished floor and label each dial thermometer.

N. Install duct accessories according to applicable details shown in SMACNA's HVAC Duct Construction Standards Metal and Flexible for metal ducts.

O. Install volume dampers in lined duct; avoid damage to and erosion of duct liner.

P. Provide test holes at fan inlet and outlet and elsewhere as indicated.

Q. Install fire dampers according to manufacturer's UL approved written instructions.

1. Install fusible links in fire dampers. Label access doors according to equipment served.

R. Adjust duct accessories for proper settings.

S. Adjust fire dampers for proper action.

3.3. DUCT LINING INSTALLATION REQUIREMENTS

A. All portions of duct designated to receive duct liner shall be completely covered with duct liner. Transverse joints shall be neatly butted and there shall be no interruptions or gaps. The black pigmented or mat faced surface of the duct liner shall face the airstream.

B. Duct liner shall be adhered to the sheet metal. with 90 percent coverage of adhesive complying with requirements of ASTM C916. All exposed leading edges and transverse joints shall be factory coated or coated with adhesive during fabrication. Install perforated galvanized inner liner where indicated

C. Duct liner shall be additionally secured with mechanical fasteners, either weld-secured or impact-driven, which shall compress the duct liner sufficiently to hold it firmly in place. Adhesive bonded pins are not permitted due to long term adhesive aging characteristics. Spacing of mechanical fasteners with respect to duct liner interior width shall be in accordance with SMACNA HVAC DGS. Maximum spacing for mechanical fasteners shall be as follows:

Velocity = 0 to 2,500 feet per minute (0 to 12.8m/s):

From transverse end of liner	3: (75mm)
Across width of duct	12 inches (300 mm) O.C.
From corners of duct	4 inches (100mm)
Along length of duct	18 inches (450mm) O.C.

Velocity = 2,501 to 5,000 feet per minute (12.8 to 25.4 m/s):

From transverse end of liner	3 inches (75m)
Across width of duct	6 inches (150mm) O.C.
From corners of duct	4 inches (100mm)
Along length of duct	16 inches (400mm) O.C.

D. When air velocities exceed 4,000 fpm (20.3m/s), galvanized sheet metal nosing shall be applied to all leading edges of duct liner.

E. Acoustical Duct Liner shall be cut to assure overlapping and compressed longitudinal corner joints.

F. Upon completion of installation of duct liner and before operation is to commence, visually inspect the system and verify that the duct liner insulation has been correctly installed.

G. Open all system dampers and turn on fans to blow all scraps and other loose pieces of material out of the duct system. Allow for a means of removal of such material.

H. Check the duct system to ensure that there are no air leaks through joints.

3.4. CLEANING

A. Clean duct system and force air at high velocity through ducts to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

B. Clean duct systems with high power vacuum machines. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.

C. Ductwork shall be cleaned in accordance with “Duct Cleanliness for New Construction (SMACNA 2000)”, and shall achieve a “Basic” cleanliness level.

3.5. LEAKAGE TESTS

A. All low pressure sheet metal ductwork shall undergo leakage tests at 2 inch W.G. Tests shall be accomplished under this section and witnessed as specified under Division 23 Section, “Testing, Adjusting, and Balancing for HVAC and Plumbing”.

B. Leakage from each duct system shall not exceed 3 percent for low pressure systems and 1 percent for medium pressure systems of the normal air handling capacity of the system. If the system ductwork is tested in sections, the leakage shall not exceed ½ of 1 percent

of the CFM to be handled by that section, and the total leakage of the system shall not exceed 1 percent of the total system CFM. Test pressure shall not exceed the pressure limits of the duct construction as defined in SMACNA High Pressure Duct Construction Standards. Repair all leaks which are audible, regardless of the leakage rate of the duct system as a whole, by remaking the entire defective joint or seam. Spot sealing of ducts in place will not be acceptable.

C. All duct accessories, including but not limited to volume dampers, ATC sensors, duct detectors, duct coils shall be installed prior to duct leakage testing.

D. Submit a complete report of the ductwork leakage tests to the Architect and include final approved copies in test and balance reports.

3.6. DUCTWORK IDENTIFICATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

B. All ductwork shall be identified with painted background marked with the name of the service with arrows to indicate flow direction. Color Code and System Identification shall comply with ANSI Standards.

C. Marking shall be plain block letters, stenciled on ductwork (above and below ceilings) and shall be located near each branch connection and at least every ten feet on straight runs of ductwork. Where ductwork is aligned adjacent to each other, markings shall be neatly lined up. All markings shall be located in such a manner as to be easily legible from the floor.

D. Identify ductwork with plastic nameplates or stenciled painting. Identify with air handling unit identification and area served.

E. Length of color field for ductwork shall be 32 inches. Lettering shall be minimum 3-1/2 inches high.

END OF SECTION

DIVISION 23
SECTION 238126
VARIABLE REFRIGERANT VOLUME SPLIT SYSTEMS WITH HEAT RECOVERY (AIR COOLED SYSTEMS)
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SECTION 238126 - VARIABLE REFRIGERANT VOLUME SPLIT SYSTEMS WITH HEAT RECOVERY (AIR COOLED SYSTEMS)

PART 1 GENERAL

1.1. RELATED DOCUMENTS

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

1.2. SUMMARY

A. This Section includes Variable Refrigerant Volume Split Systems with Heat Recovery.

B. Related Sections include the following:

1. Division 23 Section, “HVAC Piping, Fittings and Valves” for refrigerant piping materials.
2. Division 23 Section, “HVAC Insulation” for refrigerant pipe insulation requirements.
3. Division 23 Section, “Vibration Controls for HVAC, Plumbing, & Fire Protection Equipment” for isolation materials.
4. Division 23 Section, “Instrumentation & Controls of HVAC & Plumbing Systems” for temperature-control devices, and control wiring and control devices connected to indoor, outdoor and refrigerant distribution devices.
5. Division 26 Section, “Disconnect Switches & Circuit Breakers” and circuit breakers for field installed disconnect switches.

1.3. DEFINITIONS

A. *BICSI:* Building Industry Consulting Service International.

B. *EER*: Cooling full load energy efficiency ratio.

C. *IEER*: Cooling integrated (part load) energy efficiency ratio.

D. *High Temperature COP*: Heating coefficient of performance at 42°F.

E. *Low Temperature COP*: Heating coefficient of performance at 17°F.

F. *SCHE*: Simultaneous cooling and heating efficiency.

G. *VRV*: Variable Refrigerant Volume

1.4. SUBMITTALS

A. Product Data: Include manufacturer's technical data for each model indicated, including rated capacities of selected model clearly indicated; dimensions; required clearances; shipping, installed, and operating weights; furnished specialties; accessories; and installation and startup instructions.

B. Product data for Variable Refrigerant Volume units specified, including the following:

1. Dimension and plans and elevation drawings including field piping, required clearances and locations of all field connections.
2. Certified fan-sound power ratings.
3. Certified coil-performance rating with system operating conditions indicated.
4. Motor ratings and electrical characteristics plus motor and fan accessories.
5. Filters with performance characteristics.
6. Outdoor air cooled heat pump unit.
7. Summary of all auxiliary utility requirements such as electricity, refrigerant piping, and condensate piping. Summary shall indicate quality and quantity of each required utility.
8. Branch selector box data.
9. Refnet data.
10. ARHI 1230 certification including EER, IEER, high temperature COP, low temperature COP, and SCHE.
11. Equipment selections de-rated to reflect scheduled data.
12. VRV equipment certified installer's certificate.
13. Wiring material product data and wiring layout for all systems: power, VRV control, control systems, interface to BMS and associated VRV equipment.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Detail mounting, securing, and flashing of roof curb to roof structure for roof mounted units. Detail mounting and securing to concrete pads for grade mounted systems. Indicate coordinating requirements with roof membrane system or concrete pads and vibration isolation.

D. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

E. Field Test Reports: Indicate results of manufacturer's startup and testing requirements. Submit copies of checklists.

F. Maintenance Data: For equipment to include in the maintenance manuals specified in Division 01.

G. Warranties: Special warranties specified in this Section.

H. Install factory certified documents indicating approval to install the VRV equipment.

1.5. SYSTEM DESCRIPTION

A. Furnish and install where indicated, a variable capacity, heat recovery air conditioning system. System shall be a Variable Refrigerant Volume Series split system as manufactured by Daikin, Mitsubishi, Trane, Samsung, Johnson Controls, or approved equal. The system shall consist of multiple indoor units capable of cooling or heating, branch selector boxes, refrigerant joints to separate refrigerant flow between units and headers (refnets), a three pipe or two pipe refrigeration distribution system using PID control, and an outdoor unit. The

indoor units shall be connected to the outdoor units utilizing the specialized piping joints provided by the equipment manufacturer. The outdoor unit shall be direct expansion (DX), air-cooled heat recovery, multi-zone air-conditioning system with fixed speed and variable speed inverter driven compressors using R-410A refrigerant. The outdoor unit may connect to a connected indoor capacity up to 130% of the outdoor unit capacity. All zones are each capable of operating separately with individual temperature control. A dedicated hot gas pipe shall be provided to provide optimum heating operation performance.

B. Operation of the system shall permit either individual cooling or heating of each indoor unit simultaneously or all of the indoor units associated with one branch cool/heat selector box. Each indoor unit or group of indoor units shall be able to provide set temperature independently via a BMS interface. Provide all interlock wiring between system controllers and building automation system.

C. Branch cool/heat selector boxes shall be located as shown on the drawing. The branch selector boxes shall have the capacity to control cooling and heating downstream of the box to each individual heat pump unit. The box shall consist of electronic expansion valves, refrigerant control piping and electronics to facilitate communications between the branch selector box and main processor and between the branch selector box and indoor units. The branch selector box shall control the operational mode of the subordinate indoor units. The use of electronic expansion valves ensures continuous heating during defrost, no heating impact during changeover and reduced sound levels.

D. Manufacturer shall have five years prior experience making similar equipment as described in this specification.

1.6. QUALITY ASSURANCE

A. All equipment and systems shall be tested and certified in accordance with AHRI 1230 (Performance Rates of Variable Refrigerant Flow (VRF) Multi-Split Air Conditioning and Heat Pump Equipment) and bear the AHRI certification seal.

B. Fabricate and label refrigeration system to comply with ASHRAE 15, *Safety Code for Mechanical Refrigeration.*

C. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.
   1. The Terms *Listed and Labeled*: As defined in the National Electrical Code, Article 100.
   2. Listing and Labeling Agency Qualifications: A *Nationally Recognized Testing Laboratory* as defined in OSHA Regulation 1910.7.

D. Comply with NFPA 70 for components and installation.

E. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995 – Heating and Cooling Equipment and bear the Listed Mark.

F. The system shall be factory tested for safety and function.

G. Coordination: Coordinate layout and installation of indoor units, outdoor units, refrigerant piping, branch selector boxes, refnets, and other appurtenances with piping and ductwork and with other installations.

H. Contractor's certified VRV equipment installer must be on site during installation of VRV system, refrigeration piping, control wiring, system controls and interface to BMS, and associated VRV equipment.

I. Obtain all necessary permits for low voltage and power wiring for VRV system.

1.7. DELIVERY, STORAGE, AND HANDLING

A. Deliver outdoor and indoor units as factory assembled units with protective crating and covering.

B. Coordinate delivery of units in sufficient time to allow movement into building or on to roof as indicated.

1.8. WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

B. Special Warranty: A written warranty, executed by the manufacturer and signed by the Contractor, agreeing to replace components that fail in materials or workmanship, within the specified warranty period, provided manufacturer's written instructions for installation, operation, and maintenance have been followed.

1. Warranty Period: Compressors and Compressor Motor Contactors: Manufacturers standard, but not less than 6 years after date of Substantial Completion.

1.9. ALTERNATES

A. Refer to Division 01 Section, "Alternates" for description of work under this section affected by alternates.

PART 2. PRODUCTS

2.1. MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:

1. Daikin, Samsung, Sanyo, Johnson Controls, Mitsubishi, Trane, Samsung, Fujitsu, or approved equal.

B. Basis of Design was a Daikin 3-pipe system. All scheduled capacities and efficiencies must be met. Cost of any electrical, piping, design, insulation, additional branch selector boxes,

heat recovery boxes, refnets, or other changes associated with other approved manufacturers shall be included in the bid and shall be the responsibility of the Contractor. If manufacturer other than the Basis of Design is utilized and the same requires drains at branch selector boxes, Contractor must provide piping, insulation and if needed to condensate pumps at no additional cost to the Owner. This includes power requirements for condensate pumps.

2.2. OUTDOOR UNITS – AIR COOLED

A. The outdoor unit is designed specifically for use with variable refrigerant volume system components. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, refrigerant regulator and all components for a complete functioning system.

B. The outdoor unit shall be modular in design and should allow for side-by-side installation with minimum spacing.

C. The following safety devices shall be included on the outdoor unit; high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.

D. Unit Cabinet: The outdoor unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.

E. Fan: The unit shall have one or more propeller type, direct-drive fan motors that have multiple speed operation via a DC (digitally commutating) inverter. The condensing unit fan motor shall have multiple speed operation of the DC (digitally commutating) inverter type, and be of high external static pressure. A field setting switch to a maximum 0.32 in. WG pressure is available to accommodate field applied duct for indoor mounting of condensing units. The fan shall be a vertical discharge configuration and the motor shall have inherent protection and permanently lubricated bearings and be mounted.

F. Condenser Coil: The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance. The fins are to be covered with an anti-corrosion acrylic resin and hydrophilic film and pipe plates shall be treated with powdered polyester resin for corrosion prevention.

G. Compressor: Unit shall contain both fixed speed scroll and variable speed inverter scroll compressors. Inverter scroll compressors shall be variable speed (PAM inverter) controlled which shall be capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read and calculated. Each non-inverter compressor shall also be of the hermetically sealed scroll type. With each reading, the compressor capacity (INV frequency or STD ON/OFF) shall be controlled to eliminate deviation from target value.

Compressors shall be spring mounted to avoid the transmission of vibration.

H. Surge Protection: Provide unit with DIN Rail Plug-in Surge Protection for each compressor unit installed for all telecom and control circuits. Surge protection shall be factory or field installed per manufacturer's recommendations. Surge protectors shall be model DLA as manufactured by Citel or approved equal. Units shall be listed in accordance with UL497B.

2.3. BRANCH SELECTOR/HEAT RECOVERY BOX

A. Branch selector (BS)/heat recovery boxes shall be located as shown on the drawing. The BS/heat recovery box shall be furnished with at least 5 electronic expansion valves (EEV's), refrigerant control piping and electronics to facilitate communications between the BS/heat recovery box and main processor and between the BS/heat recovery box and indoor units. The BS box shall control the operational mode of the subordinate indoor units. The use of five EEV's shall control the direction of refrigerant flow and ensure continuous heating during defrost, no heating impact during changeover and reduced sound levels. The branch selector/heat recovery boxes shall be designed specifically for use with heat recovery system components. These selector/heat recovery boxes shall be factory assembled, wired, and piped and shall be run tested at the factory. Unit Cabinet shall have a galvanized steel plate casing. Each cabinet shall house a liquid gas separator and contain a tube in tube heat exchanger. The unit shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene. Each circuit shall have at least one branch selector/heat recovery box to facilitate simultaneous heating and cooling in the system. Multiple indoor units may be connected to a branch selector/heat recovery box provided they are within the capacity range of the branch selector. The unit electrical power shall be as scheduled on the Contract Drawings. East branch selector shall support up to four heat pump units, each served by dedicated refrigerant suction and liquid piping. Each heat pump unit shall be able to individually operate in heating or cooling mode.

2.4. INDOOR UNITS

A. Ceiling Cassette Indoor Unit - The unit shall be completely factory assembled and wired. The casing shall be galvanized sheet with grey heat insulation. This unit shall fit in the ceiling and have the capability of attaching a branch supply duct as well as a fresh air duct. The evaporator fan shall be an assembly with a high performance, fan direct driven by a single motor. The fans shall be statically and dynamically balanced and run on permanently lubricated bearings. The indoor unit shall have an adjustable air outlet system offering 4-way air flow, 3-way air flow, or 2-way air flow. The auto air swing vanes shall automatically swing up and down for uniform air distribution. Return air shall be filtered by a long-life filter to provide approximately, 2500 hours of use in a normal office environment before cleaning. The indoor unit shall be covered with a flat panel which protrudes only 1 inch below the ceiling to provide a neat and clean installation. The coils shall be of nonferrous construction with smooth plate fins bonded to copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tubes joints shall be brazed with phoscopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan shall extend under the coil and piping. An integral drain pan pump capable of lifting condensate 22 inches shall be provided. An integral booster heater shall not be provided to supplement the unit during the heating mode. The unit electrical power requirements shall be as scheduled on the contract drawings. Furnish with condensate overflow float switch that will shut down unit should a high condensate level condition be sensed.

B. Vertical Floor Mounted Unit - The indoor unit shall be a built-in floor mounted fan coil unit, low static pressure (LSP), for installation onto a housekeeping pad. The unit shall be constructed of a galvanized steel casing and shall be manufactured for a vertical discharge air with bottom return air configuration (as scheduled or shown on the drawings). The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have a booster cable for adjustable static pressure capability. The indoor units shall be equipped with a condensate pan. The indoor units shall be equipped with a return air thermistor. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation. The fan shall be direct-drive Sirocco type fan, statically and dynamically balanced impeller with high, medium and low fan speeds and the fan motor shall be thermally protected. The return air shall be filtered by means of a washable long-life filter with mildew proof resin. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminium fins to form a mechanical bond. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance. The coil shall be a 3 row cross fin copper evaporator coil with 14 FPI design completely factory tested. A thermistor shall be located on the liquid and gas line. Furnish with condensate overflow float switch that will shut down unit should a high condensate level condition be sensed.

C. Ceiling Concealed Ducted Unit - The indoor unit shall be a built-in ceiling concealed fan coil unit, low static pressure (LSP), for installation into the ceiling cavity. The unit shall be constructed of a galvanized steel casing and shall be manufactured for a horizontal discharge air with horizontal return air or bottom return air configuration (as scheduled or shown on the drawings). The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have a booster cable for adjustable static pressure capability. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump shall provide up to 18” of lift from drain connection. The indoor units shall be equipped with a return air thermistor. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation. The fan shall be direct-drive Sirocco type fan, statically and dynamically balanced impeller with high, medium and low fan speeds and the fan motor shall be thermally protected. The return air shall be filtered by means of a washable long-life filter with mildew proof resin. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance. The coil shall be a 3 row cross fin copper evaporator coil with 14 FPI design completely factory tested. A thermistor shall be located on the liquid and gas line. Install sheet metal auxiliary drain pans with overflow switches for all ducted units. Furnish with condensate overflow float switch that will shut down unit should a high condensate level condition be sensed.

2.5. CONTROL SYSTEM

A. The control system shall consist of multiple microprocessors interconnected by a single non-

polar two wire multiplex transmission system. Wiring shall be daisy chained from unit to unit direct. NO SPLICES. One microprocessor shall be factory wired and located within each indoor unit. It shall have the capability of sensing return air temperature and indoor coil temperature; receive and process commands from the remote controller. The microprocessor within the wall mounted remote controller shall provide automatic cooling and heating system changeover; display set point and room temperature; a 24 hour on/off timer so that automatic operation can be set on the timer at one hour intervals from one to twenty-four hours; have self-diagnostic function display; check mode for memory of most recent problem; and provide on-off and system/mode function switching. The heating system shall be controlled so that only warm air is discharged whenever the fan speed exceeds the very low (VLO) speed. Normal operation of the remote controller provides individual system control in which one remote controller and one indoor unit are installed in the same room. The control voltage between the indoor units and the outdoor unit shall be 16 volts D.C. 16 VDC shall be generated from the outdoor unit microprocessor board. The system shall be capable of automatic restart when power is restored after power interruption. System shall include twenty function self diagnostics including total hours of compressor run time. Compressor capacity shall be modulated automatically to maintain a constant suction pressure, while varying the refrigerant volume for the needs of the cooling or heating loads. Indoor units shall use PID control to control superheat.

B. System Controller: Control system shall include a central controller for user interface with system. Controller shall include a Liquid Crystal Display (LCD) touch screen capable of controlling up to 16 outdoor units and 64 indoor unit groups (maximum 128 indoor units).

C. System Controller shall be able to control the following functions:

1. On/Off selection for each indoor unit group or zone that is defined with several indoor unit groups.
2. Setpoint adjustment for each indoor unit group or zone.
3. Fan speed adjustment for each indoor unit group or zone.
4. Heat/cool/fan mode selection for each indoor unit group or zone.
5. Automatic changeover and antifreeze/overheat protection.
6. Forced shutdown terminals.
7. Priority settings for restriction of local access for start/stop, heat/cool mode and setpoint adjustment (at local remote controllers).
8. Setpoint limitation in both heating and cooling mode.
9. Weekly schedule with start-up and shut off times, temperature settings, and operation modes; 16 operations/each day can be set in one schedule, and 8 different schedules are available for special working days, holidays, or period of non-use.
10. Actual time display and setting.
11. Reset ability for malfunction codes and filter maintenance warning.
12. Maximum 13 months back up power supply to maintain the memory.
13. Non systems units (e.g. energy recovery ventilator) can be started/stopped and general alarm/status reported using Digital Input or Digital Input/Output units, including interlock program.
14. Controller must be BACnet compatible.

D. Controller shall provide control transformer for 24 VAC supply voltage for controllers as required.

E. Provide interface devices as required to interface to Building Automation System. ATC Interface shall allow monitoring of all points indicated on the point list.

F. Furnish the controls with the necessary interfaces to communicate via BACnet/IP or LonWorks to a building automation system. Exact protocol to be determined by the ATC subcontractor and VRV installing contractor.

G. All inputs and outputs on the manufacturer's controller shall be viewable via the interface.

H. All set points and schedules shall be editable via the interface by the building automation system.

I. In addition to standard inputs/outputs provide additional input/outputs as required to accomplish sequence of operation and items listed on point list.

J. The manufacturer shall be responsible for assisting and participating in the integration of the equipment into the building automation system and shall provide programming support, testing, verification, and on site personnel as required.

K. Report all system alarms including but not limited to low refrigerant, compressor follow-up, low pressure and high pressure alarms to ATC system.

2.6. WIRING

A. All wiring devices and wire/cable shall be approved for the proposed purpose.
   1. Communication cable shall be indicated for use in the data sheet
      a). Bacnet
      b). Lon
      c). RS-232
      d). RS-485 for VRV Loop wiring
   2. All wire/cable shall be installed per VRV and wire/cable manufacturers' data sheets.
   3. All wiring devices and wire/cable shall be labeled by UL or approved listing agency.

B. All installation contractors must have one person on site with five years experience in the trade during the complete installation process.

C. All wiring shall be installed per National Electric Code, BICSI and all other codes.

D. All wiring shall be installed in a neat, best and most workmanlike manner using the proper hangers and the protection of wiring in the installed method used.

E. Installing contractor musts supply an electrical permit for record purposes before work begins.

F. Equipment supplier equipment shall not be installed as a single point of failure by the control contractor.

G. Equipment manufacturer shall supply control contractor with a pre-wired and tested control

NEMA 1 enclosure with gateway, power supply and terminal strips. A complete set of wiring diagrams for the interface must be submitted and included in the O&M manuals.

H. Control panel power shall have a separate 120 volt single phase circuit with no other load on the circuit.

2.7. VRF/VRV SYSTEMS BACNET GATEWAY

A. The VRF/VRV Systems BACnet™ Gateway shall be capable of monitoring up to 256 indoor units and 64 outdoor units through its embedded web browser. The BACnet Gateway shall be capable of controlling 92 indoor units and 8 outdoor units through its embedded web browser with third-party Building Automation Systems interface. The BACnet Gateway provides multiple energy management schemes and integrates with third-party Building Automation Systems.

2.8. FILTERS

A. In addition to the washable filters provided with each indoor unit, provide two (2) sets of spare additional washable filters for every indoor unit on the project. Provide correspondence documenting filters have been turned over to Owner at Substantial Completion.

PART 3. EXECUTION

3.1. EXAMINATION

A. Examine space for compliance with requirements for conditions affecting installation and performance of units. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2. INSTALLATION

A. Mount indoor and outdoor units as detailed on contract drawings and according to manufacturer's written instructions.

B. Install all interlock and control wiring between indoor units, outdoor units thermostats, and condensate pumps.

C. Supply initial charge of refrigerant and oil as required.

D. Install indoor ceiling cassettes and ducted units on vibration isolators.

E. Install outdoor units on concrete pads or on roof curbs as indicated on drawings.

F. Comb out fins on condensing unit where deformed or bent. Replace or repair broken fins.

G. Install condensate lift pumps, float switches, alarm, unit shut down wiring and detection block units per manufacturer's recommendations.

H. For wall mounted units field wire power wiring, alarm circuits, control cable, safety circuit

connection, alarm, and condensate pump. Condensate pump shall be powered from indoor unit power wiring. Coordinate condensate pump electrical characteristics with indoor unit electrical characteristics.

I. Install system controller and interlock all indoor and outdoor units.

J. Install lockable caps on all outdoor unit refrigerant service valves to prevent tampering.

K. All final pipe lengths shall be submitted to VRV manufacturer to verify compliance with manufacturer's requirements.

L. Install all refrigerant piping per manufacturer's requirements without deviation.

M. Label and identify all indoor units, outdoor units, piping, and branch selector boxes.

N. Install refnets and Y-fittings with manufacturers' required unobstructed distances upstream and downstream of the same.

O. Submit pressure test reports and vacuum test reports as informational submittals.

P. Install all branch selector boxes with manufacturer's required clearances. Also branch selector boxes shall be installed level per manufacturer's requirements.

3.3. CONNECTIONS

A. Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements:

1. High/low pressure gas line, liquid and suction lines must be individually insulated between the outdoor and indoor units.
2. Refrigerant Piping: conform to applicable requirements of Division 23 Section, *HVAC Piping, Fittings, and Valves*.
3. Install refrigerant piping, refnets, Branch selector boxes, insulation, and control wiring as required by the manufacturer.
4. Install isolation valves on all three pipes between outdoor unit and branch selector boxes.
5. Install isolation valves on both pipes at every indoor unit.

B. Electrical: Conform to applicable requirements in Division 26 Sections.

C. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4. COMMISSIONING AND MANUFACTURER'S FIELD SERVICES

A. Verify that installation is as indicated and specified. Provide factory authorized start-up and training.

B. Complete manufacturer's installation and startup checks and perform the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to compressor, air-cooled condenser coil, and fans.
3. Verify that clearances have been provided for servicing.
4. Check that labels are clearly visible.
5. Clean condenser and inspect for construction debris.
6. Verify wiring is installed per VRF installation manual requirements
   a). Grounds
   b). Shielding
   c). Prior to applying power perform and document end to end continuity test for each wire in the communication cable.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Adjust vibration isolators.
10. Verify all piping and branch selector boxes are insulated.

C. Start unit according to manufacturer's written instructions.

1. Complete startup sheets and attach copy with Contractor's startup report.
2. Start-up units in close coordination with testing/balancing.

D. Check and record performance of interlocks and protection devices; verify sequences.

E. Operate unit for an initial period as recommended or required by manufacturer.

F. Calibrate thermostats and humidity sensors.

G. Check internal isolators.

H. Start refrigeration and measure and record the following:

1. Coil leaving-air, dry- and wet-bulb temperatures.
2. Coil entering-air, dry- and wet-bulb temperatures.
3. Refrigerant suction/discharge pressures.
4. Indoor and outdoor unit amperage, voltage, and watts.
5. Fan Rotation and RPM.
6. Condensate pump operation.
7. Condensate overflow safety switch operation.
8. System controller operation.

3.5. VRF INSTALLATION SUPPORT

A. The authorized manufacturer’s representative shall include installation support for the project as specified in this section by means of a dedicated technical VRF support specialist.

B. This project support shall be completed by an employee whose sole responsibility is to provide direct technical support for the VRF system. Sales staff or other roles are not permitted to provide these duties.

C. The VRF support specialist must be available for a kick off meeting prior to work being started. This meeting should include the installing contractor, engineer, controls contractor, owner (or owner's representative) and general contractor.

D. This meeting shall cover the following items:

1. Review installation best practices for the VRF manufacturer.
2. Review mechanical drawings and VRF system layout.
3. Provide contact information for support during the project.
4. Review integration requirements and mapping of points with ATC sub-contractor.

E. Project support by the manufacturer's representative during the project shall include the following:

1. Provide periodic onsite technical support for the installation contractor during the project.
2. Review as-built information provided by the Mechanical Contractor.
3. Provide documented reports and recommendations to the installing contractor.

F. The manufacturer's representative shall monitor progress of the installing contractor and support set up of the VRF system prior to system start-up.

G. The mechanical contractor shall provide all functions of the installation of the VRF system but not limited to the following:

1. Piping per manufacturer's recommendations within the design software guidelines furnished by the manufacturer's representative.
2. Wiring per the manufacturer's recommendations.
3. Brazing with nitrogen per manufacturer's recommendations.
4. Pressure testing to 550 psi pressure test for 24 hours. This must be documented and verified by the VRF support specialist from the manufacturer's representative.
5. Evacuation of the system to 500 microns. This must be documented and verified by the VRF support specialist from the manufacturer's representative.
6. Providing as-built piping information throughout the project must be documented and verified by the VRF support specialist from the manufacturer's representative. This is necessary to provide accurate refrigerant charge to be added by the installing contractor.
7. Proper set up of the VRF system addressing.

H. Start-up assistance for the installing contractor shall be provided by the VRF manufacturer's representative with the following guidelines:

1. The manufacturer's representative shall assist with starting the system and verifying that all VRF equipment is communicating properly and operating within the pressure and temperature guidelines of the VRF manufacturer.
2. The manufacturer's representative must compile 1 hour of operational runtime data per system during this start-up.
3. The manufacturer's representative will not be responsible for troubleshooting wiring, installation of any components, evacuation or pressure testing of the

systems.

3.6. DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Review data in the maintenance manuals. Refer to Division 01 Section, *Contract Closeout*.
2. Review data in the maintenance manuals. Refer to Division 01 Section, *Operation and Maintenance Data.*
3. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

3.7. TRAINING

A. The Variable Refrigerant Volume Split System manufacturer shall include in his bid, provisions for additional training at the company's regular school or training center. The VRV manufacturer shall include in his bid all costs associated with sending two (2) individuals to the VRV manufacturer's school for a period of not less than one (1) week. This training is in addition to the aforementioned training required under the General Provisions.

B. The training time period shall be coordinated with the school system's facility Engineer. The schedule training period shall be arranged at the owner's convenience.

C. Cost shall include all training material, instruction books, and two copies of video tape with sound DVD of training session.

D. Upon completion of the work, the Contractor shall have completely adjusted the entire control system. He shall arrange to instruct the Owner's representative on the operation of the VRV split system for a period of not less than four (4) four (4) hour days. All training shall be by the VRV split system manufacturer and shall utilize specified manuals and as-built documentation.

E. 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. Include a minimum of 40 hours' dedicated instructor time on-site.
3. Review data in maintenance manuals. Refer to Division 01 Section, *Contract Closeout.*
4. Review data in maintenance manuals. Refer to Division 01 Section, *Operation and Maintenance Data*.
5. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION

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SECTION 260500 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Sleeve seals.
4. Grout.
5. Common electrical installation requirements.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

1.5 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 26 Section "Electrical Firestopping."

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).

b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:

a. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Metraflex Co.

d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

3. Pressure Plates: Carbon steel. Include two for each sealing element.

4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Through-Penetration Firestop Systems."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 26 Section "Electrical Firestopping."

END OF SECTION

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3.18 CUTTING AND PATCHING
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SECTION 260501 – GENERAL ELECTRICAL REQUIREMENTS

PART 1. GENERAL

1.1 GENERAL

A. Provide all labor, materials, equipment and services necessary for and incidental to the complete installation and operation of all electrical work.

B. All work under this Division is subject to the General Conditions and Special Requirements for the entire contract.

C. Unless otherwise specified, all shop drawings and submissions required under Division 26 shall be made to, and acceptances and approvals made by, the ENGINEER.

D. Conform to the requirements of all rules, regulations, and codes of local, state, and federal authorities having jurisdiction. Conform to the National Electrical Code and all NECA – National Electrical Installation Standards (NEIS).

E. Perform the work in a first-class, substantial, and workmanlike manner. Any materials installed which do not present an orderly and neat workmanlike appearance shall be removed and replaced when so directed by the Engineer, at the Contractor's expense.

F. Coordinate the work of all trades.

G. Arrange conduit, wiring, equipment, and other work generally as shown, providing proper clearances and access. Carefully examine all contract drawings and fit the work in each location without substantial alteration. Where departures are proposed because of field conditions or other causes, prepare and submit detailed drawings for approval in accordance with “Submittals” specified below. The right is reserved to make reasonable changes in location of equipment, conduit, and wiring up to the time of rough-in or fabrication.

H. The contract drawings are generally diagrammatic and all offsets, bends, fittings, and accessories are not necessarily shown. Provide all such items as may be required to fit the work to the conditions.

I. Be responsible for all construction means, methods, techniques, procedures, and phasing sequences used in the work. Furnish all tools, equipment and materials necessary to properly perform the work in a first class, substantial, and workmanlike manner, in accordance with the full intent and meaning of the Contract Documents.

J. The Contractor shall provide other work and services not otherwise included in the Contract Documents that are customarily forwarded in accordance with generally-accepted construction practices.

1.2 PERMITS, INSPECTIONS, AND FEES

A. The Contractor shall obtain and pay for all charges and fees, and deliver all permits, licenses, certificates of inspection, etc., required by the authorities having jurisdiction.

Deliver inspection, approval, and other certificates to the Owner prior to final acceptance of the work.

B. File necessary plans, prepare documents, give proper notices, and obtain necessary approvals.

C. Permits and fees shall comply with the General Requirements of the Specification.

D. Notify Inspection Authorities to schedule inspections of work. All work shall be subject to field inspections.

E. Notify Engineer in advance of scheduled inspections.

F. An electrical foreman, superintendent or other supervisor shall be in attendance for all scheduled inspections.

G. The Contractor shall provide an electrical certificate from an independent electrical inspection agency approved by the Owner and the State of Delaware Fire Marshal. The Contractor shall submit certificate prior to final payment invoice. The Contractor shall pay all fees, including filing fees.

1.3 ELECTRICAL WORK UNDER OTHER DIVISIONS

A. Mechanical Equipment and Systems:

1. In general, power wiring and motor starting equipment for mechanical equipment and systems are furnished and installed under Electrical Division 26.

2. Certain mechanical units contain starters, contacts, transformers, fuses, wiring, etc., required for fans, pumps, etc., furnished with the equipment from the factory. When this equipment is supplied from the factory, the Contractor must supply power circuit(s) to the unit and a disconnecting means. Coordinate with Contractor so that one, and only one, set of starters, fuses, switches, etc., is provided and installed.

3. In general, control and interlock equipment for HVAC systems (including associated wiring, conduit, transformers, relays, contacts, etc.) is furnished under Mechanical Divisions. Contractor shall install and connect all such equipment as necessary.

4. Controls, wiring, conduit, transformers, etc., for smoke, fire, and motor-operated dampers are provided by Mechanical. Electrical shall install and connect all such equipment.

B. Architectural Equipment: In general, any electrically operated or controlled equipment furnished under architectural divisions shall be supplied with control wiring, transformers, contacts, etc. Contractor shall provide power circuits to such equipment and install all electrical control equipment related thereto.

C. Carefully review the contract documents and coordinate the electrical work under the various Divisions.

1.4 CONTRACTOR QUALIFICATIONS

A. Any Any Contractor performing work under this Division shall be fully qualified and acceptable to the Engineer. Submit the following evidence for approval:

1. A list of not less than five (5) comparable projects that the Contractor completed.

2. Letters of reference from not less than three (3) registered professional engineers, contractors, or building owners, explaining Contractor proficiency, quality of work, or other attribute on projects of similar size or substance.

3. Local or State license.

4. Membership in trade or professional organization where required;

5. Copy of Master Electrician's License.

B. Contractor is any individual, partnership, corporation, or firm performing work by Contract or subcontract on this project.

C. Acceptance of a subcontractor will not relieve the Contractor of any contractual requirements or his responsibility to supervise and coordinate the various trades.

D. Supervisory Qualifications: The electrical work on the project shall be under the direct supervision of a licensed Master Electrician.

E. Qualifications of Installers:

1. For the actual fabrication, installation, and testing of the work, the Contractor shall use only thoroughly trained and experienced personnel who are completely familiar with the requirements of this work and with the installation recommendations of the manufacturers of the specified items.

2. The Electrical Installer shall utilize a full time project foreman in charge of all electrical work. This person shall be fully qualified and experienced in such work and shall be available, on site, at all times during Construction. All problems, questions, coordination, etc., relating to electrical work shall take place through this person to the Architect.

1.5 FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials and equipment shall conform to UL, NFPA, or ASTM Standards for Fire Safety with Smoke and Fire Hazard Rating not exceeding flame spread of 25 and smoke developed of 50.

1.6 REFERENCED STANDARDS, CODES, ORDINANCES AND SPECIFICATIONS

A. Specifications, Codes and Standards listed below are included as part of this specification, latest edition.

ADA	Americans with Disabilities Act
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
IBC	International Building Code
CABO	Council of American Building Officials
FM	Factory Mutual
IEEE	Institute of Electrical and Electronics Engineers
NEC	National Electrical Code
NECA	National Electrical Contractors Association
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety & Health Administration
UL	Underwriters Laboratories
	Applicable State and Local Codes

B. All electrical equipment and materials shall comply with the Codes and Standards listed in the latest edition of IEEE Standard 241, *Electric Power Systems in Commercial Buildings*, Chapter 1, Section 1.6, entitled "Codes and Standards".

C. Comply with all Codes applicable to the work:

1. Bidders shall inform themselves of all local and state codes and regulations.

2. In case of conflict between Contract Documents and governing Codes, the most stringent shall take precedence. Where, in any specific case, different sections of any applicable codes or when Drawings and Specifications specify different

materials, methods of Construction, or other requirements, the most restrictive shall govern.

3. Where Contract Documents exceed minimum Code requirements, and are permitted under the Code, the Contract Documents take precedence and shall govern.

4. No extra payment will be allowed for work or changes required by local Code enforcement authorities.

D. Underwriters Laboratories Labels shall apply to all materials and devices, etc., except specified items not covered by existing UL Standards.

E. Conflicts with applicable regulations:

1. Resolve at Contractor's expense.

2. Prepare and submit details of alternate construction:

a. Acceptable solution of conflict.

b. List of substitute materials;

For approval of inspecting authorities.

For approval of Engineer.

F. Comply with all NECA's National Electrical Installation Standards (NEIS), including NECA 1-2000 "Standard Practices for Good Workmanship in Electrical Contracting".

1.7 INTERPRETATION OF DOCUMENTS

A. Any discrepancies between Drawings, Specifications, Drawings and Specifications, or within Drawing and Specifications shall be promptly brought to the attention of the Owner during the bidding period. No allowance shall subsequently be made to the Contractor by reason of his failure to have brought said discrepancies to the attention of the Owner during the bidding period or of any error on the Contractor's part.

B. The locations of products shown on Drawings are approximate. The Contractor shall place the devices to eliminate all interference with above-ceiling ducts, piping, etc. Where any doubt exists, the exact location shall be determined by the Owner.

C. All general trades and existing conditions shall be checked before installing any outlets, power wiring, etc.

D. Equipment sizes shown on the Drawings are estimated. Before installing any wire or conduit, the Contractor shall obtain the exact equipment requirements and install wire, conduit, or other item of the correct size for the equipment actually installed. However, wire and conduit sizes shown on the Drawings shall be taken as a minimum and shall not be reduced without written approval from the Owner.

E. Where variances occur between the drawings and specifications or within either document itself, the item or arrangement of better quality, greater quality, or higher cost shall be included in the Contract Price. The Engineer will decide on the item and manner in which the work shall be installed.

F. Contract Drawings are generally diagrammatic and all offsets, fittings, transitions, and accessories are not necessarily shown. Furnish and install all such items as may be required to fit the work to the conditions encountered. Arrange conduits, equipment, and other work generally as shown on the Contract Drawings, providing proper clearance and access. Where departures are proposed because of field conditions or other causes, prepare and submit detailed Shop Drawings for approval in accordance with "submittals" specified below. The right is reserved to make reasonable changes in location of equipment, piping, and ductwork, up to the time of rough-in or fabrication.

G. Work not specifically outlined, but reasonably incidental to the completion of the work, shall be included without additional compensation from the Owner.

PART 2. PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Material and equipment installed as a part of the permanent installation shall be new, unless otherwise indicated or specified, and shall be approved by the Underwriters' Laboratories, Inc., for installation in each particular case where standards have been established.

B. Where material or equipment is identified by proprietary name, model number, and/or manufacturer, furnish the named item or equivalent thereof, subject to acceptance.

C. Material submissions shall conform to requirements outlined in SUBMITTALS, REVIEW, AND ACCEPTANCE.

D. The suitability of named item only has been verified. Where more than one Manufacturer is named, only the first named Manufacturer has been verified as suitable. Manufacturers and items other than the first named shall be equal or better in quality and performance to that of specified items, and must be suitable for available space, required arrangement, and application. The Contractor, by providing other than the first named Manufacturer, assumes responsibility for all necessary adjustments and modifications necessary for a satisfactory installation.

E. The Contractor shall only submit those manufacturers indicated in the Specification. Proposed alternate manufacturers will not be considered unless the specific item indicates "or as approved equal". Submit all data necessary to determine suitability of substituted items for approval.

F. All items of equipment furnished shall have a service record of at least five (5) years.

2.2 SUBSTITUTIONS

A. Substituted items or items other than those named shall be equal or better in quality and performance and must be suitable for the available space, required arrangement, and application. Submit any and all data necessary to determine the suitability of substituted items. The Contractor shall be responsible for correct application, placement, and installation of substituted equipment. Cost savings data shall also be submitted with submittal data for substituted items. Total cost savings or a per-unit saving to the Owner shall be clearly indicated. If a substituted item is accepted, all cost savings shall be returned to the Owner as a credit.

B. Substitutions will not be permitted for specific items of material or equipment where specifically indicated.

C. For substituted items, clearly list on the first page of the submittal all differences between the specified item and the proposed item. The Contractor shall be responsible for corrective action (or replacement with the specified item) while maintaining the specification requirements if differences have not been clearly indicated in the submittal.

D. Where the Contractor proposes to use an item of equipment or application other than that specified or detailed on the Drawings, which requires any redesign of the structure, partitions, foundation, HVAC, piping, wiring, or any other part of the mechanical, electrical, or architectural layout, all such redesign and all new drawings and detailing required thereafter shall be prepared by the Contractor at his own expense for review by the Owner representative before any such work is implemented.

E. All Contractor-proposed changes and revisions shall be at the Contractor's risk and expense. The Contractor shall fully coordinate all revisions, substitutions and changes with other trades. The Contractor shall provide all necessary provisions, including HVAC, ventilation, foundations, access, etc., for a complete, code compliant, and fully functional installation.

F. Where the Contractor elects to submit a substitution for equipment or materials, he shall:

1. Submit Shop Drawings that show complete compliance to each statement or requirement of the Specifications.

2. Submit certified test data from an independent testing laboratory for each product.

3. Submit one complete working sample of the equipment or materials to be furnished. In cases involving large or heavy items of equipment, the Owner may waive the requirement to submit the sample.

G. Failure to comply with the above-required submissions shall constitute an automatic rejection of the substitution.

2.3 SUBMITTALS, REVIEW, AND ACCEPTANCE

A. General:

1. The equipment, material, installation, workmanship, arrangement of work, final instruction, and final documentation is subject to review and acceptance. No substitution will be permitted after acceptance of equipment or materials except where such substitution is considered by the Engineer to be in the best interest of the Owner. Submit for review in clear and legible form the following documents:
   a. Material and Equipment List
   b. Descriptive Data
   c. Shop Drawings
   d. Installation and Coordination Drawings
   e. Contractor As-Built Drawings
   f. Owner Instructions and Manuals
   g. Construction Phasing and Outage Schedule
2. Prepare all submittals specifically for this project and stamp each submittal in a form indicating that the documents have been Contractor reviewed, are complete, and are in compliance with the requirements of the plans and specifications. Each submittal item shall be clearly identified and numbered. Each submittal shall contain a complete schedule of Manufacturer's part numbers and quantity listings of all supplied components. Each proposed item shall be highlighted and tagged with a star, an arrow, etc., including all options and accessories.
3. Coordinate the installation requirements and any mechanical requirements for the equipment submitted. Submittals will be reviewed for general compliance with design concept in accordance with the contract documents. The Contractor is responsible for the correctness of all submittals. Reviews will not verify dimensions, quantities, or other details.
4. Identify all submittals, indicating the intended application, location, or service of the submitted item. Refer to specification sections or paragraphs where applicable. Clearly indicate the exact type, model number, size, and special features of the proposed item. Clearly list on the first page of the Submittal all differences between the specified item and the proposed item. The Contractor shall be responsible for corrective action (or replacement with the specified item) while maintaining the specification requirements, if differences have not been clearly indicated in the submittal. Submittals of a general nature will not be acceptable.
5. Submit actual operating conditions or characteristics for all equipment where required capacities are indicated. Factory order forms showing only required capacities will not be acceptable. Indicate all options used to meet the specifications. It is not the responsibility of the Engineer or Owner to make selections of factory options other than colors. Submittals lacking proper selection of factory options or special features required by the specification shall be RETURNED WITHOUT REVIEW.
6. Acceptance will not constitute waiver of contract requirements unless deviations are specifically indicated and clearly noted.
7. Documents of general form indicating options shall be clearly marked to show what is specifically proposed for this project.
8. Submittals NOT IN COMPLIANCE with the requirements of this section will be RETURNED WITHOUT REVIEW.

B. Material, Equipment, Manufacturer and Subcontractor List: Within 30 calendar days after the award of contract, submit a complete MATERIAL, EQUIPMENT, MANUFACTURER AND SUBCONTRACTOR LIST for preliminary review. List all proposed materials and equipment, the associated proposed Manufacturer, and any proposed subcontractors. After the receipt of reviewed Material and Equipment List, submit complete Shop Drawings for approval. List all materials and equipment, indicating manufacturer, type, class, model, curves, and other general identifying information. Submittals shall be specific for each building as contained in the individual building Specifications and Drawings.

C. Upon approval of the List of Materials, the Contractor shall prepare a complete Master Submittal Register, listing all products and materials that will be submitted for approval. Items shall be listed by referenced specification paragraph in ascending order. This master list shall be included with each submittal, updated to reflect the status of approval for each item, and shall highlight the items pertaining to the submittal. A suggested Submittal Register Format is shown below:

SUBMITTAL REGISTER					
Item/Material	Ref'd Spec. Paragraph	Specified or Substitute	Submittal Date	Status	Remarks

D. No Drawing Submittals will be considered for approval until the complete List of Subcontractors and the complete List of Materials/Manufacturers and Equipment have been approved.

E. Descriptive Data: After acceptance of the MATERIAL and EQUIPMENT LIST, submit additional DESCRIPTIVE DATA for all items. Data shall consist of specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, installation instructions, and any other information necessary to indicate complete compliance with the contract documents. Where several ratings or sizes are shown or available, clearly indicate the exact size or rating relating to the particular device being proposed.

F. Submit complete descriptive data for all items. Data shall consist of Specifications, data sheets, samples, capacity ratings, performance curves, operating characteristics, catalog cuts, dimensional drawings, wiring diagrams, specific electrical/wiring requirements and connections including control and interlock wiring, installation instructions, and any other information necessary to indicate complete compliance with the Contract Documents. Edit submittal data specifically for application to this project.

G. Shop Drawings shall be submitted and approved for all materials and equipment prior to installation. If any material and/or equipment is installed prior to receipt by the Contractor of approved Shop Drawings, the Contractor is liable for its replacement at no additional cost to the Owner.

H. Data submitted shall include information on all materials and equipment to demonstrate compliance with the Contract Drawings and Specifications. Where installation procedures or any part thereof are required to be in accordance with manufacturer's recommendations, furnish printed copies of the recommendations prior to installation. Installation of the item shall not proceed until recommendations are received. Failure to furnish recommendations shall be cause for rejection of the equipment or material.

I. Any deviation of submitted material or equipment from the Contract Drawings or Specifications shall be clearly marked in red ink on Submittals, and itemized in a transmittal letter, in order to receive consideration for approval.

J. Approval of material or equipment submittals containing deviations not specifically identified by Contractor shall not relieve the Contractor from compliance with specified requirements.

K. All major items of mechanical equipment shall be the latest standard catalog products of reputable manufacturers. Where two (2) or more items of the same kind of equipment are required, they shall be the products of a single manufacturer.

L. Thoroughly review and stamp all submittals to indicate compliance with Contract requirements prior to submission. Coordinate installation requirements and any electrical requirements for equipment submitted. Contractor shall be responsible for correctness of all submittals.

M. Submittals will be reviewed for general compliance with design concept in accordance with Contract Documents, but dimensions, quantities, or other details will not be verified.

N. Increase, by the quantity listed below, the number of electrical related Shop Drawings, product data, and samples submitted, to allow for required distribution plus two copies of each submittal required, which will be retained by the Electrical Consulting Engineer.

1. Shop Drawings - Initial Submittal: 1 additional blue- or black-line print.

2. Shop Drawings - Final Submittal: 1 additional blue- or black-line print.

3. Product Data: 1 additional copy of each item.

O. Additional copies may be required by individual sections of these Specifications.

P. Shop Drawings:

1. Prepare and submit SHOP DRAWINGS AND/OR DIAGRAMS for all specially fabricated items, modifications to standard items, specially designed systems

where detailed design is not shown on the contract drawings, or where the proposed installation differs from that shown on the contract drawings.

2. Shop drawings shall include plans, elevations, sections, mounting details of component parts, point to point interconnection diagrams, elementary diagrams, single line diagrams, and any other drawings necessary to show the fabrication and connection of the complete item or system.

3. Shop drawings shall be provided for, but not limited to the following items:
   Basic Electrical Materials
   Cable - 600 volt
   Circuit Breakers
   Conduit and Surface Raceway
   Contractor and Subcontractor Qualifications
   Controllers & Control Devices
   Electrical Connection Coordination Schedule
   Equipment Connections
   Equipment Pads
   Excavation and Backfill
   Fire Alarm System
   Firestopping
   Fuses
   Ground Conductors, Rods
   Identification System
   Material and Equipment List
   Motor Starters
   Outlet Boxes
   Panelboards
   Receptacles
   Record and Information Booklet
   Safety Switches
   Schedule of Values
   Sleeves, Hangers, Supports
   Submittal Schedule
   Tests and Reports
   Wiring Devices
   Wiring Diagrams

Q. The Contractor, additionally, shall submit for approval any other shop drawings as required by the Engineer. No item listed above shall be delivered to the site, or installed, until approved. After the proposed materials have been approved, no substitution will be permitted except where approved by the Engineer.

R. The Contractor shall prepare and submit a Detail Schedule of Values indicating the Contract costs for the major work items. The Contractor shall provide additional detail and information as requested by the Engineer.

S. The Contractor shall prepare and submit a complete Submittal Schedule. The Schedule shall include a listing of all Submittals, Shop Drawings, and Coordination Drawings.

2.4 COORDINATION DRAWINGS

A. Prepare, submit, and use composite installation and coordination drawings to assure proper coordination and installation of the work. Drawings shall include, but not be limited to the following:

1. Telecommunication Rooms indicating data rack assemblies, panels, etc.

2. Electrical Rooms indicating switchboard assemblies, transformers, equipment pads, panels, etc.

3. Mechanical Equipment Rooms, including panels, transformers, starters, equipment, etc.

B. Draws plans to a scale not less than 1/4-inch equals one foot. Include plans of the proposed work, showing all equipment, major elements, conduit, and wiring in the areas involved. Fully dimension all work, horizontally and vertically. Show coordination with other work including piping, ductwork and other mechanical work, walls, doors, ceilings, columns, beams, joists, and other architectural and structural work.

C. Identify all equipment and devices on wiring diagrams. Where field connections are shown to factory-wired terminals, furnish manufacturer's literature showing internal wiring.

D. Prepare, submit, and use scaled layout drawings indicating dimensions, clearances, and actual equipment dimensions. Layout drawing shall include, but not be limited to the following:

1. Pad-mounted equipment and equipment connections.

2. Underground conduits, ductbanks, manholes, handholes, and building penetrations

2.5 RECORD DRAWINGS

A. As the work progresses, record on a set of white prints the installed locations, sizes of electric feeders, equipment, etc. Upon completion of the work, submit one (1) complete set of white prints with "As-Built" information neatly recorded thereon in red ink. Use other colors to distinguish between variations in separate categories of the work. Note related change-order numbers where applicable.

B. Write step-by-step detailed instructions for turn-on, turn-off, seasonal changeover, and periodic checks of all systems and equipment. Include all precautions and warnings.

C. Prepare a list of the manufacturers of all major equipment, their local service representative and procedures for obtaining service.

D. Post one (1) copy of all instructions, lists, charts, and diagrams at the equipment or where indicated, mounted under glass or approved plastic cover.

E. Furnish to the Owner two (2) copies of the Manufacturer's installation and operations instructions. Include replacement parts lists where applicable. Also include copies of all posted instructions, lists and charts. Assemble the material in one or more heavy duty 8-1/2" x 11" loose leaf binders with tab separators. Submit for approval before final delivery. Binder shall be labeled on spine and on cover with Project Name.

F. Deliver all instruction materials to the Owner prior to the formal instruction period.

G. Deliver two (2) complete sets of all approved submittals to the Owner for filing.

H. Prepare record documents in accordance with the requirements in the specifications. In addition to the requirements specified, indicate installed conditions for:

1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and circuit breaker size and arrangements.

2. Approved Substitutions, Contract Modifications, and actual equipment and materials installed

I. The Contractor shall keep at the site at all times during construction, one set of up-to-date Contract prints for the express purpose of showing any and all changes made during construction. The Contractor shall make the prints showing each change and shall incorporate all changes in “Record/As-Built Drawings” to be submitted to the Engineer upon completion of the project.

J. The Contractor shall show proof of up-to-date record drawings to the Owner prior to submitting monthly invoice.

K. The Contractor shall conform to all drawings, including all revisions, addendums, alternates, change orders, deletions, existing conditions, and as-built conditions without extra cost to the Owner.

2.6 DEMONSTRATION AND OPERATING INSTRUCTIONS

A. Furnish the necessary technicians, skilled workers, and helpers to operate the electrical systems and equipment of the entire project. The Contractor shall provide a minimum of eight (8) hours of system demonstration and eight (8) hours of system operation for each system.

B. Where specified in technical sections, provide longer periods required for specialized equipment.

C. Contractor shall provide start-up of all systems in an orderly, organized, and coordinated manner to ensure that all systems are functioning as designed. The Contractor shall provide a detailed start-up, testing, and demonstration plan for all systems in a coordinated manner that is documented in writing at least 45 days prior to system start-up. Start-up, testing and demonstration plans shall include detailed point-by-point checklists that clearly show that systems are, in fact, functioning as designed. Instruct

the Owner or designated personnel in operation, maintenance, lubrication, and adjustment of systems and equipment.

D. The Operating and Maintenance Manual shall be available at the time of the instructions, for use by Instructors and Owner personnel.

E. Videotape each instruction session, including both the sessions specified above and added sessions required in technical sections for specialized equipment. Provide one complete set of DVD video disks with each Operating and Maintenance Manual.

F. Schedule the general and specialized instruction periods for a time agreed upon by he Owner and Engineer. All operation training and demonstrations shall be complete prior to Owner acceptance of any given system.

PART 3. EXECUTION

3.1 EXAMINATION OF SITE, SURVEYS, AND MEASUREMENTS

A. Examine the site, determine all conditions and circumstances under which the work must be performed, and make all necessary allowances for same. No additional cost to the Owner shall be permitted for Contractor’s failure to do so.

B. Examine the site and observe the conditions under which the work will be done or other circumstances which will affect the contemplated work. Special attention shall be given to areas where work is to be done in existing buildings. No allowance will be made subsequently in this connection for any error or negligence on the Contractor's part.

C. The Contractor shall base all measurements, both horizontal and vertical, from established benchmarks. All work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the work.

D. Any discovery of discrepancy between actual measurements and those indicated which prevents following good practice or the intent of the Drawings and Specifications shall be brought to the attention of the Owner’s Representative. Work shall not proceed until receiving instructions from the Owner’s Representative.

E. The Contractor shall follow Drawings in laying out the work and check Drawings of other trades to verify spaces in which work will be installed. Maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, the Owner’s Representative shall be notified before proceeding with the installation.

F. To prevent conflict with the work of other trades and for proper execution of the work, the Contractor, as directed by the Owner’s Representative, shall make the necessary modifications in the layout as needed, at no extra charge to the Owner.

G. The Contractor shall be solely responsible for the proper arrangement of his conduit and equipment.

H. The Engineer shall make all final decisions as to any conditions that require the changing of any work.

I. The Contractor shall have competent supervision on the site at all times to lay out, check, coordinate, and supervise the installation of all electrical work and be responsible for the accuracy thereof. He shall plan the installation of all electrical work, giving consideration to the work of other trades, to prevent interference.

J. The Contractor shall determine the location, size, etc., of all chases, sleeve openings, etc., required for the proper installation of the electrical work and see that such are provided. All chases, sleeves, openings, etc., shall be set prior to erection of new work to prevent delay in the progress of other work or trades.

K. Conditions and/or situations that prevent the proper installation of any equipment or item where shown on the Drawings shall be called to the attention of the Engineer for instructions.

L. The Contractor shall have equipment shipped or fabricated in sections of suitable size for entering the building and being removed from the finished building in the future, if necessary.

M. The Contractor shall fully investigate all peculiarities and space limitations for all materials and equipment.

N. Outlet, pull, and junction boxes and other appliances that require operation, examination, adjustment, servicing or maintenance shall be readily accessible.

O. The Contractor shall take all field measurements necessary for this work and shall assume responsibility for their accuracy.

P. The Contractor shall coordinate the electrical work with all other sub-contractors. All work shall be so arranged that there will be no delay in the proper installation and completion of any part or parts of electrical equipment. All electrical work shall be installed in proper sequence with other trades without any unnecessary delay.

Q. The Drawings are to some extent diagrammatic and indicate the general arrangement of the equipment, the runs of conduit, and the manner of connection.

R. The Contractor shall confer with all sub-contractors engaged in the construction of the project, regarding the work that may, in any way, affect his installation. Whenever interference occurs, before installing any of the work in question, the Contractor shall consult with all sub-contractors and shall come to an agreement with them as to the exact location and level of his conduit parts of his equipment.

S. The Contractor shall be responsible for determining exact property lines and area of work. The Contractor shall not install any equipment or conduits outside of the property lines and/or area of work without written direction from the Owner. Any work indicated diagrammatically on the Contract Documents to be installed beyond the property lines and/or area of work shall be verified with the Owner prior to installation.

3.2 GENERAL RESPONSIBILITIES

A. The Contractor shall be responsible for systems and related damages possible, and shall hold harmless the Owner, the Architect and his consultants from malfunction of systems and equipment installed under this Contract as defined in the laws of the State of Delaware pertaining to real property for the period of time as defined by such laws.

B. It is the intent of these Specifications to fully cover without exception all required labor and materials so that the finished work will be delivered to the Owner in a complete and satisfactory working installation. Excavation, wiring, distribution, etc., shall be performed in compliance with the Contract Documents.

C. Work not specifically outlined, but reasonably incidental to the completion of the work, shall be included without additional compensation from the Owner.

D. Conflicting points in the Specifications or on the Drawings shall be called to the attention of the Architect prior to the execution of the Contract.

3.3 STORAGE AND PROTECTION OF EQUIPMENT

A. All electrical equipment to be used in the construction shall be properly stored and protected against the elements. All equipment shall be stored under cover, and shall not be stored at the construction site on the ground, in mud, water, snow, rain, sleet or dust. Large diameter cables may be stored on reels with weatherproof materials. Such weatherproof materials shall be heavy-duty, securely fastened and made impervious to the elements.

B. Conventional electrical construction materials such as building wire, outlet and junction boxes, wiring devices, conduit, lighting fixtures, fittings, etc., shall be stored in construction buildings, covered trailers or portable covered warehouses. Any equipment subject to damage or corrosion from excessive moisture shall be stored in dry, heated areas. Any equipment containing plastic or material subject to damage caused by excessive heat or sunlight shall be stored to prevent such damage. This includes plastic ducts and lenses.

C. Switchboard, motor controllers, panelboards, breakers, emergency lighting, and supervisory equipment, if delivered to the construction site before the building is under cover, shall be warehoused and protected as follows: All gear and equipment shall be covered and protected from the elements and other damage and shall be stored in a clean, dry, heated atmosphere, under cover.

D. All gear and equipment delivered to the construction site after the building is under cover shall be protected as described above and in addition shall be provided with auxiliary heat to prevent condensation damage. The gear shall also be protected against damage caused by installation of any building systems and equipment; or damage caused by carelessness of workmen who are installing equipment connected to or adjacent to the above electrical equipment.

E. Equipment damaged as a result of the above conditions shall be properly repaired at the Contractor's expense or shall be replaced at the Contractor's expense, if, in the opinion of

the Engineer the equipment has been damaged to such an extent it cannot operate properly after repairs are made.

F. All electrical enclosures exposed to construction damages such as paint spots, spackling or plaster spatter, grout splashes, waterproofing compound, tar spots or runs and pipe covering compound splashes, shall be completely covered and protected against damage.

G. In the event leakage into the building of any foreign material or fluid occurs or may occur, the Contractor shall take all steps as described above to protect any and all equipment.

H. After connections to electrical equipment are complete and the equipment is ready for operation, all construction debris shall be removed from all enclosures. Such debris includes dust, dirt, wire clippings, tape and insulation removed in order to make the connection.

3.4 ELECTRICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, materials, and installation with landscape/irrigation contractor(s).

2. Verify all dimensions by field measurements.

3. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.

4. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components where installed exposed in finished spaces.

5. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. All equipment and disconnects shall maintain proper working space to conform to NEC.

6. Install systems, materials, and equipment giving right-of-way priority to systems that require installation at a specified slope.

7. Arrange for chases, slots and openings in other building components during progress of construction, to allow for electrical installation.

8. Space, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work.

3.5 SUPERVISION AND COORDINATION

A. Provide complete supervision, direction, scheduling and coordination of all work under the contract, including that of subcontractors, using full attention and the best skill. Be responsible for all work and make all subcontractors, suppliers and manufacturers fully aware of all requirements of the contract.

B. Coordinate the rough-in of all work performed under Divisions Mechanical and Electrical Divisions.

C. The Contractor shall coordinate all electrical rough-ins with approved shop drawings and coordination drawings. Any rough-in installed without complete coordination shall be at the Contractor's risk and expense.

D. Coordinate the installation of all necessary rough-in of work, sleeves, anchors and supports for conduit, wiring, and other work performed under Mechanical and Electrical Divisions. Coordinate Division 26 work with all trades.

E. Where a discrepancy exists within the Specifications or drawings or between the Specifications and Drawings, the more stringent (or costly) requirement shall apply until a clarification can be obtained from the Engineer. Failure to clarify such discrepancies with the Engineer will not relieve the Contractor of the responsibility of conforming to the requirements of the Contract

F. Failure of the Contractor to obtain a full and complete set of Contract Documents (either before or after bidding) will not relieve the Contractor of the responsibility of complying with the intent of the Contract Documents.

G. To ensure proper electrical coordination between the electrical components supplied under the Electrical Divisions and the equipment supplied under the Mechanical Divisions, a schedule shall be submitted, prior to start of work, for review by the Engineer with the following column headings

1.Equip. or Item	2. HP or KVA	3.Voltage and Phase	4. Power Factor	5. Capacitor	6.Motor Starter	7.Discon.	8.Controls	9.Remarks

Description of Column Headings:

1. List all the approved equipment furnished under Mechanical Division that requires electrical connections and designate the equipment as it appears in the Mechanical Divisions. Indicate the quantity, if more than one, in parentheses of identical equipment being supplied.

2. Indicate the supplied horsepower of the equipment listed under Column No. 1. If equipment listed has more than one motor, indicate each motor and its respective horsepower. Indicate the kVA rating for all other equipment requiring an electrical connection, unless the electrical connection is for a control circuit only.

3. Indicate the voltage and phase requirements for equipment listed under Column No. 1. If more than one electrical circuit or voltage is required for the listed equipment, it shall be so indicated. Indicate wiring required for connection, including all phase, neutral, and ground conductors.

4. Indicate the power factor rating for all motors listed under Column No. 2.

5. Where a capacitor is to be provided, indicate specification it is supplied under and indicate the KVAR size for any capacitor provided under Division 26.

6. Where a motor starter is required, indicate the specification division it is supplied under and the type of motor starter; across-the-line, reversible, variable speed, two speed-single winding, etc. Indicate in Column No. 9 if the motor starter provided under Division 26 is not compatible with the motor specified.

7. Where a disconnect switch is required by the National Electric Code or by the contract documents for the equipment listed under Column No. 1, indicate under which Division the disconnect switch is supplied.

8. Indicate the Division under which the controls for the equipment listed under Column No. 1 are provided.

9. Indicate any discrepancies between what is indicated in the contract documents and what is actually being provided.

H. The Contractor shall fully coordinate the electrical connections to all equipment prior to installations, with the approved Shop Drawings and the trades involved. Coordination shall include voltage, phases, quantity and size of wiring, device sizes, terminations, rough-in work, and other coordination for a complete installation.

I. Coordinate the spacing and arrangement of lighting fixtures, diffusers, grilles and access panels in ceilings to establish a symmetrical pattern.

J. Coordinate light switch locations with door swings prior to rough-in. No switches permitted behind doors.

K. Coordinate electrical work with architectural items and equipment. Typical equipment refers to, but is not limited to, the following:

1. Countertops, Casework and Cabinets.

2. Fume and Exhaust Hoods.

3. Kitchen equipment.

4. Do not install outlets, switches, etc., behind casework, cabinets, etc.

5. Data, phone, and other low voltage system outlets shall be mounted above the counter tops to match power outlets in the same areas.

6. Coordinate counter top outlets with drilling of casework/counters.

7. Coordinate surface raceways and outlets above and below counters with approved casework shop drawings to avoid conflicts with sinks and other appurtenances.

8. Verify lab/kitchen equipment nameplates and connection requirements prior to rough-in.

9. Shop equipment connections, including busways.

L. This Contractor shall make all system connections required to equipment furnished and installed under other divisions. Connections shall be complete in all respects to render this equipment functional to its fullest intent. The Contractor shall make all system connections required to equipment furnished under other Divisions. Circuits shall be extended to all equipment which is incidental to, but not necessarily shown, for equipment specified under other divisions such as magnetic flow meters, ATC panels, liquid level controls, leak detection systems, etc. Connections shall be complete in all respects to render this equipment functional to its fullest extent.

M. Install work with proper clearances and access. Carefully examine all contract drawings and fit the work in each location without substantial alteration. Where departures are proposed or required, submit detailed drawings for acceptance. The right is reserved to make reasonable changes in location of equipment, conduit and wiring up to the time of rough-in or fabrication.

N. It shall be the responsibility of the Contractor to obtain complete instructions for connections.

3.6 GUARANTEE

A. Guarantee obligations shall be as hereinbefore specified in the GENERAL AND SPECIAL CONDITIONS of these specifications, except as follows:

1. Guarantee the complete electrical system free from all mechanical and electrical defects for the period of two (2) years beginning from the day of final acceptance of the work by the Owner.

2. Also, during the guarantee period, be responsible for the proper adjustments of all systems, equipment and apparatus installed by the Contractor and do all work necessary to ensure efficient and proper functioning of the systems and equipment.

3. Upon receipt of notice from the Owner of failure of any part of the electrical installation during the guarantee period, new replacement parts shall be furnished and installed promptly at no cost.

4. Warranty From the Manufacturer: Contractor shall obtain all warranty papers and records from the Original Equipment Manufacturer according to their warranty policy and deliver the same to the Owner. Contractor shall fulfill all the Original Manufacturer's requirements to validate the warranty as offered by the Original Equipment Manufacturer.

B. Provide 24-hour service for any and all warranty problems experience in the operation of the equipment provided.

C. Any equipment or system in need of warranty work whether during regular hours or on an emergency basis, shall be immediately serviced and repaired. The warranty work and guarantee shall include all parts and labor and shall be furnished at no cost to the Owner.

D. The Contractor shall guarantee to make good any and all defects in his work, exclusive of lamps, which may develop due to defective workmanship or materials, within one year from the date of final acceptance of the work by the Owner.

E. In addition to the warranty and correction of work obligations contained in the General and supplementary Conditions, correct the work of the system as embraced by the Specification, free from Mechanical and Electrical defects for the warranty period beginning from the day of acceptance of the building by the Engineer for the beneficial use of the Owner.

F. During the warranty period, take responsibility for the proper adjustments of systems, equipment and apparatus installed and perform work necessary to ensure the efficient and proper functioning of the systems and equipment.

G. Certain items of equipment hereinafter specified shall be guaranteed for a longer time than the general warranty period. These guarantees shall be strictly adhered to and the Contractor shall be responsible for service or replacement required in connection with guarantee of these items. These guarantees shall commence on the same date as the final acceptance by the Engineer.

H. Submission of a bid proposal for this Project warrants that the Contractor has reviewed the Contract Documents and has found them free from ambiguities and sufficient for the construction and proper operation of systems installed for this project. If discrepancies are found, have them clarified by Addendum.

I. It is possible that certain areas of the building or certain systems will be accepted at a time different than as specified. The date of acceptance by the Architect for beneficial use of the Owner for these building areas or systems will be adjusted accordingly.

3.7 SCHEDULING OF WORK

A. The Contractor shall not be permitted to do any work in any area of any occupied building during normal hours, except in areas specifically assigned.

B. Coordination of work by the Contractor is essential such that power outages are kept to a minimum in quantity and duration. All required outages shall be approved by the Owner for optimum time scheduling. Written notice of not less than 15 calendar days shall precede all power outages.

3.8 TEMPORARY FACILITIES

A. General: Refer to the Division 1 Sections for general requirements on temporary facilities.

B. Remove all temporary power installations and connections after permanent power is established and/or prior to completion of the project

3.9 DEMONSTRATION

A. As a part of this contract, the Contractor shall provide for the services of equipment manufacturers or their established representatives to demonstrate to selected maintenance personnel the correct operation, safety and maintenance of all electrical equipment under this contract.

3.10 PAINTING AND FINISHES

A. Provide protective finishes on all materials and equipment. Use coated or corrosion-resistant materials, hardware and fittings throughout the work. Paint bare, untreated ferrous surfaces with rust-inhibiting paint. All exterior components including supports, hangers, nuts, bolts, washers, vibration isolators, etc., shall be galvanized or stainless steel.

B. Clean surfaces prior to application of coatings, paint, or other finishes.

C. Provide factory-applied finishes where specified. Unless otherwise indicated factory-applied paints shall be baked enamel with proper pre-treatment.

D. Protect all finishes and restore any finishes damaged as a result of work under Division 26 to their original condition.

E. The preceding requirements apply to all work, whether exposed or concealed.

F. Remove all construction marking and writing from exposed equipment, conduit, and building surfaces. Do not paint manufacturer's labels or tags.

G. All exposed conduit, etc., shall be painted, except in electrical rooms, mechanical rooms, storage rooms, and crawl spaces. Colors shall be selected by the Architect and conform to ANSI Standards.

H. Submit color of factory-finished equipment for approval prior to ordering.

3.11 PROTECTION OF WORK

A. Protect work, material and equipment from weather and construction operations before and after installation. Properly store and handle all materials and equipment.

B. Cover temporary openings in conduit and equipment to prevent the entrance of water, dirt, debris, or other foreign matter.

C. Cover or otherwise protect all finishes.

D. Replace damaged materials, devices, finishes and equipment.

3.12 OPERATION OF EQUIPMENT

A. Clean all systems and equipment prior to initial operation for testing, retesting, or other purposes. Set, adjust, and test all equipment in accordance with manufacturer's instructions. Do not operate equipment unless all proper safety devices or controls are operational. Provide all maintenance and service for equipment that is authorized for operation during construction.

B. Where specified, or otherwise required, provide the services of the manufacturer's factory-trained servicemen or technicians to start up the equipment.

C. Do not use electrical systems for temporary services during construction unless authorized in writing by the Owner. Where such authorization is granted, temporary use of equipment shall in no way limit or otherwise affect warranties or guaranty period of the work.

D. Upon completion of work, clean and restore all equipment to new conditions; replace expendable items such as filters.

3.13 TESTING AND ADJUSTMENT

A. Perform all tests which are specified or required to demonstrate that the work is installed and operating properly. Where formal tests are required, give proper notices and perform all necessary preliminary tests to assure that the work is complete and ready for final test.

B. Adjust all systems, equipment and controls to operate in a safe, efficient and stable manner.

C. On all circuits, 600 volts or less, provide circuits that are free from ground faults, short circuits and open circuits.

D. Other tests of a specific nature for special equipment shall be as specified under the respective equipment.

3.14 IDENTIFICATIONS, ELECTRICAL DIAGRAMS AND OPERATING INSTRUCTIONS

A. Contractor shall submit for approval schematic diagrams of each electrical system installed in the building. Diagrams shall indicate device location, service, type, make, model number and the identification number of each device in the particular system. Following approval by all authorities, the diagrams shall be framed, mounted under glass and hung in each Main Equipment Room where directed. Contractor shall deliver the tracing or sepia from which the diagrams were reproduced to the Owner.

B. All equipment shall be plainly tagged.

C. All items of equipment, including motor starters, panels, etc., shall be furnished with white letters and numbers on black plastic identification plates or aluminum letters and numbers on black engraved aluminum identification plates. Lettering shall be a minimum of 1/4" high. Identification plates shall be securely affixed to each piece of equipment, starters, panels, etc., by screws or adhesive (Tuff-Bond #TB2 or as approved equal). Pressure sensitive tape backing is prohibited.

D. Provide three (3) copies of operating and maintenance instructions for all principal items of equipment furnished. This material shall be bound as a volume of the "Record and Information Booklet" as hereinafter specified.

E. Provide at least 24 hours of straight time instruction to the operating personnel. This instruction period shall consist of not less than three (3) consecutive 8-hour days. Time of instruction shall be designated by the Owner. Provide two VHS video taped copies of all instructional periods/demonstrations.

3.15 RECORD DRAWINGS AND SPECIFICATIONS

A. Upon completion of the Electrical installations, the Contractor shall deliver to the Engineer one complete set of prints of the Electrical Contract Drawings which shall be legibly marked in red pencil to show all Addenda, approved Shop Drawings, Change Orders, changes and departures of the installation as compared with the original design. They shall be suitable for use in preparation of Record Drawings.

B. The Contractor shall provide a record specification including all Addenda and other modifications. Record substantial variations in actual work performed. Identify all substitutions.

3.16 RECORD AND INFORMATION BOOKLET

A. The Contractor shall have prepared three (3) copies of the Record and Information Booklet and deliver these copies of the booklet to the Owner. The booklet shall be as specified herein. The booklet must be approved and will not be accepted as final until so stamped.

B. The booklet shall be bound in a three-ring loose-leaf binder similar to "National" No. 3881 with the following title lettered on the front and on the spine of the binder: "Record and Information Booklet (insert name of the project)". No sheets larger than 8-1/2" x 11" shall be used, except sheets that may be neatly folded to 8-1/2" x 11" and used as a pull-out. An Index will include the section tabs for each subject included. If more than one binder is required, print covers and spines with Volume numbers. Include in the front of every binder an index to all binders.

1. Internally subdivide the binder contents with permanent page dividers, logically organized as described below; with tab titling clearly printed under reinforced laminated plastic tabs.

2. Contents: Prepare a Table of Contents for each volume, with each product or system description identified, typed on white paper.

3. Part 1: Directory, listing names, addresses, and telephone numbers of Electrical Engineers; Contractor; Electrical Subcontractors; and major Electrical equipment suppliers. Provide sales and service representative names and phone numbers of all equipment.

4. Part 2: Operation and Maintenance Instructions, arranged by Specification Section. For each category, identify names, addresses, and telephone numbers of Subcontractors and suppliers. Identify the following:

   a. Significant design criteria.

   b. List of equipment. Complete record of material list. Catalog brochures and product data for all components. Include all submittal comments, and corrected catalog data and shop drawings on each piece of equipment and each system.

   c. Parts list for each component, including recommended spare parts list. Include motor starter overload schedules.

   d. Operating instructions, including sequence of operation.

      1) Description of function, normal operating characteristics and limitations, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts. Provide a description of each system installed.

      2) Manufacturer printed operating procedures to include start-up, break-in, and routine and normal operating instructions; control, stopping.

e. Maintenance instructions for equipment and systems. Detailed checkout procedures to insure operation of systems and gear, including recommended cleaning methods and materials and special precautions identifying detrimental agents.

f. Servicing, diagnostic and troubleshooting instructions and procedures for systems and major equipment.

g. Recommended preventative maintenance program, including a list of items requiring inspection and servicing. Provide Chart Form indicating time and type of routine and preventative maintenance of electrical equipment, etc. The chart shall also indicate tag number, model number of equipment, location and service.

1) For replacement items, indicate type, size and quantity of the replaceable items.

2) Provide lubrication schedule, including type, grade, temperature range and frequency.

3) Provide a list of each type of lighting fixture lamp used, lamp fixture used, and source.

4) Include estimated mean time between failures for major parts.

h. Wiring Diagrams, Block Diagrams, and Assembly Drawings.

i. Panelboard Circuit Directory for each panelboard, including Panel Name, Panel Location, Panel Ratings, spare circuit breakers, spaces for additional circuit breakers.

j. List of equipment keys turned over to the Owner.

5. Part 3: Project Documents and Certificates, including the following:

a. Shop Drawings and Product Data. Record Documents of the systems.

b. Photocopies of certificates.

c. Photocopies of Manufacturers' and Contractors' warranties, guarantees.

d. Test Reports: Copies of the approved results of all tests required under all sections of specifications.

e. Inspection Certificates.

f. Manufacturer's Conformance Certificates.

6. Provide one copy (DVD video disk) of video instruction session with each booklet set. Label video disk with all pertinent information.

7. Submit one copy of completed volumes in final form 15 days prior to final Inspection. This copy will be returned with Engineer comments. Revise content of documents as required prior to final submittal.

8. Submit final volumes revised, within ten days after final inspection.

C. Upon completion of the project, the Contractor shall furnish the Owner a complete list of suppliers of equipment for parts and maintenance purposes. The list shall include the name, address, and telephone number of the parts and maintenance firm on a single 8-1/2" x 11" sheet of paper.

D. This item shall include the furnishing of a complete list of equipment installed on the project, including the Manufacturer's name, the make and model number of the equipment, and address and telephone number of the nearest supplier who stocks maintenance and/or replacement parts. The list should be submitted along with as-built drawings and be typed in an organized manner.

3.17 INSTALLATION AND COORDINATION DRAWINGS

A. In congested areas, prepare, submit, and use composite installation and coordination drawings to assure proper coordination and installation of work. Drawings shall include, but not be limited, to the following: Complete Electrical Drawings showing coordination with lights, electrical equipment, mechanical, plumbing, HVAC, structural, and architectural elements and provision for access.

B. Draw plans to a scale not less than 3/8-inch equals one foot. Include plans, sections, and elevations of proposed work, showing all equipment and conduit in areas involved. Fully dimension all work including lighting fixtures, conduits, pullboxes, panelboards, and other electrical work, walls, doors, ceilings, columns, beams, joists, mechanical equipment, and other architectural and structural work.

C. Identify all equipment and devices on wiring diagrams and schematics. Where field connections are shown to factory-wired terminals, include manufacturer's literature showing internal wiring.

3.18 CUTTING AND PATCHING

A. The cutting of walls, floors, partitions, etc., for the passage and/or accommodation of conduits, etc., the closing of superfluous openings and the removal of all debris caused by said work under this contract shall be performed by and at the expense of the Contractor.

B. No cutting of any structure or finishes shall be done until the condition requiring such cutting has been examined and approved by the Architect.

C. All surfaces disturbed as a result of such cutting shall be restored under this division to match original work and all materials used for any patching, mending or finishing must conform to the class of materials originally installed.

D. Openings through precast planks for the passage of hanger rods, conduits, outlet boxes, etc., shall be drilled with power driven carbine tip drills. This drilling shall be done by the trades needing the openings and shall be in accordance with Architect's instructions. No reinforcing bars shall be cut without specific approval of the Structural Engineer.

3.19 WATERPROOFING

A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls and interior waterproof construction. Where such penetrations are necessary, furnish and install all necessary sleeves, flashings, fittings, and caulking to make penetrations absolutely watertight.

END OF SECTION

DIVISION 26 SECTION 260502
ELECTRICAL DEMOLITION FOR REMODELING
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SECTION 260502 – ELECTRICAL DEMOLITION FOR REMODELING

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 SCOPE

A. Electrical demolition shall be carried out per the Contract Documents.

B. Provide all cutting and patching for electrical construction.

C. Provide temporary service and provisions to maintain existing systems.

PART 2. PRODUCTS

2.1 MANUFACTURERS AND EQUIPMENT

A. Materials and equipment for patching and extending work: As specified in individual sections.

PART 3. EXECUTION

3.1 EXAMINATION

A. The Contractor shall examine the site, determine all conditions and circumstances and gather all data and information required for the work. Field investigations include, but are not limited to, performing surveys, opening of equipment enclosures, and other work as required to maintain existing systems.

B. The Contractor shall survey all new and existing wiring, circuitry, cabling, equipment and devices. Data gathering shall include, but not be limited to, equipment nameplate information, ratings, voltage, wiring configurations, conductor lengths, conductor routing, conductor sizes, equipment connections, and other information as required to maintain existing systems.

C. The Contractor shall provide complete field investigations to determine existing and new conductor, cable, and conduit routing, points of connections, and tracing of existing systems.

D. Verify that field measurements and circuiting arrangements are as shown on the Drawings.

E. Verify that abandoned wiring and equipment serve only abandoned facilities.

F. Demolition Drawings are based on casual field observation. Report discrepancies to the Owner, Engineer before disturbing existing installation.

G. Beginning of demolition means installer accepts existing conditions.

3.2 PREPARATION

A. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.

B. Coordinate utility service outages with the Owner, Architect, and Engineer. Also, coordinate utility service outages with Utility Company.

3.3 CONNECTIONS AND ALTERATIONS TO EXISTING SYSTEMS

A. Keep all existing electrical systems in operation during the progress of the work. Provide temporary electrical connections to systems of equipment, etc., where necessary to maintain continuous operation until the new systems and equipment are ready for operation.

B. When existing electrical work is removed, remove all conduit, ducts, supports, etc. to a point below the finished floors or behind finished walls and cap. Such points shall be far enough behind finished surfaces to allow for the installation of the normal thickness of finished material.

C. When the work specified hereunder connects to any existing equipment, conduit, wiring, etc., perform all necessary alterations, cuttings, fittings, etc., of the existing work as may be necessary or required to make satisfactory connections between the new and existing work and leave the complete work in a finished and workmanlike condition.

D. When the work specified under other divisions necessitates relocation of existing equipment, conduits, wiring, etc., perform all work and make all necessary changes to existing work as may be required to leave the completed work in a finished and workmanlike condition.

E. Contractor shall be responsible for removing and replacing existing ceiling tile within the lay-in ceiling areas as required. Contractor shall provide all necessary cutting and fitting of bushed holes for cable passage through tiles. Any tiles damaged during the Contract shall be replaced with like kind at no cost to the Owner.

F. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations. In particular, all security and safety systems must be maintained in operation at all times as required by the Owner. This includes security and safety lighting.

G. Existing Electrical Service: Disable system only to make switchovers and connections. Obtain permission from Owner, Architect/Engineer and other trades at the site at least 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

H. Trace all circuits and controls to be disconnected to ensure that vital services to other areas are not interrupted.

3.4 PROTECTION

A. Provide protection for all existing and new cabling. Provide inner duct, conduit or other suitable means of protection to prevent damage to cables located in renovated areas.

B. Damage to wiring, cabling or equipment shall be repaired by skilled mechanics for the trade involved at no additional contract amount.

C. Fixtures, materials and equipment shall be protected at all times. The Contractor shall make good any damage caused either directly or indirectly by his workmen. Conduit openings shall be closed with caps or plugs during installation. Fixtures and equipment shall be tightly covered and protected against dirt, water and chemical or other injury. At the completion of all work, the fixtures, materials and equipment shall be thoroughly cleaned and turned over in a condition satisfactory to the Owner.

D. Damage: Where wiring, raceways, lighting fixtures, devices or equipment to remain is inadvertently damaged or disturbed, cut out and remove damaged section and provide new of equal or capacity or quality.

3.5 ELECTRICAL DEMOLITION

A. Remove from the premises and dispose of all existing wiring, conduit, material, fixtures, devices, equipment, etc., not required for re-use or re-installation.

B. Deliver on the premises where directed existing material and equipment which is removed and is desired by the Owner or is indicated to remain the property of the Owner.

C. All other equipment and materials which are removed shall become the property of the Contractor and shall be removed by him from the premises.

D. Where electrical equipment is removed, also remove all wiring back to source panelboard or switch or to last remaining device on the same circuit. All conduit, hangers, supports, etc., shall also be removed unless otherwise noted. Such conduit may remain to be reused for new work provided said conduit is of the proper size and type as that specified and in a condition acceptable to Engineer and Owner.

E. Any conduit abandoned in concrete slabs, walls, or other inaccessible locations shall be left empty except for a nylon pull wire. Ends shall be capped with push plugs for future use.

F. Where an existing system is indicated to be removed, the Contractor shall provide complete removal of entire system including all wiring, conduit, and connected/associated fixtures and devices. The system shall be removed in its entirety unless otherwise noted.

3.6 EXISTING CONDUIT WORK

A. Remove all abandoned raceway, including abandoned raceway above accessible ceiling finishes. Cut raceway flush with walls and floors, and patch surfaces. Remove conduit back to point of penetration/exposure.

B. Remove concealed abandoned raceway to its source.

C. Abandoned Work: buried electrical work abandoned in place, shall be cut out approximately 2 inches beyond the face of adjacent construction, capped and the adjacent surface patched to match the existing finish.

D. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if raceway servicing them is abandoned and removed. Provide blank cover for abandoned outlets that are not removed.

E. Ensure access to existing boxes and other installations which remain active and which require access. Modify installation or provide access panel as appropriate.

F. Extend existing raceway and box installations using materials and methods compatible with existing electrical installations, or as specified.

G. Clean and repair existing raceway and boxes that remain or are to be reinstalled.

H. Remove all abandoned wiring from exiting conduits and ductbanks. Abandoned wiring that cannot be removed shall be tagged at each end as “Abandoned”.

I. Contractor shall provide all cutting and patching required to connect to and extend existing conduits, wiring, circuits, etc.

3.7 EXISTING WIRING AND CABLING WORK

A. Remove all abandoned and unused wire and cable, including abandoned wire and cable above accessible ceiling finishes. Patch surfaces where removed cables pass through building finishes. Remove abandoned and unused cabling and wiring back to the source.

B. Disconnect abandoned circuits and remove circuit wire and cable. Remove abandoned boxes if wire and cable servicing them is abandoned and removed. Provide blank cover for abandoned boxes that are not removed.

C. Ensure access to existing wiring connections which remain active and which require access. Modify installation or provide access panel as appropriate.

D. Extend existing circuits using materials and methods compatible with existing electrical installations or as specified.

E. Clean and repair existing wire and cable that remain or is to be reinstalled.

F. Provide supports for all wiring and cabling to remain as required by NEC.

G. Contractor shall provide field services for racing out of all existing circuits to be maintained. Contractor shall locate, trace and label, all existing circuits being re-used.

3.8 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Demolish and extend existing electrical work to meet all requirements of these specifications.

B. If certain raceways and boxes are abandoned but not scheduled for removal, those items must be shown on the As-Built Drawings.

C. Remove, relocate, and extend existing installations to accommodate new construction.

D. Remove abandoned wiring to source of supply.

E. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.

F. Repair adjacent construction and finishes damaged during demolition and extension work.

G. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.

H. Extend existing installations using materials and methods (compatible with existing electrical installations, or) as specified. This includes the extension of the circuit from the last active device to the next device in the system to be activated.

3.9 CLEANING AND REPAIR

A. The Consultant shall show, on the drawings, all items to be cleaned or repaired.

B. Clean and repair existing equipment and materials that remain or are to be reused.

C. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement. Trace existing circuits to determine exact location and type of load served by each circuit breaker.

D. Provide new labels on all existing electrical equipment being re-used.

3.10 INSTALLATION

A. Install relocated materials and equipment under the provisions of other sections.

END OF SECTION

DIVISION 26 SECTION 260519
LOW-VOLTAGE ELECTRICAL POWER
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SECTION 260519 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1. GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.

2. Connectors, splices, and terminations rated 600 V and less.

1.3 SUBMITTALS

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

B. Qualification Data: For testing agency.

C. Field quality-control test reports.

1.4 QUALITY ASSURANCE

A. Testing Agency: Engage a qualified independent testing agency to perform field quality-control testing.

PART 2. PRODUCTS

2.1 CONDUCTORS AND CABLES

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. Alcan Products Corporation; Alcan Cable Division.

2. American Insulated Wire Corp.; a Leviton Company.

3. General Cable Corporation.

4. Senator Wire & Cable Company.

5. Southwire Company.

B. Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN, XHHW, USE, and SO.

D. Multicolor Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC, with ground wire.

2.2 CONNECTORS AND SPLICES

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. AFC Cable Systems, Inc.

2. Hubbell Power Systems, Inc.

3. O-Z/Gedney; EGS Electrical Group LLC.

4. 3M; Electrical Products Division.

5. Tyco Electronics Corp.

B. UL-listed, factory-fabricated wiring connectors of size, ampacity rating, material, type, and class for application and service indicated. Comply with Project's installation requirements and as specified in Part 3 "Wire and Insulation Applications" Article.

C. Split Bolt Connectors: Not Acceptable.

D. Solderless Pressure Connectors: High copper alloy terminal. May be used only for cable termination to equipment pads or terminals. Not approved for splicing.

E. Spring Wire Connectors: Solderless spring type pressure connector with insulating covers for copper wire splices and taps. Use for conductor sizes 10 AWG and smaller.

F. All wire connectors used in underground or exterior pull boxes shall be gel-filled twist connectors or a connector designed for damp and wet locations.

G. Mechanical Connectors: Bolted type tin-plated; high conductivity copper alloy; spacer between conductors; beveled cable entrances.

H. Compression (crimp) Connectors: Long barrel; seamless, tin-plated electrolytic high conductivity copper tubing, internally beveled barrel ends. Connector shall

be clearly marked with the wire size and type and proper number and location of crimps.

I. Heat shrinkable tubing shall meet the requirements of ANSI C119.1-1986 for buried connections to 90°C and shall be material flame-retarded per IEEE 383 "Vertical Tray Flame Test". Motor connection kits shall consist of heat-shrinkable, polymeric insulating material over the connection area and a high dielectric strength mastic to seal the ends against ingress of moisture and contamination. Motor connection kits shall accommodate a range of cable sizes for both in-line and stub-type configurations. Connection kits shall be independent of cable manufacturer's tolerances.

J. Wire Nut Connectors:

1. Wire nuts install in wet locations, exterior, etc., shall be self-contained, waterproof and corrosion-proof units incorporating prefilled silicone grease to block out moisture and air.
2. Connectors shall be UL listed appropriately sized according to manufacturer's recommendation for the suitable wire sizes and voltage rating (600 volt minimum).
3. Connectors body shall have a color-coded outer shell.
4. Connectors shall be as manufactured by King Technology or approved equal.

2.3 SYSTEM DESCRIPTON

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 3. EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICOLOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type RHW, single conductors in raceway.

D. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWH, single conductors in raceway, except the last 10' from a junction box to recessed lighting fixture may be type MC cable.

F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

G. Conductors shall be rated 75 deg C in wet locations and 90 deg C in dry locations.

3.3 INSTALLATION OF CONDUCTROS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Division 26 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260429, "Hangers and Supports for Electrical Systems".

G. Identify and color-code conductors and cables according to Section 260553, "Identification for Electrical Systems".

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches (300 mm) of slack.

D. Joints of #10 AWG and smaller shall be made with properly insulated solderless type pressure connectors. Where stranded conductors or multiple solid conductors are connected to terminals, solderless lugs manufactured by Thomas and Betts Company or equivalent shall be used.

E. Joints of #8 AWG and larger in power and lighting circuits shall be of the type indented into the conductor by means of a hand or hydraulic pressure tool. Connectors shall be Burndy “Hy-dent’, T&B “St-Kon”, or equivalent. Connectors for control wiring shall be Burndy “Hy-Lug”, or equivalent.

F. All circuits for exterior electric work shall be #10 AWG (minimum) and contain an extra #10 AWG (minimum) copper ground conductor. All exterior wiring shall be installed in conduit as specified above, unless otherwise noted as larger on the Drawings

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordination sleeve selection and application with selection and application of firestopping specified in Division 26 Section "Electrical Firestopping." and “Basic Electrical Materials and Methods”.

3.6 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations according to Division 26 Section, “Basic Electrical Materials and Methods”.

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 7 Section "Through Penetration Firestop System”.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Perform tests and inspections and prepare test reports.

C. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the mechanical equipment and services for compliance with requirements.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

D. Measure tightness of bolted connections and compare torque measurements with manufacturer's recommended values.

E. Verify continuity of each branch circuit conductor.

F. Demonstration: Subsequent to wire and cable hook-ups, energize circuit and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

G. Test Reports: Prepare a written report to record the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

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

END OF SECTION

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GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
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SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1. GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes grounding and bonding systems and equipment.
B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 01 Section "Operating, Maintenance, Project Data," include the following:

a. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, grounding connections for separately derived systems based on NETA MTS.

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.

2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2. PRODUCTS

2.1 MANUFACTURERS

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

1. Burndy; Part of Hubbell Electrical Systems

2. Dossert; AFL Telecommunications LLC

3. ERICO International Corporation

4. Fushi Copperweld Inc

5. Galvan Industries, Inc.; Electrical Products Division, LLC

6. Harger Lightning and Grounding

7. ILSCO.

8. O-Z/Gedney; A Brand of the EGS Electrical Group

9. Robbins Lightning, Inc

2.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.

2. Stranded Conductors: ASTM B 8.

3. Tinned Conductors: ASTM B 33.

4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter, unless otherwise noted.

5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor, unless otherwise noted.

6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm)] in cross section, unless otherwise indicated, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.5 GROUNDING ELECTRODES

Ground Rods: Copper-clad steel,3/4 inch by 10 feet (19 mm by 3 m).

PART 3. EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum.

1. Bury at least 24 inches (600 mm) below grade.

C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Pad-Mounted Transformers and Switches: Install four ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

C. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.

3.5 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

3.6 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

2. For grounding electrode system not detailed on the drawings, install at least three rods spaced at least one-rod length from each other and located

at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.

1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor. Provide all test wells with twist lock cover, Harger#GAW910 or approved equal

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.

2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping.

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

F. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

G. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.

2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.7 FIELD QUALITY CONTROL

A. Test Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instruction.

3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

   a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

   b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

D. Grounding system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.

2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.

3. Substations and Pad-Mounted Equipment: 5 ohms.

4. Manhole Grounds: 10 ohms.

G. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

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SECTION 260528- ELECTRICAL FIRESTOPPING

PART 1. GENERAL

1.1 SUMMARY

A. This Section includes:

1. Through penetration firestopping in fire rated construction.
2. Through-penetration smoke-stopping in smoke partitions.

1.2 REFERENCES

A. Underwriters Laboratories

1. UL Fire Resistance Directory.

a. Through- penetration firestop devices (XHCR).

b. Fire resistance rating (BXUV).

c. Through- penetration firestop systems (XHEZ).

d. Fill void, or cavity material (XHHW).

B. American Society for Testing and Materials Standards: ASTM E 814-88: Standard Test Method for Fire Tests of Through-Penetration Firestops.

1.3 REFERENCES

A. Assembly: Particular arrangement of materials specific to given type of construction described or detailed in referenced documents.

B. Barriers: Time-rated fire walls, smoke barrier walls, time rated ceiling/floor assemblies and structural floors.

C. Firestopping: Methods and materials applied in penetrations and unprotected openings to limit spread of heat, fire, gasses and smoke.

D. Penetration: Opening or foreign material passing through or into barrier or structural floor such that full thickness of rated materials is not obtained.

E. System: Specific products and applications, classified and numbered by Underwriters Laboratories, Inc. to close specific barrier penetrations.

F. Sleeve: Metal fabrication or pipe section extended through thickness of barrier and used to permanently guard penetration. Sleeves are described as part of penetrating system in other sections and may or may not be required.

1.4 SYSTEM DESCRIPTION

A. Design Requirements

1. Fire-rated rated construction: Maintain barrier and structural floor fire resistance ratings including resistance to cold smoke at all penetrations, connections with other surfaces or types of construction, at separations required to permit building movement and sound or vibration absorption.

2. Smoke barrier construction: Maintain barrier and structural floor resistance to cold smoke at all penetrations, connections with other surfaces and types of construction and at all separations required to permit building movement and sound or vibration absorption.

1.5 SUBMITTALS

A. Submit in accordance with Section 16010, unless otherwise indicated.

B. Product data: Manufacturer's specifications and technical data including the following:

1. Detailed specification of construction and fabrication.

2. Manufacturer’s installation instructions.

C. Shop drawings: Indicate dimensions, description of materials and finishes, general construction, specific modifications, component connections, anchorage methods, hardware, and installation procedures, plus the following specific requirements.

1. Details of each proposed assembly identifying intended products and applicable UL system number, or UL classified devices.

2. Manufacturer or manufacturer's representative shall provide qualified engineering judgment and drawings relating to non-standard applications as needed.

D. Quality control submittals: Statement of qualifications.

E. Applicators’ qualifications statement: List past projects indicating required experience

1.6 QUALITY ASSURANCE

A. Installer’s qualifications: Fire experienced in installation or application of systems similar in complexity to those required for this project, plus the following:

B. Local and State regulatory requirements: Submit forms or acceptance for proposed assemblies not conforming to specific UL Firestop System numbers, or UL classified devices.

C. Materials shall have been tested to provide fire rating at least equal to that of the construction.

D. Manufacturer shall be a member of the International Firestop Council (IFC).

1.7 DELIVERY, STORAGE, AND HANDLING

A. Packing and shipping:

1. Deliver products in original unopened packaging with legible manufacturer's identification.

2. Coordinate delivery with scheduled installation date, allow minimum storage at site.

B. Storage and protection: Store materials in a clean, dry, ventilated location. Protect from soiling, abuse, moisture and freezing when required. Follow manufacturer's instructions.

1.8 PROJECT CONDITIONS

A. Existing conditions:

1. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.

2. Proceed with installation only after penetrations of the substrate and supporting brackets have been installed.

B. Environmental requirements:

1. Furnish adequate ventilation if using solvent.

2. Furnish forced air ventilation during installation if required by manufacturer.

3. Keep flammable materials away from sparks or flame.

4. Provide masking and drop cloths to prevent contamination of adjacent surfaces by firestopping materials.

1.9 GUARANTEE

A. Submit copies of written guarantee agreeing to repair or replace joint sealers which fall in joint adhesion, extrusion resistance, migration resistance, or general durability or appear to deteriorate in any other manner not clearly specified by submitted manufacturer's data as an inherent quality of the material for the exposure indicated. The guarantee period shall be two year from date of substantial completion unless otherwise noted.

PART 2. PRODUCTS

2.1 MANUFACTURERS

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

1. Hilti.

2. Nelson

2.2 THROUGH-PENETRATION FIRESTOPPING OF FIRE-RATED CONSTRUCTION

A. Systems of devices listed in the UL Fire Resistance Directory under categories XHCR and XHEZ may be used, providing that it conforms to the construction type, penetrant type, annular space requirements and fire rating involved in each separate instance, and that the system be symmetrical for wall applications. Systems or devices must be asbestos-free.

1. Additional requirements: Withstand the passage of cold smoke either as an inherent property of the system, or by the use of a separate product included as a part of the UL system or device, and designed to perform this function.

2. Acceptable manufacturers and products.

a. Those listed in the UL Fire Resistance directory for the UL System involved and as further defined in the System and Applications Schedule in Part 3.6 of this section

b. All firestopping products must be from a single manufacturer. All trades shall use products from the same manufacturer unless otherwise noted

2.3 SMOKE STOPPING AT SMOKE PARTITIONS

A. Through-penetration smoke-stopping: Any system complying with the requirements for through-penetration firestopping in fire-rated construction, as specified in The Systems and Applications Schedule in Part 3.6 of this section, is acceptable, provided that the system includes the specified smoke seal or will provide a smoke seal. The length of time of the fire resistance may be disregarded.

2.4 ACCESSORIES

A. Fill, void or cavity materials: As classified under category XHHW in the UL Fire Resistance Directory.

B. Forming materials: As classified under category XHKU in the UL Fire Resistance Directory.

C. Sleeves: Minimum 24 MSG galvanized steel, 12" diameter or smaller steel pipe. Sleeve shall project 1/2" from each surface of the floor/wall. Size as recommended by firestop manufacturer.

PART 3. EXECUTION

3.1 EXAMINATION

A. Verification of conditions: Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.

1. Verify barrier penetrations are properly sized and in suitable condition for application of materials.

2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATON

A. Clean surfaces to be in contact with penetration seal materials of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.

3.3 INSTALLATION

A. Install penetration seal materials in accordance with printed instructions of the UL Fire Resistance Directory and in accordance with manufacturer's instruction.

B. Seal holes or voids made by penetrations to ensure an effective smoke barrier.

C. Protect materials from damage on surfaces subject to traffic.

D. When large openings are created in walls or floors to permit installation of conduits, cable tray, or other items, close unused portions of opening with firestopping materials tested for the application. See UL Fire Resistance Directory or Paragraph 2.2 of this document.

E. Install smoke stopping as specified for firestopping.

F. Provide sleeves the full thickness of the assembly being penetrated and cut sleeves to a length of 1"more than the over-all thickness of the penetration, or as recommended by the firestop manufacturer.

G. All holes and voids shall be sealed the same day they are made.

3.4 FIELD QUALITY CONTROL

A. Examine penetration sealed areas to ensure proper installation before concealing or enclosing areas.

B. Keep areas of work accessible until inspection by applicable code authorities.

C. Perform under this section patching and repairing of firestopping caused by cutting or penetration by other trades.

3.5 ADJUST AND CLEANING

A. Clean up spills of liquid components.

B. Neatly cut and trim materials as required.

C. Remove equipment, materials and debris, leaving area in undamaged, clean condition.

3.6 SYSTEMS AND APPLICATION SCHEDULES

SEE NEXT PAGE.

PENETRATING ITEM	CONCRETE	GYPSUM	WOOD FLOOR/ CEILING
Metal Pipe	CAJ1001 CP25S/L, CP25N/S CAJ1006 CS-195+, FS-195+ CAJ1007 FS-195+, 1"& 2" Wide CAJ1009 2000, 2000+, 2003 CAJ1010 2000, 2000+, 2003 CAJ1012 2000, 2000+, 2003 CAJ1013 2000, 2000+, 2003 CAJ1014 2000, 2000+, 2003 CAJ1015 2000, 2000+, 2003 CAJ1017 FD 150 CAJ1021 FD 150 CAJ1027 MPS-2+ CAJ1044 CP 25WB+ CAJ1052 CP 25S/L, CP 25N/S CAJ1058 2000, 2000+, 2003 CAJ1060 2000, 2000+, 2003 CAJ1063 2000, 2000+, 2003 CAJ1066 CP 25N/S,CP 25S/L, CP 25WB+ CAJ1091 CP 25N/S,CP 25S/L, CP 25WB+ CAJ1092 CP 25WB+ CAJ1112 FS-195+ CAJ1160 CP 25S/L, CP 25N/S CAJ1175 CP 25WB+ CAJ1176 CP 25WB+ CAJ1188 2000+ CBJ1020 CS-195+, FS-195+ CBJ1021 CS-195+, MPS-2+ CBJ1031 2001 CBJ1032 2001 FA1002 CP 25WB+ WJ1010 CP 25WB+ WJ1023 2001	WL1001 CP 25 WL1002 FS-195+ WL1003 CP 25WB+,CP 25N/S WL1008 2000+ WL1009 2000+ WL1010 2000+ WL1016 CP 25WB+ WL1017 CP 25WB+,CP 25N/S WL1032 CP 25WB+,CP 25N/S WL1036 FD 150 WL1037 CS-195+,FS-195+ WL1067 CP 25N/S WL1073 CP 25WB+ WL1080 MPS-2+ WL1082 2000+	FC1002 CP 25 FC1003 2000,2000+,20003 FC1006 CP 25WB+
Non-Metallic	CAJ2001 FS-195+, 1"& 2" WIDE, PPD'S	WL2002 FS-195+, PPD'S WL2003 FS-195+	FC2002 FS-195+, PPD'S

PENETRATING ITEM	CONCRETE	GYPSUM	WOOD FLOOR/ CEILING
	CAJ2002 FS-195+ CAJ2003 CS-195+, FS-195+ CAJ2005 FS-195+ CAJ2006 FS-195+ CAJ2013 FS-195+ CAJ2019 2000, 2000+, 2003 CAJ2027 FS-195+, CP 25N/S, CP 25S/L, CP 25WB+ CAJ2028 FS-195, MPS-2+ CAJ2029 FS-195+, PPD'S CAJ2030 CS-195+, FS-195+ CAJ2040 FS-195+, CP 25WB+ CAJ2044 FS-195+, CP 25N/S, CP 25S/L CP 25 WB+ CAJ2090 FS-195+ CAJ2177 FS-195+, PPD'S FA2001 FS-195+, PPD'S FS2002 CS-195+, FS-195+, MPS-2+, PPD'S FA2011 FS-195+ WJ2012 FS-195+ 1" WIDE	WL2004 FS-195+ WL2005 FS-195+ 4' WIDE WL2006 FS-195+ WL2013 FS-195+ WL2031 CS-195+, FS-195+ WL2032 CS-195+, FS-195+ WL2033 FS-195+ WL2073 FS-195+ 1" WIDE	FC2007 FS-195+, PPD'S FC2008 FS-195+ FC2009 FS-195+, PPD'S FC2024 FS-195+ FC2026 FS-195+ FC2028 FS-195+, 1' & 2" WIDE, PPD'S
Insulated Cable	CAJ3001 CP 25N/S, CP 25S/L CAJ3005 CS 195+, FS-195+ CAJ3007 2001 CAJ3009 2000, 2000+, 2003 CAJ3010 2000, 2000+, 2003 CAJ3011 2001 CAJ3014 FD 150 CAJ3015 FD 150 CAJ3021 MPS-2+ CAJ3029 2000, 2000+, 2003 CAJ3030 CP 25WB+ CAJ3031 CP 25N/S, CP 25S/L CAJ3041 2000, 2000+, 2003 CAJ3044 CS-195+, FS-195+ CAJ3058 FS-195+, MPS-2+ CAJ3071 CP 25N/S, CP 25S/L CAJ3074 CP 25N/S, CP 25S/L	WL3001 CP 25, MPS-2+ WL3008 2000+ WL3009 2000+ WL3015 CP 25WB+, CP 25N/S WL3022 2000+ WL3030 FS-195+ WL3031 MPS-2+ WL3032 CP 25WB+ WL3041 2000+ WL3051 CP 25N/S WL3056 CP25N/S WL3062 CP 25WB+	FC3001 CP 25S/L, CP 25N/S FC3002 2000+ FC3003 2000, 2000+, 20003 FC3007 CP 25WB+, MPS-2+ FC3008 FS-195+

PENETRATING ITEM	CONCRETE	GYPSUM	WOOD FLOOR/ CEILING
	CAJ3075 2001 CAJ3080 CP 25WB+ CBJ3016 CS-195+, FS-195+ CBJ3017 CS-195+, MPS-2+ FA3001 CP 25WB+ FB3004 CS-195+, MP WJ3015 2001 WJ3016 2001		
Mixed Penetrating Items Combos	CAJ8001 CS-195+ FS-195+ CAJ8003 2000, 2000+, 20003 CAJ8004 2000, 2000+, 20003 CAJ8006 2001 CAJ8013 FS-195+, CP 25 CBJ8004 CS-195, FS-195+ CBJ8005 CS-195+, MPS-2+ CBJ8008 2001 FA8001 FS-195+, CP 25WB+	WL8002 CS-195+, FS-195+	

END OF SECTION

DIVISION 26 SECTION 260529
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
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SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.

2. Construction requirements for concrete bases.

B. Related Sections include the following:

1. Metal Fabrications – For requirements for miscellaneous metal items involved in supports and fastenings.

2. Joint Sealants – For requirements for firestopping at sleeves through walls and floors that are fire barriers.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

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

C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems.

1.6 QUALITY ASSURANCE

A. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories" and Division 23.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

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

   a. Allied Tube & Conduit.

   b. Cooper B-Line, Inc.; a division of Cooper Industries.

   c. ERICO International Corporation.

   d. GS Metals Corp.

   e. Thomas & Betts Corporation.

   f. Unistrut; Tyco International, Ltd.

   g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

4. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of

conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

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

      1) Hilti Inc.

      2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.

      3) MKT Fastening, LLC.

      4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

   a. 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) Cooper B-Line, Inc.; a division of Cooper Industries.

      2) Empire Tool and Manufacturing Co., Inc.

      3) Hilti Inc.

      4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.

      5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.

4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.

5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

6. Toggle Bolts: All-steel springhead type.

7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

C. Submit structural calculations for load and strength of each component and detailing of each assembly.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.

2. To New Concrete: Bolt to concrete inserts.

3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.

4. To Existing Concrete: Expansion anchor fasteners.

5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.

6. To Light Steel: Sheet metal screws.

7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

2. Install anchor bolts to elevations required for proper attachment to supported equipment.

3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

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RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
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SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Requirements: Section 16 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. FMC: Flexible metal conduit.

C. IMC: Intermediate metal conduit.

D. LFMC: Liquidtight flexible metal conduit.

E. LFNC: Liquidtight flexible nonmetallic conduit.

F. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.

1. Custom enclosures and cabinets.

C. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members in the paths of conduit groups with common supports.

2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

D. Source quality-control test reports.

1.5 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. 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. AFC Cable Systems, Inc.
2. Allied Tube & Conduit; a Tyco International Ltd. Co.
3. Electri-Flex Co.

B. Rigid Steel Conduit: ANSI C80.1.

C. IMC: ANSI C80.6.

D. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit

1. Comply with NEMA RN 1.

2. Coating Thickness: 0.040 inch (1 mm), minimum.

E. EMT: ANSI C80.3.

F. FMC: Zinc-coated steel.

G. LFMC: Flexible steel conduit with PVC jacket.

H. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.

2. Fittings for EMT: Steel or die-cast or compression type.

3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

I. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

A. 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. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Arnco Corporation.
4. Electri-Flex Co.

B. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

C. LFNC: UL 1660.

D. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

E. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

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

1. Cooper B-Line, Inc.
2. Hoffman.
3. Mono-Systems, Inc.
4. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel, dual compartment type with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect. Provide devices in multi-outlet assembly as indicated on the drawings. Provide all components, fittings, etc. required for a complete installation.

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

a. Wiremold / Legrand

b. Mono-Systems, Inc.

c. Panduit Corp.

d. Hubbell.

2.5 BOXES, ENCLOSURES, AND CABINETS

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. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.

2. Erickson Electrical Equipment Company.

3. Hoffman.

4. O-Z/Gedney; a unit of General Signal.

5. Spring City Electrical Manufacturing Company.

6. Thomas & Betts Corporation.

7. Walker Systems, Inc.; Wiremold Company (The).

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, aluminum, Type FD, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

F. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.

G. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

H. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep.

I. Gangable boxes are allowed.

J. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

K. Cabinets:

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.

2. Hinged door in front cover with flush latch and concealed hinge.

3. Key latch to match panelboards.

4. Metal barriers to separate wiring of different systems and voltage.

5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit.

2. Concealed Conduit, Aboveground: Rigid steel conduit.

3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried, unless otherwise noted.

4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC

5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.

2. Exposed, Not Subject to Severe Physical Damage: EMT.

3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:

   a. Loading dock.

   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.

   c. Mechanical rooms to 8’ AFF.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.

5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.

6. Damp or Wet Locations: Rigid steel conduit.

7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4X, stainless steel in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

2. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.

3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install surface raceways only in finished spaces where concealment of conduit in existing walls is not feasible.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within accessible ceilings space unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches (300 mm) of enclosures to which attached.

I. Stub-ups to Above Recessed Ceilings:

1. Use EMT, or RMC for raceways.

2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

K. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

L. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

M. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

N. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

O. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

P. Surface Raceways:

1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.

2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

3. Two-hole straps are required.

Q. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a

flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.

2. Where otherwise required by NFPA 70.

R. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).

1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:

a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
d. Attics: 135 deg F (75 deg C) temperature change.

2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.
3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Basic Electrical Materials and Methods."

3.4 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 26 Section "Electrical Firestopping."

3.5 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

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IDENTIFICATION FOR ELECTRICAL SYSTEMS
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SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:

1. Black letters on an orange field for normal feeders, black letters on a yellow field for emergency feeders.

2. Legend: Indicate voltage and system or service type.

C. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.2 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each cable size.

B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of cable it identifies and to stay in place by gripping action.

2.3 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

2.4 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.

2. Printing on tape shall be permanent and shall not be damaged by burial operations.

3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.

2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE,

3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

C. Tag:

1. Multilayer laminate consisting of high-density polyethylene scrim coated with pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility,compounded for direct-burial service.

2. Thickness: 12 mils (0.3 mm).

3. Weight: 36.1 lb/1000 sq. ft. (17.6 kg/100 sq. m).

4. 3-Inch (75-mm) Tensile According to ASTM D 882: 400 lbf (1780 N), and 11,500 psi (79.2 MPa).

2.5 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.

2. 1/4-inch (6.4-mm) grommets in corners for mounting.

3. Nominal size, 7 by 10 inches (180 by 250 mm).

C. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.

2. 1/4-inch (6.4-mm) grommets in corners for mounting.

3. Nominal size, 10 by 14 inches (250 by 360 mm).

D. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.6 EQUIPMENT IDENTIFICATION LABELS

A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

B. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm.

2.7 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).

3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

4. Color: Black except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).

3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

4. Color: Black.

C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.

1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength at 73 deg F ((23 deg C)), According to ASTM D 638: 7000 psi (48.2 MPa).

3. UL 94 Flame Rating: 94V-0.

4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).

5. Color: Black.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

G. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.

2. In Spaces Handling Environmental Air: Plenum rated.

H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.

I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 50A, and 120 V to ground: Identify with snap around label applied in bands. Install labels at 10-foot (3-m) maximum intervals.

B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:

1. Emergency Power - Yellow.

2. Power - Orange.

3. Fire Alarm System – Red.

4. Security System – Blue and Yellow.\

5. Mechanical and Electrical Supervisory System – Green and Blue.

6. Telecommunications Systems – Green and Yellow.

7. Control Wiring – Green and Red.

C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.

b. Colors for 208/120-V Circuits:

1) Phase A: Black.

2) Phase B: Red.

3) Phase C: Blue.

c. Colors for 480/277-V Circuits:

1) Phase A: Brown.

2) Phase B: Orange.

3) Phase C: Yellow.

d. All control wiring shall be color coded when using wires of different color from the type used to designate phase wires.

e. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

f. All emergency wiring shall have the same color-coding, but shall be clearly identified as emergency in all outlets, fixtures, etc.

D. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation.

E. Install instructional sign including thecolor-code for grounded and ungrounded conductors using adhesive-film-type labels.

F. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive vinyl labels with the conductor or cable designation, origin, and destination.

G. Control-Circuit Conductor Termination Identification: For identification at terminations provide self-adhesive vinyl labels with the conductor designation.

H. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

J. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.

2. Install underground-line warning tape for both direct-buried cables and cables in raceway.

K. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

L. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs or Metal-backed, butyrate warning signs.

1. Comply with 29 CFR 1910.145.

2. Identify system voltage with black letters on an orange background.

3. Apply to exterior of door, cover, or other access.

4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:

a. Power transfer switches.

b. Controls with external control power connections.

M. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

N. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer.

O. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.

c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be engraved, laminated acrylic or melamine label, “Panel (designation), Served from (designation).”

b. Enclosures and electrical cabinets.

c. Access doors and panels for concealed electrical items.

d. Switchgear.

e. Switchboards.

f. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.

g. Substations.

h. Emergency system boxes and enclosures.

i. Motor-control centers.

j. Enclosed switches.

k. Enclosed circuit breakers.

l. Enclosed controllers.

m. Variable-speed controllers.

n. Push-button stations.

o. Power transfer equipment.

p. Contactors.

q. Remote-controlled switches, dimmer modules, and control devices.

r. Battery-inverter units.

s. Battery racks.

t. Power-generating units.

u. Monitoring and control equipment.

v. UPS equipment.

END OF SECTION

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OVERCURRENT PROTECTIVE DEVICES COORDINATION STUDY
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SECTION 26 0573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study. Provide Arc-Flash Hazard Labels on electrical distribution equipment with level as determined by Study. Provide Labels indicating the calculated fault current on the new equipment and all existing source equipment.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

C. Qualification Data: For coordination-study specialist.

D. Other Action Submittals: The following submittals shall be made after the approval process for system protective devices has been completed. Submittals may be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.

2. Study and Equipment Evaluation Reports.

3. Coordination-Study Report.

4. Arc Fault Hazards Evaluation.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Engineering Analysis and Coordination Study performed by Coordinated Power Engineering, Inc., or a comparable product by one of the following:

1. CGI CYME.
2. EDSA Micro Corporation.
3. ESA Inc.
4. Operation Technology, Inc.
5. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Additional Required Features of the Software:

a. Arcing faults.

b. Simultaneous faults.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

3.2 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.
3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:

    a. Circuit-breaker and fuse-current ratings and types.

    b. Relays and associated power and current transformer ratings and ratios.

    c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.

    d. Generator kilovolt amperes, size, voltage, and source impedance.

    e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.

    f. Busway ampacity and impedance.

    g. Motor horsepower and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.

    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.

    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.

    d. Generator thermal-damage curve.

    e. Ratings, types, and settings of utility company's overcurrent protective devices.

    f. Special overcurrent protective device settings or types stipulated by utility company.

    g. Time-current-characteristic curves of devices indicated to be coordinated.

h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.

i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.

j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

3.3 FAULT-CURRENT STUDY

A. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:

1. Switchboard bus.

2. Distribution panelboard.

3. Branch circuit panelboard.

4. Enclosed circuit breaker.

B. Study electrical distribution system from normal power sources throughout new electrical distribution system equipment for Project and for the existing 208/120V Main Switchboard.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 141, and IEEE 242.

1. Transformers:

a. IEEE C57.12.00.

b. IEEE C57.96.

2. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.

3. Low-Voltage Fuses: IEEE C37.46.

E. Study Report:

1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.

F. Equipment Evaluation Report:

1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.

3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

G. Provide labels for each piece of equipment indicating the available fault current and date as required by the NEC.

3.4 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.

2. Calculate the maximum and minimum ground-fault currents.

B. Comply with IEEE 141 and IEEE 242 recommendations for fault currents and time intervals.

C. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

a. Inrush current when first energized.

b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.

c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

D. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

E. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:

a. Device tag.

b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.

c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.

d. Fuse-current rating and type.

e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

a. Device tag.

b. Voltage and current ratio for curves.

c. Three-phase and single-phase damage points for each transformer.

d. No damage, melting, and clearing curves for fuses.

e. Cable damage curves.

f. Transformer inrush points.

g. Maximum fault-current cutoff point.

F. Completed data sheets for setting of overcurrent protective devices.

3.5 ARC-FLASH HAZARD

A. Perform Arc-Flash Hazard Analysis for new equipment and existing main switchboard and provide results indicating personnel protective equipment required for the potential hazard.

END OF SECTION

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SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Provide lighting controls that can operate as standalone local room network(s).

B. This Section includes the following lighting control devices:

1. Time switches.
2. Photoelectric switches.
3. Daylight-harvesting controls.
4. Indoor occupancy/vacancy sensors.
5. Lighting contactors.
6. Emergency shunt relays.
7. Low voltage switches.

C. Related Sections include the following:

1. Section 262726 "Wiring Devices" for snap switches.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.4 SUBMITTALS

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

B. Coverage Plans: Show locations and coverage patterns for all occupancy and vacancy sensors. Alternative manufacturers may have differing coverage patterns. Provide quantity of sensors indicated as a minimum. Provide additional sensors as required to provide full coverage over controlled areas. Full coverage shall provide hand and arm motion detection, except in corridors which shall provide walking motion coverage. Locate the sensor(s) in accordance with the manufacturer's recommendations to maximize energy savings and to avoid nuisance activation and deactivation due to sudden temperature or airflow changes and usage.

C. Shop Drawings: Show installation details for occupancy, vacancy and light-level sensors.

1. Interconnection diagrams showing field-installed wiring.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

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

1.6 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide a digital lighting control system for individual rooms as indicated on the drawings. The system shall include, but not be limited to, occupancy/vacancy sensor(s), photo sensor(s), digital room controller(s), digital switches, and all interconnecting wiring required for a complete operational system. The Basis-of-Design System is the Wattstopper Digital Lighting Management System.

2.2 TIME SWITCHES

A. Basis-of-Design product: Subject to compliance with requirements, provide Wattstopper TS-400 Digital Time Switch, or a comparable product by one of the following:

1. Leviton Manufacturing Company, Inc.

2. Pass & Seymour.

3. Cooper Industries, Inc.

4. Intermatic, Inc.

B. Digital Time Switches: Wall switch style, electroluminescent back-lit LCD display shows timer countdown, time-out adjustments from 5 minutes to 12 hours, compatible with electronic ballasts; UL listed, five-year warranty.

2.3 OUTDOOR PHOTOELECTRIC SWITCHES

A. 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. Cooper Industries.

2. Intermatic, Inc.

3. NSi Industries, LLC; TORK Products.

4. Tyco Electronics; ALR Brand.

B. Description: Solid state, with SPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.

3. Time Delay: 15-second minimum, to prevent false operation.

4. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.

5. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.4 DAYLIGHT-HARVESTING DIMMING CONTROLS

A. Available Manufacturers: Basis of Design Products: Provide Wattstopper FD-301, LS-301, or a comparable product. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:

1. The Wattstopper.

2. Hubbell Building Automation.

3. Leviton Manufacturing Company, Inc.

4. Greengate.

5. Cooper Controls

6. Sensor Switch, Inc.

7. GE Total Lighting Controls.

B. General Description: Ceiling-mounted or fixture-integrated daylight dimming photosensor that works with standard 0-10 volt DC electronic dimming ballasts to control electric lighting in response to daylight.

1. The photosensor shall be a self-contained, ceiling-mounted daylighting control device that detects changes in light levels and raises or lowers electrical lighting in response.

2. The photosensor shall be a closed loop device that measures both the daylight contribution and the controlled electric light contribution.

3. The photosensor shall be a low voltage device, powered by 24 VDC voltage supplied by a power pack.

4. The photocell shall have an extremely linear response with greater than 1% accuracy over the sensed range.

5. The photosensor shall be capable of controlling up to 50 standard 0-10VDC electronic dimming ballasts.

6. The photosensor shall utilize an internal photocell that measures only in the visible spectrum and has a response curve that closely matches the photopic curve. The photocell shall not measure energy in either the ultraviolet or infrared spectrums. The photocell shall have a sensitivity of less than 5% for any wavelengths less than 400 nanometers or greater than 700 nanometers.

7. The photosensor shall provide dimming over the full range from .2 VDC to 10 VDC. When maximum dimming is required, a .2 volt output is supplied to the ballast; when full output lighting is required, a 10 volt output is supplied to the ballast.

8. The photosensor shall use a sliding setpoint algorithm. The photosensor shall maintain the desired task level illuminance for current daylight contribution based on two setpoints, a night setpoint and a day setpoint.

9. All setup adjustments shall be made remotely from the photosensor by means of a wireless, infrared handheld remote. All setup adjustments shall be done from the ground with no ladders required after the initial installation has been completed.

10. The photosensor shall be controllable by a compatible handheld remote that allows an occupant to adjust the light level to their preference while enabling the automatic dimming to continue to achieve the adjusted setpoint. Any adjustment made with the handheld remote shall be easily canceled by pressing one button on the remote.

11. The photosensor shall have a control range of 20-60 footcandles.

12. The photosensor shall not protrude more than 0.75-inches from the ceiling and should blend in aesthetically.

13. To ensure quality and reliability, photosensor shall be manufactured by an ISO 9002 certified manufacturing facility and shall have a defect rate of less than 1/3 of 1%.

14. The photosensor shall have a standard five-year warranty.

2.5 INDOOR OCCUPANCY SENSORS

A. Basis of Design Products: Subject to compliance with requirements, provide Wattstopper DT-200, DT-300, DW-100, DW-200, WT-1100, WT-2255, WT-2205, WT-605, or a comparable product by one of the following:

1. Building Automation.

2. Hubbell Lighting.

3. Leviton Mfg. Company Inc.

4. Cooper Lighting Controls.

5. RAB Lighting, Inc.

6. Sensor Switch, Inc.

7. The Wattstopper.

8. GE Total Lighting Controls.

B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.

3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.

4. Mounting:

a. Sensor: Suitable for mounting in any position on a standard outlet box.

b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.

c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

6. Bypass Switch: Override the on function in case of sensor failure.

7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.

C. Ultrasonic or Microphonic Types: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12-inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12-inches/s (305 mm/s).

2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. (56 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. (186 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling in a corridor not wider than 14 feet (4.3 m).

D. Dual-Technology Type: Ceiling or wall mounting; detect occupancy by using a combination of PIR and ultrasonic or microphonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.

2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12-inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12-inches/s (305 mm/s).

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

2.6 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Wattstopper DW-100, DW-103, DW-200, DW-203 (to match function indicated on the drawings) or comparable product by one of the following:

1. Sensor Switch, Inc.
2. Cooper Lighting.
3. Schneider.
4. Hubbell.

B. General Description: Wall-mounting, solid-state units suitable for mounting in a single-gang switchbox

1. Operation:
   a. Occupancy Sensor: Automatic-on when coverage area is occupied, and automatic-off when unoccupied.
   b. Vacancy Sensor: Manual-on when coverage area is occupied, and automatic-off when unoccupied.
   c. Time Delay for turning lights off, adjustable over a minimum range of 1 to 30 minutes in 1-minute increments. Default setting: 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A.
3. Mounting:
   a. Sensor: Suitable for mounting in a standard outlet box.
   b. Time-Delay and Sensitivity Adjustments: Recessed and concealed.
4. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
5. Bypass Switch: Override the on function in case of sensor failure.
6. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.

C. Dual-Technology Type: Wall mounting; detect occupancy by using a combination of PIR and ultrasonic or microphonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: separate for each sensing technology.

2. Detector Sensitivity: Detect occurrences of 6-inch (150 mm) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12-inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12-inches/s (305 mm/s).

3. Detection Coverage: (Standard Room): Detect occupancy anywhere within a 15 foot radius (4572 mm) when wall mounted at 48-inches (1220 mm) above finished floor.

2.7 DIMMER SWITCHES

A. Dimmer switches shall be modular, full-wave, solid-state units with integral, quiet on/off switches and audible and electromagnetic noise filters. Dimmer switches shall be sized by the Contractor to serve the load indicated on the Contract Drawings.

1. Control: Continuously adjustable slide. Single-pole or three-way switch to suit connections. Comply with UL 1472.

2. Led Lamp Dimmers: Modular; compatible with led dimming drivers; dimmer-driver combination capable of consistent dimming with a low end not greater than 1 percent full brightness.

2.8 LIGHTING CONTACTORS

A. Basis of Design Product: Subject to compliance with requirements, provide ASCO; 918series with solid-state control module for 2 wire control with number of poles and ratings as indicated on the drawing, or a comparable product by one of the following:

1. Square D; Schneider Electric.

2. Allen-Bradley/Rockwell Automation.

B. Description: Electrically operated and mechanically held, combination type with nonfused disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).

2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.

3. Enclosure: Comply with NEMA 250.

4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

C. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.

1. Monitoring: On-off status.

2. Control: On-off operation.

2.9 EMERGENCY SHUNT RELAY

A. Basis-of-Design Product: Subject to compliance with requirements, provide Bodine or comparable product by one of the following:

1. Lighting Control and Design, Inc.

2. Nine Twenty Four.

B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 1008 and/or UL 924.

1. Coil Rating: 120 / 277 V.

2.10 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 24 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2-inch (13 mm).

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.

2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.

2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

C. Prepare test and inspection reports.

3.6 ADJUSTING

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

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.

2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.

3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

DIVISION 26 SECTION 262416
PANELBOARDS
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SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1. RELATED DOCUMENTS

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

1.2. SUMMARY

A. This Section includes distribution panelboards, lighting and power panelboards and fusible circuit breaker panelboards with associated auxiliary equipment rated 600 V and less.

B. Related Sections include the following:

1. Division 26 Section "Common Work Results for Electrical" for general materials and installation methods.

2. Division 26 Section "Electrical Identification" for labeling materials.

1.3. SUBMITTALS

A. Product Data: For each type of panelboard, accessory item, and component specified.

B. Shop Drawings: For panelboards. Include dimensioned plans, sections, and elevations. Show tabulations of installed devices, major features, and voltage rating. Include the following:

1. Enclosure type with details for types other than NEMA 250, Type 1.

2. Bus configuration and current ratings.

3. Short-circuit current rating of panelboard.

4. Features, characteristics, ratings, and factory settings of individual protective devices and auxiliary components.

5. Wiring Diagrams: Details of schematic diagram including control wiring and differentiating between manufacturer-installed and field-installed wiring.

C. Qualification Data: For firms and persons specified in *Quality Assurance* Article.

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

E. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

F. Maintenance Data: For panelboard components to include in the Operation and Maintenance Manuals specified in Division 01.

G. Project Record Data: Record actual locations of products, indicated actual branch circuit arrangement.

1.4. QUALITY ASSURANCE

A. Testing Agency Qualifications: In addition to the requirements specified in Division 01 Section *Quality Control* an independent testing agency shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or shall be a full member company of the International Electrical Testing Association.

1. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association or National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3 of this Section.

B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms *Listed* and Labeled: As defined in the National Electrical Code, Article 100.

2. Listing and Labeling Agency Qualifications: A *Nationally Recognized Testing Laboratory* as defined in OSHA Regulation 1910.7.

C. Comply with NFPA 70, *National Electrical Code*.

D. Comply with NEMA AB1, *Molded Case Circuit Breakers*.

E. Comply with NEMA PB1, *Panelboards*.

F. Comply with NEMA PB1.1, *Instructions for Safe Installation, Operation & Maintenance of Panelboards Rated 600 Volts or Less.*

1.5. EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: 2 spares of each type for panelboard cabinet lock.

2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.

3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6. DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.7. PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).

b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.

2. Altitude not exceeding 6600 feet (2000 m).

1.8. COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1. GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548 "Seismic Controls for Electrical Systems."

B. Enclosures: Flush- and surface-mounted cabinets. Piano hinged doors and covers.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.

b. Outdoor Locations: NEMA 250, Type 4.

c. Kitchen Wash-Down Areas: NEMA 250, Type 4X, stainless steel.

d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2. Hinged Front Cover: Entire front trim piano hinged to box and with piano hinged door within hinged trim cover.
3. Finishes:

a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.

b. Back Boxes: Same finish as panels and trim.

4. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.

5. Multiple-Section Panelboards shall consist of two or more cabinets with identical interiors mounted under separate trims. Cabinets, trim, and doors shall be of the same size. Main lugs and busses of each section shall be rated as indicated on the Drawings. Where main breakers are indicated in multi-section panelboards, the main breaker shall be contained in one section with through-feed lugs and sub-feed cables installed within panel, equal to the incoming feeder size. All busses and lugs shall have ampere capacity equal to or greater than the main breaker ampere rating. Loads shall be divided as evenly as practical between the sections, in addition to being balanced over the phases.

C. Incoming Mains Location: Top and bottom.

D. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.

4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.

2. Main and Neutral Lugs: Compression type.

3. Ground Lugs and Bus-Configured Terminators: Compression type.

4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

6. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2. PERFORMANCE REQUIREMENTS

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

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

2.3. DISTRIBUTION PANELBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:

1. Eaton Corp.; Cutler-Hammer.
2. Siemens Energy & Automation, Inc.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Piano hinged doors and covers. Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches (914 mm high, provide two latches, keyed alike.

D. Mains: Circuit breaker or Lugs only, as indicated.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

2.4. LIGHTING AND APPLIANCE PANELBOARDS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:

1. Eaton Corp.; Cutler-Hammer.

2. Siemens Energy & Automation, Inc.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only, as indicated.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Piano hinged doors and covers. Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.5. DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:

1. Eaton Corp.; Cutler-Hammer.

2. Siemens Energy & Automation, Inc.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 100A through 225A, field adjustable short-time and continuous current setting for frame sizes 250A and larger.

a. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

b. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

c. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).

d. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.

e. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

1) Standard frame sizes, trip ratings, and number of poles.

2) Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.

3) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.

4) Shunt Trip: 120 -V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.

5) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

6) Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.

7) Multipole units enclosed in a single housing or factory assembled to operate as a single unit.

8) Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

9) Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.6. ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation per manufacturer's recommendations.

B. Portable Test Set: Provide for testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1. INSTALLATION

A. Install panelboards and accessory items according to NEMA PB 1.1.

B. Mounting: Plumb and rigid without distortion of box. Mount flush panelboards uniformly flush with wall finish.

C. Install filler plates in unused spaces.

D. Wiring in Panelboard Gutters: Arrange conductors into groups, and bundle and wrap with wire ties after completing load balancing.

E. Two or three pole circuit breakers shall be common trip type. Single pole breakers with handle ties will not be permitted.

F. Tandem circuit breakers will not be permitted.

G. Multiple-section panelboards, as required by number of branch circuit breakers, shall consist of two or more cabinets with identical interiors mounted under separate trims. Cabinets, trims, and doors shall be the same size. Main lugs and busses of each section shall be rated as indicated on the Drawings. Where main breakers are indicated in multi-section panelboards the main breaker shall be contained in one section with feed-through lugs and sub-feed cables installed within panel, equal to the incoming feeder size. All buses and lugs shall have ampere capacity equal to or greater than the main breaker ampere rating. Loads shall be divided as evenly as practical between the sections in addition to being balanced over the phases.

H. Provide ground buses in panelboards as indicated on the Drawings. Ground bus shall be similar in all respects to neutral bus.

I. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289, *Application Guide for Ground Fault Circuit Interrupters.*

J. Branch circuit breakers (or switches) serving clocks, telephone and communications equipment, refrigerators, exit signs, fire alarm system controls, etc., shall be equipped with lock clips to prevent accidental operation.

K. Branch circuit breakers serving electric water coolers shall be GFCI type for personnel protection (5mA).

L. Branch circuit breakers serving vending machines shall be GFCI type for personnel protection (5mA).

M. Branch circuit breakers serving receptacles and appliances located under kitchen ventilation hoods shall be equipped with shunt-trip mechanisms.

N. Height: Six-feet, six-inches to top of panelboard; install panelboards taller than 6 feet with bottom no more than 4 inches above the floor. Top breaker maximum height not to exceed 6 feet 8 inches.

O. Do not energize or connect service-entrance equipment and panelboards to their sources until surge protective devices are properly installed and connected.

3.2. IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section “Electrical Identification”.

B. Panelboard Nameplates: Label each panelboard with engraved laminated-plastic or metal nameplates mounted with corrosion-resistant screws.

C. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Panelboard Circuit Directories: Provide a typewritten directory, indicating plainly what each branch circuit of the panelboard serves and where. Provide additional information as required by NEC. Spaces and spare breakers shall be written in pencil. Copying of Contract Drawing Panel Schedules and Descriptions shall not be acceptable. Circuit directory shall reflect final circuit connections, loads and locations after balancing of panelboard loads.

3.3. GROUNDING

A. Make equipment grounding connections for panelboards as indicated.

B. Provide ground continuity to main electrical ground bus as indicated.

3.4. CONNECTIONS

A. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Neutral and ground conductors shall be isolated and terminated only at their respective bus bars. There shall only be one neutral-ground connection in service-entrance equipment by means of a removable main bonding jumper. Neutral and ground terminations at one bus bar shall not be acceptable.

3.5. FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Make insulation-resistance tests of each panelboard bus, component, and connecting supply, feeder, and control circuits.

2. Make continuity tests of each circuit.

3. Provide set of Contract Documents to test organization. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in the original Contract Documents.

B. Testing Agency: Provide services of a qualified independent testing agency to perform specified testing.

C. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units, and retest.

3. Reports by Testing Organization: Report written reports of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made.

4. Labeling: Upon satisfactory completion of tests and related effort, apply a label to tested components indicating results of tests and inspections, responsible organization and person, and date.

5. Protective Device Ratings and Settings: Verify indicated ratings and settings to be appropriate for final system configuration and parameters. Where discrepancies are found, recommend final protective device ratings and settings. Use accepted ratings or settings to make the final system adjustments.

D. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.

2. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.

3. Check panelboard mounting, area clearances, and alignment and fit of components.

4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.

5. Perform visual and mechanical inspection and related work for over-current protective devices.

6. Verify that all neutral conductors are bonded to the system ground at the service-entrance prior to installation of the surge protective device.

7. Verify that neutral-ground bonds do not exist at locations that are not service entrances or separately derived power sources.

E. Electrical Tests: Include the following items performed in accordance with manufacturer's instructions:

1. Insulation resistance test of buses and portions of control wiring that is disconnected from solid-state devices. Insulation resistance less than 100 megohms is not acceptable.

2. Ground resistance test on system and equipment ground connections.

3. Test main and subfeed over-current protective devices.

4. Test phase loss relay(s) at panelboards to verify that phase loss relays are fully operational.

F. Retest: Correct deficiencies identified by tests and observations and provide retesting of panelboards by testing organization. Verify by the system tests that the total assembly meets specified requirements.

3.6. ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.

2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.

3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.

4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.7. PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.8. CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

END OF SECTION

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MOTOR-CONTROL CENTERS
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SECTION 262419 - MOTOR-CONTROL CENTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes modifications to existing MCCs for use with ac circuits rated 600 V and less, with combination controllers and having the following factory-installed components:

1. Feeder-tap units.

2. Auxiliary devices.

1.3 DEFINITIONS

A. CPT: Control power transformer.

B. MCC: Motor-control center.

C. MCCB: Molded-case circuit breaker.

D. OCPD: Overcurrent protective device.

E. PT: Potential transformer.

F. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for MCCs.

2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories for each cell of the MCC.

B. Shop Drawings: For each MCC, manufacturer's production drawings as defined in UL 845. In addition to requirements specified in UL 845, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.

b. Factory-installed devices.

c. Enclosure types and details.

d. Nameplate legends.

e. Short-circuit current (withstand) rating of complete MCC, and for bus structure and each unit.

f. Features, characteristics, ratings, and factory settings of each installed controller and feeder device, and installed devices.

g. Specified optional features and accessories.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring for each installed controller.

3. Nameplate legends.

4. Features, characteristics, ratings, and factory settings of each installed unit.

1.5 INFORMATIONAL SUBMITTALS

A. Standard Drawings: For each MCC, as defined in UL 845.

B. Production Drawings: For each MCC, as defined in UL 845.

C. Qualification Data: For testing agency.

D. Seismic Qualification Data: Certificates, for MCCs, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Product Certificates: For each MCC.

F. Source quality-control reports.

G. Field quality-control reports.

H. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For MCCs, all installed devices, and components to include in emergency, operation, and maintenance manuals.

1. Manufacturer's Record Drawings: As defined in UL 845. In addition to requirements specified in UL 845, include field modifications and field-assigned wiring identification incorporated during construction by manufacturer, Contractor, or both.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

2. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain MCCs and controllers of a single type from single source from single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, and marked for intended use.

D. UL Compliance: MCCs shall comply with UL 845 and shall be listed and labeled by a qualified testing agency.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Handle MCCs according to the following:

1. NECA 402, "Recommended Practice for Installing and Maintaining Motor Control Centers."

2. NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600 Volts."

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace new MCC units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Provide modifications to existing Allen Bradley motor control centers as required to accommodate new devices, including but not limited, new buckets. All new components shall match existing.

2.2 SYSTEM DESCRIPTION

A. NEMA Compliance: Fabricate and label MCCs to comply with NEMA ICS 18.

B. Ambient Environment Ratings:

1. Ambient Temperature Rating: Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F (40 deg C), with an average value not exceeding 95 deg F (35 deg C) over a 24-hour period.

2. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)

3. Humidity Rating: Less than 95 percent (noncondensing).

4. Altitude Rating: Not exceeding 6600 feet (2000 m), or 3300 feet (1000 m) if MCC includes solid-state devices.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1. Controller-Mounted Auxiliary Devices:

a. Feeder Tap Units: Main Disconnect: Fusible switch, UL 98, three pole.

2.3 ASSEMBLY

A. Structure:

1. Units up to and including Size 3 shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.

2. Units in Type B and Type C MCCs shall have pull-apart terminal strips for external control connections.

3. Pull Boxes:

a. Include provisions for ventilation to maintain temperature in pull box within same limits as the MCC.

b. Set the box back from front to clear circuit-breaker removal mechanism.

c. Covers: Removable covers forming top, front, and sides.

d. Insulated bottom of fire-resistive material with separate holes for cable drops into MCC.

e. Cable Supports: Arranged to facilitate cabling and adequate to support cables, including supports for future cables.

f. When equipped with barriers, supply with access to check bus bolt tightness.

B. Compartments: Modular; individual doors with concealed hinges and quick-captive screw fasteners.

1. Interlock compartment door to require that the disconnecting means is "off" before door can be opened or closed, except by operating a concealed release device.

2. Compartment construction shall allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC.

3. The same-size compartments shall be interchangeable to allow rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

C. Bus Transition and Incoming Pull Sections: Included and aligned with the structure of the MCC.

D. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC; same-size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

E. Wiring Spaces:

1. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.

F. Integrated Short-Circuit Rating:

1. Short-Circuit Current Rating for Each Unit: Fully rated; 100 kA.

G. Factory-Installed Wiring: Factory installed, with bundling, lacing, and protection included. Use flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.4 FEEDER TAP UNITS

A. MCCBs (to 1200 A): Fixed mounted, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger. Comply with UL 489, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

1. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

B. Fusible Switches (to 600 A): Fixed-mounted, manually operated, fusible, quick-make, quick-break switch with 200-kA interrupting and short-circuit current rating when fitted with UL 248-8 Class J fuses. Comply with UL 98.

1. Indication whether the switch is open or closed, and provisions for padlocking the operating handle.

2. Include fuse clips and fuses.

3. Electrically tripped switches shall include the following:

a. Shunt trip.

b. Ground-fault protection, with adjustable time delay and test panel.

c. Single-phase protection, tripping the switch on loss of a source phase.

d. Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.

2.5 SOURCE QUALITY CONTROL

A. MCC Testing: Test and inspect existing MCCs according to requirements in NEMA ICS 18 prior to performing any modifications. Report any deficiencies in writing to owner. Retest after new units are installed.

B. MCCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine existing MCCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. NEMA Industrial Control and Systems Standards: Comply with parts of NEMA ICS 2.3 for installation and startup of MCCs.

B. Install fuses in each fusible switch.

C. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

D. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification of MCC, MCC components, and control wiring.

1. Identify field-installed conductors, interconnecting wiring, and components.

2. Mark up a set of manufacturer's connection wiring diagrams for new units with field-assigned wiring identifications and return to manufacturer for inclusion in Record Drawings.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between master terminal boards and remote devices. Bundle, train, and support wiring in enclosures.

3.5 CONNECTIONS

A. Comply with requirements for installation of conduit in Section 260533 "Raceways and Boxes for Electrical Systems." Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

4. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multipole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.

b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Submit calibration record for device.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

6. Mark up a set of manufacturer's drawings with all field modifications incorporated during construction and return to manufacturer for inclusion in Record Drawings.

D. MCCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to NETA Acceptance Testing Specification and manufacturer's written instructions.

3.8 ADJUSTING

A. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION

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WIRING DEVICES
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SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Weather-resistant receptacles.
3. Wall-switch.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Floor Service-Outlet Assemblies: One for every 10, but no fewer than one.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:

1. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).

2. Leviton Mfg. Company Inc. (Leviton).

3. Pass & Seymour/Legrand (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.

2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Hubbell; HBL5351 (single), HBL5352 (duplex).

b. Leviton; 5891 (single), 5352 (duplex).

c. Pass & Seymour; 5361 (single), 5362 (duplex).

2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, non-feed-through type.

2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.

3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements provide one of the following:

a. Hubbell; GFR5352L.

b. Pass & Seymour; 2095.

c. Leviton; 7590.

2.5 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Single Pole:

i. Hubbell; HBL1221.
ii. Leviton; 1221-2.

iii. Pass & Seymour; CSB20AC1.

b. Three Way:

i. Hubbell; HBL1223.

ii. Leviton; 1223-2.

iii. Pass & Seymour; CSB20AC3.

C. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors.

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Hubbell; HBL1557.

   b. Leviton; 1257.

   c. Pass & Seymour; 1251.

D. Pilot Light Switches; 20 A:

1. Products: Subject to compliance with requirements, provide one of the following:

   a. Hubbell; HBL 120PL for 120 and 277 V.

   b. Leviton; 1221-LH1.

   c. Pass & Seymour; PS20AC1RPL for 120 V, PS20AC1RPL7 for 277 V.

2. Description: Single pole, with neon-lighted handle, illuminated when switch is “off”.

2.6 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.

2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel.

3. Material for Unfinished Spaces: Galvanized steel.

4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.7 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: Brown unless otherwise indicated or required by NFPA 70 or device listing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.

3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.

4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.

2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.

3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

4. Existing Conductors:

a. Cut back and pigtail, or replace all damaged conductors.

b. Straighten conductors that remain and remove corrosion and foreign matter.

c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.

2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.

4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.

5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.

6. Use a torque screwdriver when a torque is recommended or required by manufacturer.

7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.

8. Tighten unused terminal screws on the device.

9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of floor service outlets to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.

2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.

2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.

3. Ground Impedance: Values of up to 2 ohms are acceptable.

4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.

5. Using the test plug, verify that the device and its outlet box are securely mounted.

6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION

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SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches, and enclosed controllers.

2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

   a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.

   b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.

3. Current-limitation curves for fuses with current-limiting characteristics.

4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

5. Coordination charts and tables and related data.

6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.

2. Current-limitation curves for fuses with current-limiting characteristics.

3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.7 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.8 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Bussmann, Inc.

2. Edison Fuse, Inc.

3. Ferraz Shawmut, Inc.

4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.

2. Finish: Gray, baked enamel.

3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.

4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Feeders: Class J, time delay.

2. Motor Branch Circuits: Class RK1, time delay.

3. Other Branch Circuits: Class RK1, time delay.

4. Control Circuits: Class CC, time delay.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s).

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

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SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

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

1.5 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.

2. Current and voltage ratings.

3. Short-circuit current ratings (interrupting and withstand, as appropriate).

4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

5. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit

2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

2. Fuse Pullers: Two for each size and type.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).

2. Altitude: Not exceeding 6600 feet (2010 m).

1.11 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:

1. Siemens Energy & Automation, Inc.

2. General Electric Company – GE Commercial & Industrial Electrical Distribution.

3. Eaton Electrical, Inc.; Cutler-Hammer Business Unit.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

1. Siemens Energy & Automation, Inc.

2. General Electric Company – GE Commercial & Industrial Electrical Distribution.

3. Eaton Electrical, Inc.; Cutler-Hammer Business Unit.

C. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.

5. Hookstick Handle: Allows use of a hookstick to operate the handle.

6. Lugs: Compression type, suitable for number, size, and conductor material.

7. Service-Rated Switches: Labeled for use as service equipment.

8. Accessory Control Power Voltage: Remote mounted and powered120-V ac. Provide as required with auxiliary conduit kit.

2.2 NONFUSIBLE SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:

1. Siemens Energy & Automation, Inc.

2. General Electric Company – GE Commercial & Industrial Electrical Distribution.

3. Eaton Electrical, Inc.; Cutler-Hammer Business Unit.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.

4. Hookstick Handle: Allows use of a hookstick to operate the handle.

5. Lugs: Compression type, suitable for number, size, and conductor material.

6. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac. Provide as required with auxiliary conduit kit.

2.3 RECEPTACLE SWITCHES

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:

1. Siemens Energy & Automation, Inc.

2. General Electric Company – GE Commercial & Industrial Electrical Distribution.

3. Eaton Electrical, Inc.; Cutler-Hammer Business Unit.

B. Type HD, Heavy-Duty, Single-Throw Nonfusible Switch: 600-V ac, UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

C. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.

D. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

2.4 SHUNT TRIP SWITCHES

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

1. Cooper Bussmann, Inc.
2. Ferraz Shawmut, Inc.
3. Littelfuse, Inc.

B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.

C. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.

E. Accessories:

1. Oiltight key switch for key-to-test function.
2. Oiltight red ON pilot light.
3. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
4. Form C alarm contacts that change state when switch is tripped.
5. Three-pole, double-throw, fire-safety and alarm relay; 120-V ac coil voltage.
6. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

2.5 MOLDED-CASE CIRCUIT BREAKERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:

1. Siemens Energy & Automation, Inc.
2. General Electric Company – GE Commercial & Industrial Electrical Distribution.
3. Eaton Electrical, Inc.; Cutler-Hammer Business Unit.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250A and larger.

D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

E. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

F. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

G. Features and Accessories:

1. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.

2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.

3. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.

4. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

5. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.6 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.

2. Outdoor Locations: NEMA 250, Type 3R.

3. Kitchen Wash-Down Areas: NEMA 250, Type 4X, stainless steel.

4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4X, stainless steel.

5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

6. Hazardous Areas Indicated on Drawings: NEMA 250,Type 9.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in fusible devices.

D. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

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

C. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

END OF SECTION

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SECTION 262913 - ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes the following enclosed controllers rated 600 V and less:

1. Full-voltage manual.

2. Full-voltage magnetic.

B. Related Section:

1. Division 23 for Variable-Frequency Motor Controllers for general-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.

1.3 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. N.C.: Normally closed.

E. N.O.: Normally open.

F. OCPD: Overcurrent protective device.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

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

1.5 ACTION SUBMITTALS

A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

1. Show tabulations of the following:

a. Each installed unit's type and details.

b. Factory-installed devices.

c. Nameplate legends.

d. Short-circuit current rating of integrated unit.

e. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.

2. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

D. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for enclosed controllers and installed components.

2. Manufacturer's written instructions for setting field-adjustable overload relays.

1.8 MATERIALS MAINTENANCE SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

2. Indicating Lights: Two of each type and color installed.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

1.10 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
2. Altitude: Not exceeding 6600 feet (2010 m).

1.12 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 FULL-VOLTAGE CONTROLLERS

A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

B. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:

   a. Siemens Energy & Automation, Inc.

   b. General Electric Company, GE Commercial & Industrial Electrical Distribution.

   c. Eaton Electrical, Inc.; Cutler-Hammer Business Unit.

2. Configuration: Nonreversing.

3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.

4. Surface mounting.

5. Red pilot light.

6. Hand-Off-Automatic Selector Switch

C. Magnetic Controllers: Full voltage, across the line, electrically held.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:

   a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
   b. Siemens Energy & Automation, Inc.

2. Configuration: Nonreversing.

3. Contactor Coils: Pressure-encapsulated type.

   a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

   a. CPT Spare Capacity: 50 VA.

6. Solid-State Overload Relay:

   a. Switch or dial selectable for motor running overload protection.

   b. Sensors in each phase.

   c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

D. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Square D; a brand of Schneider Electric or comparable product by one of the following:

   a. Siemens Energy & Automation, Inc.

   b. General Electric Company, GE Commercial & Industrial Electrical Distribution.

   c. Eaton Electrical, Inc.; Cutler-Hammer Business Unit.

2. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

3. Nonfusible Disconnecting Means:

   a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.

   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

2.2 ENCLOSURES

A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.

2. Outdoor Locations: Type 3R.

3. Kitchen Wash-Down Areas: Type 4X stainless steel.

4. Other Wet or Damp Indoor Locations: Type 4X stainless steel.

5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

6. Hazardous Areas Indicated on Drawings: Type 9.

2.3 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty type.

a. Push Buttons: types; maintained as indicated.

b. Pilot Lights: LED type; Red for “power available”, green for “running”; push to test.

B. Control Relays: Two (2) N.O./N.C. auxiliary contacts, and adjustable solid-state time-delay relays as required by automation and control sequences.

C. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings, with automatic reset. Provide ICM Controls ICM450 or approved equal, in a separate enclosure (NEMA rating to match controller).

D. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

E. Cover gaskets for Type 1 enclosures.

F. Terminals for connecting power factor correction capacitors to the line side of overload relays.

G. Hand-Off-Automatic Selector Switch, NEMA ICS2, heavy-duty type.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight

structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

D. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

E. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

F. Install power factor correction capacitors. Connect to the line side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.

G. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved nameplate.

3. Label each enclosure-mounted control and pilot device.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.

2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.

2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.

3. Test continuity of each circuit.

4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).

5. Test each motor for proper phase rotation.

6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Enclosed controllers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B. Set the taps on reduced-voltage autotransformer controllers at 50 percent.

C. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage solid-state controllers.

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.

B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION

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INTERIOR LIGHTING
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SECTION 265100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.
5. Exterior building mounted fixtures.

1.3 DEFINITIONS

A. BF: Ballast factor.

B. CCT: Correlated color temperature.

C. CRI: Color-rendering index.

D. LER: Luminaire efficacy rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting fixture, including ballast housing if provided.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
3. Ballast, including BF.
4. Energy-efficiency data.
5. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.

6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.

   a. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom lighting fixtures. Include plans, elevations, sections, details, and attachments to other work.

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

   2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples: For each lighting fixture indicated in the Interior Lighting Fixture Schedule. Each Sample shall include the following:

   1. Lamps and ballasts, installed.

   2. Cords and plugs.

   3. Pendant support system.

D. Installation instructions.

E. Samples: For each lighting fixture indicated in the Interior Lighting Fixture Schedule. Each Sample shall include the following:

   1. Lamps and ballasts, installed.

   2. Cords and plugs.

   3. Pendant support system.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

B. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.

C. Field quality-control reports.

D. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.

2. Plastic Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type

3. Fluorescent-fixture-mounted, emergency battery pack: One for every 20 emergency lighting unit

4. Ballasts: One for every 100 of each type and rating installed. Furnish at least one of each type.

5. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

6. LED Modules (light engine and driver): Furnish at least (1) of each type.

1.8 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

1.9 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.10 WARRANTY

A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Emergency Lighting Unit Batteries: Ten (10) years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine (9) years.

2. Warranty Period for Emergency Fluorescent Ballast and Self-Powered Exit Sign Batteries: Seven (7) years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six (6) years.

1.11 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.

2. Plastic Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.

3. Battery and Charger Data: One for each emergency lighting unit.

4. Ballasts: One for every 100 of each type and rating installed. Furnish at least one of each type.

5. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

6. LED Modules (light engine and driver): Furnish at least (1) of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In Interior Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection.

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are limited to manufacturers specified, or equal per Lighting Fixture Schedule.

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

C. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.

D. Metal Parts: Free of burrs and sharp corners and edges.

E. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

G. Diffusers and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

   a. Lens Thickness: At least 0.125-inch (3.175 mm) minimum unless otherwise indicated.
   b. UV stabilized.

2. Glass: Annealed crystal glass unless otherwise indicated.

H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp and ballast characteristics:

   a. "USE ONLY" and include specific lamp type.

   b. Lamp diameter code (T-4, T-5, T-8, T-12, etc.), tube configuration (twin, quad, triple, etc.), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.

   c. Lamp type, wattage, bulb type (ED17, BD56, etc.).

   d. Start type (preheat, rapid start, instant start, etc.) for fluorescent and compact fluorescent luminaires.
   e. CCT and CRI for all luminaires.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

A. General Requirements for Electronic Ballasts:

1. Comply with UL 935 and with ANSI C82.11.

2. Designed for type and quantity of lamps served.

3. Ballasts shall be designed for full light output unless another BF, dimmer, or bi-level control is indicated.

4. Sound Rating: Class A.

5. Total Harmonic Distortion Rating: Less than 10 percent.

6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.

7. Operating Frequency: 42 kHz or higher.

8. Lamp Current Crest Factor: 1.7 or less.

9. BF: 0.87.

10. Power Factor: 0.98 or higher.

11. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.

12. Ballast shall have minimum starting temperature of -0 deg F (-18 deg C) for standard T8 lamps, and 60 deg F (16 deg C) for Energy Saving T8 lamps.

13. Ballast shall contain anti-striation circuitry.

14. Ballast shall meet NEMA/CEE high performance T8 lighting system specifications.

15. Ballast shall be Advance Transformer “Optanium” or approved equal.

B. Luminaires controlled by occupancy or vacancy sensors shall have programmed-start ballasts.

C. Electronic Programmed-Start Ballasts for T5 and T5HO Lamps: Comply with ANSI C82.11 and the following:

1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.

2. Automatic lamp starting after lamp replacement.

D. Ballasts for Low-Temperature Environments:

1. Temperatures 0 Deg F (Minus 17 Deg C) and Higher: Electronic type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.

E. Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.

1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.

a. High-Level Operation: 100 percent of rated lamp lumens.

b. Low-Level Operation: 30 percent of rated lamp lumens.

2. Ballast shall provide equal current to each lamp in each operating mode.

3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

2.4 EMERGENCY FLUORESCENT POWER UNIT

A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.

1. Emergency Connection: Operate one fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.

2. Nightlight Connection: Operate one fluorescent lamp continuously.

3. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.

a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.

b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

4. Battery: Sealed, maintenance-free, nickel-cadmium type.

5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.

6. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

B. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more fluorescent lamps, remote mounted from lighting fixture. Comply with UL 924.

1. Emergency Connection: Operate one fluorescent lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.

2. Nightlight Connection: Operate one fluorescent lamp in a remote fixture continuously.

3. Battery: Sealed, maintenance-free, nickel-cadmium type.

4. Charger: Fully automatic, solid-state, constant-current type.

5. Housing: NEMA 250, Type 1 enclosure.

6. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.

7. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

8. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.5 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.

2.6 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, nickel metal hydride type.

2. Charger: Fully automatic, solid-state type with sealed transfer relay.

3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.

5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.

7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.7 LED LUMINAIRES

A. A LED luminaire consists of LED light engine and driver, heat-sink, fixture housing, and optic assembly where applicable.

1. Temperature: Minimum starting temperature of -30 deg C (-22 deg F), minimum 40 deg C (104 deg F) ambient temperature rating.

2. Life and Lumen Maintenance: Plus 50,000 hours rated life at greater than 70% lumen maintenance.

3. CRI and CCT: 3500 deg K (+/- 275 K) CCT and greater than 80 CRI.

4. Transient Voltage Protection: Rated to withstand 10 kV of transient line surge.

5. Photometric Data and Test Reports: Comply with IESNA LM-79-08, IESNA LM-80-08, and ANSI C78.377-08.

6. Radio Frequency Interference: Comply with CAP 106B Telecommunications (Control of Interference) Regulations.

7. Luminaires and components thereof shall comply with UL 8750 Standard of Safety.

8. Five-year warranty on luminaire including LED light engine and driver.

9. Power Factor: 90 percent minimum.

10. Total Harmonic Distortion Rating: Less than 20 percent.

11. RoHS compliant.

12. Sound Rating: Class A.

13. Overload, short circuit, and thermal protection.

14. LED luminaires must be listed with the Design Lights Consortium or Energy Star Qualified Products list.

2.8 FLUORESCENT LAMPS

A. T8 rapid-start lamps, rated 32 W maximum, nominal length of 48 inches (1220 mm), 3100 initial lumens (minimum), CRI 85 (minimum), color temperature 4100 K, and average rated life 30,000 hours (at 12 hours per start) unless otherwise indicated. Provide Philips “Advantage” or approved equal.

B. T8 rapid-start lamps, rated 17 W maximum, nominal length of 24 inches (610 mm), 1500 initial lumens (minimum), CRI 85 (minimum), color temperature 4100 K, and average

rated life of 30,000 hours (at 12 hours per start) unless otherwise indicated. Provide Philips “Advantage” or approved equal.

C. T8 rapid-start lamps, rated 40 W maximum, nominal length of 60 inches (1520 mm), 3725 initial lumens (minimum), CRI 85 (minimum), color temperature 4100 K, and average rated life 30,000 hours (at 12 hours per start) unless otherwise indicated. Provide Philips “800 Series” or approved equal.

D. T5 rapid-start lamps, rated 25 W maximum, nominal length of 45.2 inches (1150 mm), 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 4100 K, and average rated life of 40,000 hours (at 12 hour start) unless otherwise indicated. Provide Philips “Energy Advantage” or approved equal.

E. T5HO rapid-start, high-output lamps, rated 50 W maximum, nominal length of 45.2 inches (1150 mm), 5000 initial lumens (minimum), CRI 85 (minimum), color temperature 4100 K, and average rated life of 20,000 hours unless otherwise indicated. Provide Philips “Energy Advantage” or approved equal.

2.9 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Section 260529 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage (2.68 mm).

F. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures:

1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.

2. Install lamps in each luminaire.

B. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.

C. Remote Mounting of Ballasts: Distance between the ballast and fixture shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.

D. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.

1. Install ceiling Solid #12AWG safety wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.

2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.

3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.

4. Install at least one independent support wire from structure to a tab on lighting fixture. Wire shall have breaking strength of the weight of fixture at a safety factor of 3.

E. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.

2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.

3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 IDENTIFICATION

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Verify that self-luminous exit signs are installed according to their listing and the requirements in NFPA 101.

C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.4 STARTUP SERVICE

A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.

1. Adjust aimable luminaires in the presence of Architect.

END OF SECTION

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FIRE-ALARM SYSTEM
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SECTION 283111 – FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This specification provides the requirements for the installation, programming and configuration of an extension of the existing Fire Alarm System. The system shall include, but not be limited to: Fire Alarm Control Panel, Automatic and Manually activated alarm Initiating and Indicating Peripheral Devices and Appliances, conduit, wire and accessories required to furnish a complete and operational Fire Alarm System. System shall include, but not be limited to, the following:

1. System smoke detectors.
2. Heat detectors.
3. Carbon monoxide detectors.
4. Notification appliances.
5. Addressable interface device.

B. The system shall include all wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, alarm initiating devices, alarm indicating devices, and control equipment, and all other accessories and miscellaneous items required for an operating system.

C. The Fire Alarm System supplied under this specification shall be a microprocessor-based network system. All Control Panel Assemblies and connected Field Appliances shall be both designed and manufactured by the same company, and shall be tested and cross-listed as compatible to ensure that a fully functioning Life Safety System is designed and installed.

D. Existing system devices shall be re-used and maintained fully operational unless otherwise noted.

E. *Test system prior to performing any modifications and report any defects, etc. to the owner in writing. Any defects, malfunctions of the system not reported in advance of performing work shall be the responsibility of the contractor to correct.*

F. All related work specified in other sections shall be properly coordinated with the fire alarm equipment.

1.3 REFERENCES

A. The system, equipment, installation, and operation shall comply with the current provisions of the following standards and publications:

1. National Electric Code, Article 70.

2. National Fire Protection Association Standards:

   a. NFPA72 National Fire Alarm Code

   b. NFPA 90A Air Conditioning & Ventilation Systems

   c. NFPA101 Life Safety Code

3. Local and State Building Codes.

4. Local Authorities Having Jurisdiction.

5. Underwriters Laboratories Inc.: The system and all components shall be listed by Underwriters Laboratories Inc. for use in fire protective signaling system under the following standards as applicable:

   a. UL 864/UOJZ, APOU - Control Units for Fire Protective Signaling Systems.

   b. UL 268 - Smoke Detectors for Fire Protective Signaling Systems.

   c. UL 268A - Smoke Detectors for Duct Applications.

   d. UL 217 - Smoke Detectors Single Station.

   e. UL 521 - Heat Detectors for Fire Protective Signaling Systems.

   f. UL 228 - Door Holders for Fire Protective Signaling Systems.

   g. UL 464 - Audible Signaling Appliances.

   h. UL 1638 - Visual Signaling Appliances.

   i. UL 38 - Manually Activated Signaling Boxes.

   j. UL 346 - Waterflow Indicators for Fire Protective Signaling Systems.

   k. UL 1971 - Standard for Signaling Devices for the Hearing Impaired.

   l. UL 1481 - Power Supplies for Fire Protective Signaling Systems.

   m. UL 1711 - Amplifiers for Fire Protective Signaling Systems.

   n. UL Fire Protection Equipment Directory.

o. UL Electrical Construction Materials Directory/

6. Americans with Disabilities Act (ADA)

7. International Standards Organization (ISO)

a. ISO-9000

b. ISO-9001

8. Factory Mutual Approval Guide.

9. State of Delaware Fire Prevention Code.

10. American Insurance Association Fire Protection Code (Article 14).

11. Delaware Occupational Safety & Health Act.

12. International Building Code (IBC).

1.4 DEFINITIONS

A. FACP: Fire Alarm Control Panel.

B. HLI: High Level Interface.

C. NICET: National Institute for Certification in Engineering Technologies.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.

2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.

2. Include plans, elevations, sections, details, and attachments to other work.

3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.

4. Detail assembly and support requirements.

5. Include voltage drop calculations for notification-appliance circuits.

6. Include battery-size calculations.

7. Include input/output matrix.

8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.

9. Include performance parameters and installation details for each detector.

10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.

11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.

    b. Locate detectors according to manufacturer's written recommendations.

12. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.

13. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

14. Submit wiring diagrams for all equipment connected to fire alarm system. Examples are monitoring of hood extinguishing systems, sprinkler systems, HVAC control, damper control, elevator recall and elevator power shunt trip of the elevator system control.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.

    a. Secure permits and approvals prior to installation.

    b. Prior to commencement and after completion of work, notify Authorities Having Jurisdiction.

    c. Submit letter of approval for installation before requesting acceptance of system.

2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.

b. NICET-certified, fire-alarm technician; Level III minimum.

c. Licensed or certified by authorities having jurisdiction.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field quality-control reports.

1.7 WARRANTY

A. For materials and workmanship for a period of two years from final system acceptance.

1.8 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 01 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.

c. Complete wiring diagrams showing connections between all new devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.

d. Riser diagram.

e. Device addresses.

f. Record copy of site-specific software.

g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.

2) Frequency of testing of installed components.

3) Frequency of inspection of installed components.

4) Requirements and recommendations related to results of maintenance.

5) Manufacturer's user training manuals.

h. Manufacturer's required maintenance related to system warranty requirements.

i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.

2. Program Software Backup: On magnetic media or compact disk, complete with data files. A total of two copies shall be provided; one read only type and one writeable type.

3. Device address list.

4. Printout of software application and graphic screens.

5. All passcode information required to make alternations to the Fire Alarm Control Panel.

1.9 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.

2. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.

3. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.

4. Keys and Tools: One extra set for access to locked or tamperproofed components.

5. Audible and Visual Notification Appliances: One of each type installed.

6. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.10 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.11 PROJECT CONDITIONS

A. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.

2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be match the existing system, and operate as one system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Noncoded, UL-certified addressable system, with multiplexed signal transmission and horn/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.

2. Heat detectors.

3. Smoke detectors.

4. Automatic sprinkler system water flow.

5. Fire-extinguishing system operation.

6. Dry system pressure flow switch.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances, including voice evacuation notices.

2. Identify alarm and specific initiating device at fire-alarm control unit, connected network control panels, and remote annunciators.

3. Transmit an alarm signal to the remote alarm receiving station.

4. Unlock electric door locks in designated egress paths.

5. Release fire and smoke doors held open by magnetic door holders.

6. Activate voice/alarm communication system.

7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.

8. Close smoke dampers in air ducts of designated air-conditioning duct systems.

9. Activate emergency shutoffs for gas and fuel supplies.

10. Record events in the system memory.

11. Indicate device in alarm on the graphic annunciator.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.

2. High- or low-air-pressure switch of a dry-pipe or preaction sprinkler system.

3. Duct smoke detectors.

4. Independent fire-detection and -suppression systems.

5. User disabling of zones or individual devices.

6. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.

2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.

3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.

4. Loss of primary power at fire-alarm control unit.

5. Ground or a single break in internal circuits of fire-alarm control unit.

6. Abnormal ac voltage at fire-alarm control unit.

7. Break in standby battery circuitry.

8. Failure of battery charging.

9. Abnormal position of any switch at fire-alarm control unit or annunciator.

10. Voice signal amplifier failure.

E. System Supervisory Signal Actions:

1. Identify specific device initiating the event at fire-alarm control unit, connected network control panels, and remote annunciators.

2. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.

3. Transmit system status to building management system.

4. Display system status on graphic annunciator.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

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

2.4 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.

2. Detectors shall be two-wire type.

3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.

5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.

6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.

7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

   a. Multiple levels of detection sensitivity for each sensor.

   b. Sensitivity levels based on time of day.

B. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.

2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

   a. Primary status.

   b. Device type.

   c. Present average value.

   d. Present sensitivity selected.

   e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.

4. Each sensor shall have multiple levels of detection sensitivity.

5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

6. Relay fan shutdown: fully programmable relay related to interrupt fan motor-control circuit.

2.5 CARBON MONOXIDE DETECTORS

A. Provide carbon monoxide detector listed for connection to fire-alarm system.

1. Mounting: Adapter plate for outlet box mounting.

2. Testable by introducing test carbon monoxide into the sensing cell.

3. Detector shall provide alarm contacts and trouble contacts.

4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.

5. Comply with UL 2075.

6. Locate, mount, and wire according to manufacturer's written instructions.

7. Provide means for addressable connection to fire-alarm system.

8. Test button simulates an alarm condition

2.6 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.

2. Store an internal identifying code for control panel use to identify the module type.

3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts. Provide for all sprinkler flow and tamper switches, and as required.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall, to circuit-breaker shunt trip for power shutdown, etc.

1. Allow the control panel to switch the relay contacts on command.

2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.

2. Operate solenoids for use in sprinkler service.

3. Mute sound system(s).

4. Unlock security doors.

2.7 REMOTE TEST/INDICATING STATION

A. Provide keyed test switch with LED indicating light for each duct detector. Locate 12” below accessible ceiling.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.

2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.

C. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.

2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.

3. Smooth ceiling spacing shall not exceed 30 feet (9 m).

4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A in NFPA 72.

5. HVAC: Locate detectors not closer than 36 inches (910 mm) from air-supply diffuser or return-air opening.

6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

D. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

E. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.

F. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

G. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 PATHWAYS

A. Pathways above recessed ceilings and in non-accessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches (2440 mm) above the floor shall be installed in EMT.

B. Pathways shall be installed in EMT.

C. Exposed EMT shall be painted red enamel.

3.4 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.

2. Magnetically held-open doors.

3. Electronically locked doors and access gates.

4. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.

5. Supervisory connections at valve supervisory switches.

6. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.

7. Data communication circuits for connection to building management system.

C. Each addressable analog loop shall be circuited as shown on the drawings but device loading is not to exceed 80% of loop capacity in order to leave space for future devices.

D. Where it is necessary to interface conventional initiating devices, provide intelligent input modules to supervise Class B zone wiring.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 16075 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual Inspection: Conduct visual inspection prior to testing.

   a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.

   b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.

4. Test audible appliances for the private operating mode according to manufacturer's written instructions.

5. Test visible appliances for the public operating mode according to manufacturer's written instructions.

6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.8 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.9 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

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

END OF SECTION