SPECIFICATIONS
FOR
Omaha Public Schools – McMillan Roof Top HVAC Units Replacement

Location:
McMillan Middle School
3802 Redick Ave.
Omaha, NE 68112

Owner:
Omaha Public Schools
District Operational Services
3215 Cuming Street
Omaha, Nebraska 68131-2024

Design Firm:
Advanced Engineering System
4630 Antelope Creek Road, Suite 200
Lincoln, NE 68506
P: (402) 488-0075
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AES’s Project No. 24080-253
OPS Bid # 24-076

June 05, 2024
I hereby certify that the portion of this technical submission described below was prepared by me or under my direct supervision and responsible charge. I am a duly registered engineer under the laws of the State of Nebraska and will be the Coordinating Professional on this project.

Kyle J Wilkinson E-12957
Name (Printed) Registration Number

Signature

Drawings covered by this Seal:
T0.0, Structural analysis, M series, E series,

Sections covered by this Seal:
Divisions 00, 01, 22, 23, 26

Date Issued: 06/05/2023
I hereby certify that the portion of this technical submission described below was prepared by me or under my direct supervision and responsible charge. I am a duly registered engineer under the laws of the State of Nebraska.

Rebecca A Furtado  E-18192
Name (Printed)  Registration Number

Signature

Drawings covered by this Seal:
E series

Sections covered by this Seal:
Division 26

Date Issued: 06/05/2023

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PART 1 - GENERAL

1.01 LIST OF DRAWINGS

GENERAL

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END OF SECTION 00 01 15
SECTION 01 31 00
PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.01 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.

1.02 SUMMARY

A. Section includes administrative provisions for coordinating construction operations on Project including, but not limited to, the following:

   1. General coordination procedures.
   2. Coordination drawings.
   3. RFIs.
   4. Digital project management procedures.
   5. Project meetings.

1.03 DEFINITIONS

A. BIM: Building Information Modeling.

B. RFI: Request for Information. Request from Owner, Architect/engineer, or Contractor seeking information required by or clarifications of the Contract Documents.

1.04 INFORMATIONAL SUBMITTALS

A. Subcontract List: Prepare a written summary identifying individuals or firms proposed for each portion of the Work, including those who are to furnish products or equipment fabricated to a special design. Include the following information in tabular form:

   1. Name, address, telephone number, and email address of entity performing subcontract or supplying products.
   2. Number and title of related Specification Section(s) covered by subcontract.
   3. Drawing number and detail references, as appropriate, covered by subcontract.

1.05 GENERAL COORDINATION PROCEDURES

A. Coordination: Coordinate construction operations included in different Sections of the Specifications to ensure efficient and orderly installation of each part of the Work. Coordinate construction operations included in different Sections that depend on each other for proper installation, connection, and operation.

   1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
   2. Coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair.
   3. Make adequate provisions to accommodate items scheduled for later installation.
B. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities and scheduled activities of other contractors to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:

1. Preparation of Contractor's construction schedule.
2. Preparation of the schedule of values.
3. Installation and removal of temporary facilities and controls.
4. Delivery and processing of submittals.
5. Progress meetings.
6. Preinstallation conferences.
7. Project closeout activities.
8. Startup and adjustment of systems.

1.06 REQUEST FOR INFORMATION (RFI)

A. General: Immediately on discovery of the need for additional information, clarification, or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified.

1. Architect / engineer will return without response those RFIs submitted to Architect / engineer by other entities controlled by Contractor.
2. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:

1. Project name.
2. Project number.
3. Date.
4. Name of Contractor.
5. Name of Architect / engineer
6. RFI number, numbered sequentially.
7. RFI subject.
8. Specification Section number and title and related paragraphs, as appropriate.
9. Drawing number and detail references, as appropriate.
10. Field dimensions and conditions, as appropriate.
11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
12. Contractor's signature.
13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.

C. RFI Forms: AIA standard Document or approved Contractors standard document

D. Architect / engineer's Action: Architect / engineer will review each RFI, determine action required, and respond. Allow 7 working days for Architect / engineer's response for each RFI. RFIs received by Architect / engineer after 1:00 p.m. will be considered as received the following working day.

1. The following Contractor-generated RFIs will be returned without action:
   a. Requests for approval of submittals.
b. Requests for approval of substitutions.
c. Requests for approval of Contractor's means and methods.
d. Requests for coordination information already indicated in the Contract Documents.
e. Requests for adjustments in the Contract Time or the Contract Sum.
g. Incomplete RFIs or inaccurately prepared RFIs.

2. Architect / engineer's action may include a request for additional information, in which case Architect / engineer's time for response will date from time of receipt by Architect / engineer of additional information.

3. Architect / engineer's action on RFIs that may result in a change to the Contract Time or the Contract Sum may be eligible for Contractor to submit Change Proposal according to Section 012600 "Contract Modification Procedures."

a. If Contractor believes the RFI response warrants change in the Contract Time or the Contract Sum, notify Architect / engineer in writing within 10 days of receipt of the RFI response.

E. RFI Log: Prepare, maintain, and submit a tabular log of RFIs organized by the RFI number.

F. On receipt of Architect / engineer's action, update the RFI log and immediately distribute the RFI response to affected parties. Review response and notify Architect / engineer within 7 days if Contractor disagrees with response.

1.07 DIGITAL PROJECT MANAGEMENT PROCEDURES

A. Architect / engineer's Data Files Not Available: Architect / engineer will not provide Architect / engineer's BIM model or CAD drawing digital data files for Contractor's use during construction.

B. Use of Architect / engineer's Digital Data Files: Digital data files of Architect / engineer's BIM model or CAD drawings may be requested of the Architect / engineer for Contractor's use during construction.

1. Contractor must fill out the architect / engineer's waiver form and pay the applicable fee.

C. PDF Document Preparation: Where PDFs are required to be submitted to Architect / engineer, prepare as follows:

1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
2. Name file with submittal number or other unique identifier, including revision identifier.
3. Certifications: Where digitally submitted certificates and certifications are required, provide a digital signature with digital certificate on where indicated.

1.08 PROJECT MEETINGS

A. General: Schedule and conduct meetings and conferences at Project site unless otherwise indicated.
B. Preconstruction Conference: Architect / engineer will schedule and conduct a preconstruction conference before starting construction, at a time convenient to Owner and Architect / engineer.

1. Attendees: Authorized representatives of Owner, architect / engineer, and their consultants; Contractor and its superintendent; major subcontractors; suppliers; and other concerned parties shall attend the conference. Participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.

2. Agenda: Discuss items of significance that could affect progress, including the following:
   a. Responsibilities and personnel assignments.
   b. Tentative construction schedule.
   c. Phasing.
   d. Critical work sequencing and long lead items.
   e. Designation of key personnel and their duties.
   f. Lines of communications.
   g. Use of web-based Project software.
   h. Procedures for processing field decisions and Change Orders.
   i. Procedures for RFIs.
   j. Procedures for testing and inspecting.
   k. Procedures for processing Applications for Payment.
   l. Distribution of the Contract Documents.
   m. Submittal procedures.
   n. Sustainable design requirements.
   o. Preparation of Record Documents.
   p. Use of the premises.
   q. Work restrictions.
   r. Working hours.
   s. Owner's occupancy requirements.
   t. Responsibility for temporary facilities and controls.
   u. Procedures for moisture and mold control.
   v. Procedures for disruptions and shutdowns.
   w. Construction waste management and recycling.
   x. Parking availability.
   y. Office, work, and storage areas.
   z. Equipment deliveries and priorities.
   aa. First aid.
   cc. Progress cleaning.

3. Minutes: Entity responsible for conducting meeting will record and distribute meeting minutes.

C. Progress Meetings: Conduct progress meetings at regular (minimum monthly) intervals or as required and decided by owner.

1. Coordinate dates of meetings with preparation of payment requests.

2. Attendees: In addition to representatives of Owner, and Architect / engineer, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the meeting shall be familiar with Project and authorized to conclude matters relating to the Work.
3. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.

   a. Contractor's Construction Schedule: Review progress since the last meeting. Determine whether each activity is on time, ahead of schedule, or behind schedule, in relation to Contractor's construction schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.

      1) Review schedule for next period.

   b. Review present and future needs of each entity present, including the following:

      1) Interface requirements.
      2) Sequence of operations.
      3) Resolution of BIM component conflicts.
      4) Status of submittals.
      5) Status of sustainable design documentation.
      6) Deliveries.
      7) Off-site fabrication.
      8) Access.
      9) Site use.
      10) Temporary facilities and controls.
      11) Progress cleaning.
      12) Quality and work standards.
      13) Status of correction of deficient items.
      14) Field observations.
      15) Status of RFIs.
      16) Status of Proposal Requests.
      17) Pending changes.
      18) Status of Change Orders.
      19) Pending claims and disputes.
      20) Documentation of information for payment requests.

4. Minutes: Entity responsible for conducting the meeting will record and distribute the meeting minutes to each party present and to parties requiring information.

   a. Schedule Updating: Revise Contractor's construction schedule after each progress meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with the report of each meeting.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 31 00
SECTION 01 33 00

SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes requirements for the submittal schedule and administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals.

B. Contractor will provide and set up an electronic submittal sharing web based program. The site will be initially set up by the contractor. All submittals, RFIs, etc. will be transmitted and approved through this site. All references to submittals below will be through the web program, no paper copies are required unless otherwise specified.

1.02 DEFINITIONS

A. Action Submittals: Written and graphic information and physical samples that require Architect's responsive action.

B. Informational Submittals: Written and graphic information and physical samples that do not require Architect's responsive action. Submittals may be rejected for not complying with requirements.

1.03 ACTION SUBMITTALS

A. Submittal Schedule: Submit a schedule of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or modifications to submittals noted by the Architect and additional time for handling and reviewing submittals required by those corrections.

1.04 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Architect's Digital Data Files: Electronic copies of CAD Drawings of the Contract Drawings will not be provided by Architect for Contractor's use in preparing submittals.


a. Architect makes no representations as to the accuracy or completeness of digital data drawing files as they relate to the Contract Drawings.

b. Contractor shall execute a data licensing agreement in a form acceptable to the Owner and Architect.

B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.

2. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
a. Architect reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

C. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Initial Review: Allow 15 days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Architect will advise Contractor when a submittal being processed must be delayed for coordination.

2. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.

3. Resubmittal Review: Allow 15 days for review of each resubmittal.

D. Identification and Information: Place a permanent label or title block on each paper copy submittal item for identification.

1. Indicate name of firm or entity that prepared each submittal on label or title block.
2. Provide a space approximately 6 by 8 inches on label or beside title block to record Contractor's review and approval markings and action taken by Architect.
3. Include the following information for processing and recording action taken:
   a. Project name.
   b. Date.
   c. Name of Architect.
   d. Name of Construction Manager.
   e. Name of Contractor.
   f. Name of subcontractor.
   g. Name of supplier.
   h. Name of manufacturer.
   i. Submittal number or other unique identifier, including revision identifier.
      1) Submittal number shall use Specification Section number followed by a decimal point and then a sequential number (e.g., 061000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., 061000.01.A).
   j. Number and title of appropriate Specification Section.
   k. Drawing number and detail references, as appropriate.
   l. Location(s) where product is to be installed, as appropriate.
   m. Other necessary identification.

E. Identification and Information: Identify and incorporate information in each electronic submittal file as follows:

1. Assemble complete submittal package into a single indexed file with links enabling navigation to each item.
2. Name file with submittal number or other unique identifier, including revision identifier.
   a. File name shall use project identifier and Specification Section number followed by a decimal point and then a sequential number (e.g., LNHS-061000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., LNHS-061000.01.A).
3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Architect.

4. Include the following information on an inserted cover sheet:
   a. Project name.
   b. Date.
   c. Name and address of Architect.
   d. Name of Construction Manager.
   e. Name of Contractor.
   f. Name of firm or entity that prepared submittal.
   g. Name of subcontractor.
   h. Name of supplier.
   i. Name of manufacturer.
   j. Number and title of appropriate Specification Section.
   k. Drawing number and detail references, as appropriate.
   l. Location(s) where product is to be installed, as appropriate.
   m. Related physical samples submitted directly.
   n. Other necessary identification.

F. Options: Identify options requiring selection by the Architect.

G. Deviations: Identify deviations from the Contract Documents on submittals.

H. Additional Paper Copies: Unless additional copies are required for final submittal, and unless Architect observes noncompliance with provisions in the Contract Documents, initial submittal may serve as final submittal.

1. Submit one copy of submittal to concurrent reviewer in addition to specified number of copies to Architect.

I. Transmittal: Assemble each submittal individually and appropriately for transmittal and handling. Transmit each submittal using a transmittal form. Architect will discard submittals received from sources other than Contractor.

2. On an attached separate sheet, prepared on Contractor's letterhead, record relevant information, requests for data, revisions other than those requested by Architect on previous submittals, and deviations from requirements in the Contract Documents, including minor variations and limitations. Include same identification information as related submittal.

J. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.

1. Note date and content of previous submittal.
2. Note date and content of revision in label or title block and clearly indicate extent of revision.
3. Resubmit submittals until they are marked with approval notation from Architect's action stamp.

K. Distribution: Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers, authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.

L. Use for Construction: Use only final submittals that are marked with approval notation from Architect's action stamp.
PART 2 - PRODUCTS

2.01 SUBMITTAL PROCEDURES

A. General Submittal Procedure Requirements:

1. Submit electronic submittals via email as PDF electronic files.

2. Action Submittals: Submit three paper copies of each submittal, unless otherwise indicated. Architect will return two copies.

3. Informational Submittals: Submit two paper copies of each submittal, unless otherwise indicated. Architect will not return copies.

4. Closeout Submittals and Maintenance Material Submittals: Comply with requirements specified in Division 01 Section "Closeout Procedures."

5. Certificates and Certifications Submittals: Provide a statement that includes signature of entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity.
   a. Provide a digital signature with digital certificate on electronically-submitted certificates and certifications where indicated.
   b. Provide a notarized statement on original paper copy certificates and certifications where indicated.

6. Test and Inspection Reports Submittals: Comply with requirements specified in Division 01 Section "Quality Requirements."

B. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.

1. If information must be specially prepared for submittal because standard published data are not suitable for use, submit as Shop Drawings, not as Product Data.

2. Mark each copy of each submittal to show which products and options are applicable.

3. Include the following information, as applicable:
   a. Manufacturer's catalog cuts.
   b. Manufacturer's product specifications.
   c. Standard color charts.
   d. Statement of compliance with specified referenced standards.
   e. Testing by recognized testing agency.
   f. Application of testing agency labels and seals.
   g. Notation of coordination requirements.
   h. Availability and delivery time information.

4. For equipment, include the following in addition to the above, as applicable:
   a. Wiring diagrams showing factory-installed wiring.
   b. Printed performance curves.
   c. Operational range diagrams.
d. Clearances required to other construction, if not indicated on accompanying Shop Drawings.

5. Submit Product Data before or concurrent with Samples.
6. Submit Product Data in the following format:
   a. PDF electronic file.

C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.

1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:
   a. Identification of products.
   b. Schedules.
   c. Compliance with specified standards.
   d. Notation of coordination requirements.
   e. Notation of dimensions established by field measurement.
   f. Relationship and attachment to adjoining construction clearly indicated.
   g. Seal and signature of professional engineer if specified.

2. Sheet Size: Except for templates, patterns, and similar full-size drawings, submit Shop Drawings on sheets at least 8-1/2 by 11 inches but no larger than 30 by 42 inches.
3. Submit Shop Drawings in the following format:
   a. PDF electronic file.

D. Samples: Submit Samples for review of kind, color, pattern, and texture for a check of these characteristics with other elements and for a comparison of these characteristics between submittal and actual component as delivered and installed.

1. Transmit Samples that contain multiple, related components such as accessories together in one submittal package.
2. Identification: Attach label on unexposed side of Samples that includes the following:
   a. Generic description of Sample.
   b. Product name and name of manufacturer.
   c. Sample source.
   d. Number and title of applicable Specification Section.

3. Disposition: Maintain sets of approved Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.
   a. Samples that may be incorporated into the Work are indicated in individual Specification Sections. Such Samples must be in an undamaged condition at time of use.
   b. Samples not incorporated into the Work, or otherwise designated as Owner's property, are the property of Contractor.
4. Samples for Initial Selection: Submit manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available.

   a. Number of Samples: Submit one full set(s) of available choices where color, pattern, texture, or similar characteristics are required to be selected from manufacturer's product line. Architect will return submittal with options selected.

5. Samples for Verification: Submit full-size units or Samples of size indicated, prepared from same material to be used for the Work, cured and finished in manner specified, and physically identical with material or product proposed for use, and that show full range of color and texture variations expected. Samples include, but are not limited to, the following: partial sections of manufactured or fabricated components; small cuts or containers of materials; complete units of repetitively used materials; swatches showing color, texture, and pattern; color range sets; and components used for independent testing and inspection.

   a. Number of Samples: Submit three sets of Samples. Architect will retain two Sample sets; remainder will be returned. Mark up and retain one returned Sample set as a Project record sample.

      1) If variation in color, pattern, texture, or other characteristic is inherent in material or product represented by a Sample, submit at least three sets of paired units that show approximate limits of variations.

E. Product Schedule: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:

   1. Submit product schedule in the following format:

      a. PDF electronic file.

F. Contractor's Construction Schedule: Comply with requirements specified in Division 01 Section "Construction Progress Documentation."

G. Application for Payment: Comply with requirements specified in Division 01 Section "Payment Procedures."

H. Schedule of Values: Comply with requirements specified in Division 01 Section "Payment Procedures."

I. Subcontract List: Prepare a written summary identifying individuals or firms proposed for each portion of the Work, including those who are to furnish products or equipment fabricated to a special design.

   1. Submit subcontract list in the following format:

      a. PDF electronic file.

J. Coordination Drawings: Comply with requirements specified in Division 01 Section "Project Management and Coordination."
K. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of architects and owners, and other information specified.


M. Installer Certificates: Submit written statements on manufacturer's letterhead certifying that Installer complies with requirements in the Contract Documents and, where required, is authorized by manufacturer for this specific Project.

N. Manufacturer Certificates: Submit written statements on manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.

O. Product Certificates: Submit written statements on manufacturer's letterhead certifying that product complies with requirements in the Contract Documents.

P. Material Certificates: Submit written statements on manufacturer's letterhead certifying that material complies with requirements in the Contract Documents.

Q. Material Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements in the Contract Documents.

R. Product Test Reports: Submit written reports indicating current product produced by manufacturer complies with requirements in the Contract Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.

S. Research Reports: Submit written evidence, from a model code organization acceptable to authorities having jurisdiction, that product complies with building code in effect for Project.

T. Schedule of Tests and Inspections: Comply with requirements specified in Division 01 Section "Quality Requirements."

U. Preconstruction Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements in the Contract Documents.

V. Compatibility Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.

W. Field Test Reports: Submit reports indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Contract Documents.

X. Maintenance Data: Comply with requirements specified in Division 01 Section "Operation and Maintenance Data."
Y. Design Data: Prepare and submit written and graphic information, including, but not limited to, performance and design criteria, list of applicable codes and regulations, and calculations. Include list of assumptions and other performance and design criteria and a summary of loads. Include load diagrams if applicable. Provide name and version of software, if any, used for calculations. Include page numbers.

2.02 DELEGATED-DESIGN SERVICES

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.

1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect.

B. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit digitally-signed PDF electronic file and three paper copies of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.

1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

PART 3 - EXECUTION

3.01 CONTRACTOR'S REVIEW

A. Action and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Architect.

B. Project Closeout and Maintenance/Material Submittals: Refer to requirements in Division 01 Section "Closeout Procedures."

C. Approval Stamp: Stamp each submittal with a uniform, approval stamp. Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

3.02 ARCHITECT'S ACTION

A. General: Architect will not review submittals that do not bear Contractor's approval stamp and will return them without action.

B. Action Submittals: Architect will review each submittal, make marks to indicate corrections or modifications required, and return it. Architect will stamp each submittal with an action stamp and will mark stamp appropriately to indicate action.

C. Informational Submittals: Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.
D. Incomplete submittals are not acceptable, will be considered nonresponsive, and will be returned without review.

E. Submittals not required by the Contract Documents may not be reviewed and may be discarded.

END OF SECTION 01 33 00
SECTION 01 77 00
CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following:
   1. Substantial Completion procedures.
   2. Final completion procedures.
   3. Warranties.
   4. Final cleaning.

B. Related Sections:
   1. Division 01 Section "Operation and Maintenance Data" for operation and maintenance manual requirements.
   2. Division 01 Section "Project Record Documents" for submitting Record Drawings, Record Specifications, and Record Product Data.
   3. Division 01 Section "Demonstration and Training" for requirements for instructing Owner's personnel.
   4. Divisions 02 through 49 Sections for specific closeout and special cleaning requirements for the Work in those Sections.

1.02 SUBSTANTIAL COMPLETION

A. Preliminary Procedures: Before requesting inspection for determining date of Substantial Completion, complete the following. List items below that are incomplete with request.
   1. Prepare a list of items to be completed and corrected (punch list), the value of items on the list, and reasons why the Work is not complete.
   2. Advise Owner of pending insurance changeover requirements.
   3. Submit specific warranties, workmanship bonds, maintenance service agreements, final certifications, and similar documents.
   4. Obtain and submit releases permitting Owner unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
   5. Prepare and submit Project Record Documents, operation and maintenance manuals, final completion construction photographic documentation, damage or settlement surveys, property surveys, and similar final record information.
   6. Deliver tools, spare parts, extra materials, and similar items to location designated by Owner. Label with manufacturer's name and model number where applicable.
   7. Make final changeover of permanent locks and deliver keys to Owner. Advise Owner's personnel of changeover in security provisions.
   8. Complete startup testing of systems.
   10. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
   11. Advise Owner of changeover in heat and other utilities.
   12. Submit changeover information related to Owner's occupancy, use, operation, and maintenance.
13. Complete final cleaning requirements, including touchup painting.
14. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.

B. Inspection: Submit a written request for inspection for Substantial Completion. On receipt of request, Architect will either proceed with inspection or notify Contractor of unfulfilled requirements. Architect will prepare the Certificate of Substantial Completion after inspection or will notify Contractor of items, either on Contractor's list or additional items identified by Architect, that must be completed or corrected before certificate will be issued.

1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.
2. Results of completed inspection will form the basis of requirements for final completion.

C. Each phase shall have its own substantial completion after punch list have been completed and equipment is fully operational. The substantial completion dates shall correspond with the unit startup dates.

1.03 FINAL COMPLETION

A. Preliminary Procedures: Before requesting final inspection for determining final completion, complete the following:

1. Submit a final Application for Payment.
2. Submit certified copy of Architect's Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by Architect. The certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.
3. Submit evidence of final, continuing insurance coverage complying with insurance requirements.
4. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment, and systems. Submit demonstration and training video recordings.

B. Inspection: Submit a written request for final inspection for acceptance. On receipt of request, Architect will either proceed with inspection or notify Contractor of unfulfilled requirements. Architect will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.

1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.

1.04 LIST OF INCOMPLETE ITEMS (PUNCH LIST)

A. Organization of List: Include name and identification of each space and area affected by construction operations for incomplete items and items needing correction including, if necessary, areas disturbed by Contractor that are outside the limits of construction.

1. Organize list of spaces in sequential order.
2. Organize items applying to each space by major element, including categories for ceiling, individual walls, floors, equipment, and building systems.
3. Submit list of incomplete items in the following format:
1.05 Warranties

A. Submittal Time: Submit written warranties on request of Architect for designated portions of the Work where commencement of warranties other than date of each phases’ Substantial Completion is indicated.

B. General Warranty: General Contractor to provide one-year comprehensive parts and labor warranty for all equipment installed under Contract Documents. Warranty to begin on date of Substantial Completion and include expiration date. General Warranty letter to be incorporated into warranty documents in Project Manual.

C. Organize warranty documents into an orderly sequence based on the table of contents of the Project Manual.

1. Bind warranties and bonds in heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2-by-11-inch paper.

2. Provide heavy paper dividers with plastic-covered tabs for each separate warranty. Mark tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product and the name, address, and telephone number of Installer.

3. Identify each binder on the front and spine with the typed or printed title "WARRANTIES," Project name, and name of Contractor.

4. Scan warranties and bonds and assemble complete warranty and bond submittal package into a single indexed electronic PDF file with links enabling navigation to each item. Provide table of contents at beginning of document.

D. Provide additional copies of each warranty to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.

1. Use cleaning products that meet Green Seal GS-37, or if GS-37 is not applicable, use products that comply with the California Code of Regulations maximum allowable VOC levels.

PART 3 - EXECUTION

3.01 FINAL CLEANING

A. General: Perform final cleaning. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations.

B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.
1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a portion of Project:

   a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.

   b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.

   c. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.

   d. Remove tools, construction equipment, machinery, and surplus material from Project site.

   e. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.

   f. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.

   g. Sweep concrete floors broom clean in unoccupied spaces.

   h. Vacuum carpet and similar soft surfaces, removing debris and excess nap; shampoo if visible soil or stains remain.

   i. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Replace chipped or broken glass and other damaged transparent materials. Polish mirrors and glass, taking care not to scratch surfaces.

   j. Remove labels that are not permanent.

   k. Touch up and otherwise repair and restore marred, exposed finishes and surfaces. Replace finishes and surfaces that cannot be satisfactorily repaired or restored or that already show evidence of repair or restoration.

      1) Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates.

   l. Wipe surfaces of mechanical and electrical equipment and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.

   m. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.

   n. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.

   o. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency. Replace burned-out bulbs, and those noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and mercury vapor fixtures to comply with requirements for new fixtures.

   p. Leave Project clean and ready for occupancy.

END OF SECTION 01 77 00
SECTION 01 78 23
OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:

1. Operation and maintenance documentation directory.
2. Emergency manuals.
3. Operation manuals for systems, subsystems, and equipment.
4. Product maintenance manuals.
5. Systems and equipment maintenance manuals.

B. Related Sections:

1. Divisions 02 through 49 Sections for specific operation and maintenance manual requirements for the Work in those Sections.

1.02 CLOSEOUT SUBMITTALS

A. Format: Submit operations and maintenance manuals in the following format:

   a. Name each indexed document file in composite electronic index with applicable item name. Include a complete electronically-linked operation and maintenance directory.
   b. Enable inserted reviewer comments on draft submittals.

AND

2. Three paper copies. Include a complete operation and maintenance directory. Enclose title pages and directories in clear plastic sleeves. Contractor shall deliver 3 completed copies to the owner.

B. Manual Submittal: Submit each manual in final form prior to requesting inspection for Substantial Completion and at least 15 days before commencing demonstration and training. Architect will return copy with comments.

1. Correct or modify each manual to comply with Architect's comments. Submit copies of each corrected manual within 15 days of receipt of Architect's comments and prior to commencing demonstration and training.

PART 2 - PRODUCTS

2.01 REQUIREMENTS FOR EMERGENCY, OPERATION, AND MAINTENANCE MANUALS

A. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following materials, in the order listed:
1. Title page.
2. Table of contents.

B. Title Page: Include the following information:

1. Subject matter included in manual.
2. Name and address of Project.
3. Name and address of Owner.
4. Date of submittal.
5. Name and contact information for Contractor.
6. Name and contact information for Construction Manager.
7. Name and contact information for Architect.
8. Name and contact information for Commissioning Agent.
9. Names and contact information for major consultants to the Architect that designed the systems contained in the manuals.
10. Cross-reference to related systems in other operation and maintenance manuals.

C. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.

D. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.

E. Manuals, Electronic Files: Submit manuals in the form of a multiple file composite electronic PDF file for each manual type required.

1. Electronic Files: Use electronic files prepared by manufacturer where available. Where scanning of paper documents is required, configure scanned file for minimum readable file size.
2. File Names and Bookmarks: Enable bookmarking of individual documents based upon file names. Name document files to correspond to system, subsystem, and equipment names used in manual directory and table of contents. Group documents for each system and subsystem into individual composite bookmarked files, then create composite manual, so that resulting bookmarks reflect the system, subsystem, and equipment names in a readily navigated file tree. Configure electronic manual to display bookmark panel upon opening file.

F. Manuals, Paper Copy: Submit manuals in the form of hard copy, bound and labeled volumes.

1. Binders: Heavy-duty, three-ring, vinyl-covered, loose-leaf binders, maximum thickness of 3-1/2", sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine and front cover to hold label describing contents and with pockets inside covers to hold folded oversize sheets.
   a. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, subject matter of contents, and indicate Specification Section number on bottom of spine. Indicate volume number for multiple-volume sets.
2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section of the manual. Mark each tab to indicate contents. Include typed list of products and
major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.

3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software storage media for computerized electronic equipment.

4. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.
   
   a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
   
   b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

2.02 EMERGENCY MANUALS

A. Content: Organize manual into a separate section for each of the following:

   1. Type of emergency.
   2. Emergency instructions.
   3. Emergency procedures.

B. Type of Emergency: Where applicable for each type of emergency indicated below, include instructions and procedures for each system, subsystem, piece of equipment, and component:

   1. Fire.
   2. Flood.
   5. Power failure.
   7. System, subsystem, or equipment failure.
   8. Chemical release or spill.

C. Emergency Instructions: Describe and explain warnings, trouble indications, error messages, and similar codes and signals. Include responsibilities of Owner's operating personnel for notification of Installer, supplier, and manufacturer to maintain warranties.

D. Emergency Procedures: Include the following, as applicable:

   1. Instructions on stopping.
   2. Shutdown instructions for each type of emergency.
   3. Operating instructions for conditions outside normal operating limits.
   4. Required sequences for electric or electronic systems.
   5. Special operating instructions and procedures.

2.03 OPERATION MANUALS

A. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and the following information:

   2. Performance and design criteria if Contractor is delegated design responsibility.
3. Operating standards.
4. Operating procedures.
5. Operating logs.
6. Wiring diagrams.
7. Control diagrams.
8. Piped system diagrams.
9. Precautions against improper use.
10. License requirements including inspection and renewal dates.

B. Descriptions: Include the following:

1. Product name and model number. Use designations for products indicated on Contract Documents.
2. Manufacturer's name.
3. Equipment identification with serial number of each component.
4. Equipment function.
5. Operating characteristics.
6. Limiting conditions.
7. Performance curves.
8. Engineering data and tests.
9. Complete nomenclature and number of replacement parts.

C. Operating Procedures: Include the following, as applicable:

1. Startup procedures.
2. Equipment or system break-in procedures.
3. Routine and normal operating instructions.
4. Regulation and control procedures.
5. Instructions on stopping.
7. Seasonal and weekend operating instructions.
8. Required sequences for electric or electronic systems.
9. Special operating instructions and procedures.

D. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.

E. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

2.04 PRODUCT MAINTENANCE MANUALS

A. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.

B. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.

C. Product Information: Include the following, as applicable:

1. Product name and model number.
2. Manufacturer's name.
3. Color, pattern, and texture.
5. Reordering information for specially manufactured products.

D. Maintenance Procedures: Include manufacturer's written recommendations and the following:
   1. Inspection procedures.
   2. Types of cleaning agents to be used and methods of cleaning.
   3. List of cleaning agents and methods of cleaning detrimental to product.
   4. Schedule for routine cleaning and maintenance.
   5. Repair instructions.

E. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.

F. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

2.05 SYSTEMS AND EQUIPMENT MAINTENANCE MANUALS

A. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers’ maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.

B. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.

C. Manufacturers’ Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:
   1. Standard maintenance instructions and bulletins.
   2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
   3. Identification and nomenclature of parts and components.
   4. List of items recommended to be stocked as spare parts.

D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:
   1. Test and inspection instructions.
   2. Troubleshooting guide.
   3. Precautions against improper maintenance.
   4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
   5. Aligning, adjusting, and checking instructions.
   6. Demonstration and training video recording, if available.

E. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.
F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers’ maintenance documentation and local sources of maintenance materials and related services.

G. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.

H. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

PART 3 - EXECUTION

3.01 MANUAL PREPARATION

A. Emergency Manual: Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by Owner's operating personnel for types of emergencies indicated.

B. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.

C. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.

D. Manufacturers’ Data: Where manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data include more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

E. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in record Drawings to ensure correct illustration of completed installation.

1. Do not use original project record documents as part of operation and maintenance manuals.

F. Comply with Division 01 Section "Closeout Procedures" for schedule for submitting operation and maintenance documentation.

END OF SECTION 01 78 23
PART 1 - GENERAL

1.01 SUMMARY

A. Section includes administrative and procedural requirements for project record documents, including the following:

1. Record Drawings.

B. Related Sections:

1. Division 01 Section "Operation and Maintenance Data" for operation and maintenance manual requirements.
2. Divisions 02 through 49 Sections for specific requirements for project record documents of the Work in those Sections.

1.02 CLOSEOUT SUBMITTALS

A. Record Drawings: Comply with the following:

1. Number of Copies: Submit one set(s) of marked-up record prints.
2. Number of Copies: Submit copies of record Drawings as follows:
   a. Initial Submittal: Submit one paper copy set and one PDF electronic files of marked-up record prints and one set(s) of plots from corrected record digital data files. Architect will indicate whether general scope of changes, additional information recorded, and quality of drafting are acceptable.
   b. Final Submittal: Submit one paper copy set and one PDF electronic files of marked-up record prints. Print each Drawing, whether or not changes and additional information were recorded.

PART 2 - PRODUCTS

2.01 RECORD DRAWINGS

A. Record Prints: Maintain one set of marked-up paper copies of the Contract Drawings and Shop Drawings.

1. Preparation: Mark record prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to provide information for preparation of corresponding marked-up record prints.

   a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.
   b. Record data as soon as possible after obtaining it.
   c. Record and check the markup before enclosing concealed installations.
2. Mark the Contract Drawings and Shop Drawings completely and accurately. Utilize personnel proficient at recording graphic information in production of marked-up record prints.

3. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.

4. Note Construction Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.

B. Format: Identify and date each record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location.

1. Record Prints: Organize record prints and newly prepared record Drawings into manageable sets. Bind each set with durable paper cover sheets. Include identification on cover sheets.


3. Identification: As follows:
   a. Project name.
   b. Date.
   c. Designation "PROJECT RECORD DRAWINGS."
   d. Name of Architect.
   e. Name of Contractor.

2.02 MISCELLANEOUS RECORD SUBMITTALS

A. Assemble miscellaneous records required by other Specification Sections for miscellaneous record keeping and submittal in connection with actual performance of the Work. Bind or file miscellaneous records and identify each, ready for continued use and reference.

B. Format: Submit miscellaneous record submittals as PDF electronic file and paper copy.

PART 3 - EXECUTION

3.01 RECORDING AND MAINTENANCE

A. Recording: Maintain one copy of each submittal during the construction period for project record document purposes. Post changes and modifications to project record documents as they occur; do not wait until the end of Project.

B. Maintenance of Record Documents and Samples: Store record documents and Samples in the field office apart from the Contract Documents used for construction. Do not use project record documents for construction purposes. Maintain record documents in good order and in a clean, dry, legible condition, protected from deterioration and loss. Provide access to project record documents for Architect's reference during normal working hours.

END OF SECTION 01 78 39
SECTION 01 79 00
DEMONSTRATION AND TRAINING

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes administrative and procedural requirements for instructing Owner's personnel, including the following:

1. Demonstration of operation of systems, subsystems, and equipment.
2. Training in operation and maintenance of systems, subsystems, and equipment.
3. Demonstration and training video recordings.

1.02 INFORMATIONAL SUBMITTALS

A. Instruction Program: Submit outline of instructional program for demonstration and training, including a list of training modules and a schedule of proposed dates, times, length of instruction time, and instructors’ names for each training module. Include learning objective and outline for each training module.

1. Indicate proposed training modules utilizing manufacturer-produced demonstration and training video recordings for systems, equipment, and products in lieu of video recording of live instructional module.

B. Owner Training Documentation – Include items such as:

1. Written instructions and videos documenting startup
2. Shutdown
3. Adjustments
4. Emergency procedures
5. Regular required maintenance items.

C. Owner training shall be performed on all equipment and systems including controls. Training times shall be coordinated with the owner and done after systems are operational.

1. Control systems shall have a minimum of (2) separate 4-hour sessions included to be scheduled at the owner’s convenience.

1.03 CLOSEOUT SUBMITTALS

A. Demonstration and Training Video Recordings: Submit two copies within seven days of end of each training module.

1. At completion of training, submit complete training manual(s) for Owner's use.

1.04 QUALITY ASSURANCE

A. Facilitator Qualifications: A firm or individual experienced in training or educating maintenance personnel in a training program similar in content and extent to that indicated for this Project, and whose work has resulted in training or education with a record of successful learning performance.
B. Instructor Qualifications: A factory-authorized service representative, experienced in operation and maintenance procedures and training.

C. Preinstruction Conference: Conduct conference at Project site to comply with requirements in Division 01 Sections. Review methods and procedures related to demonstration and training.

1.05 COORDINATION

A. Coordinate instruction schedule with Owner’s operations. Adjust schedule as required to minimize disrupting Owner’s operations.

B. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data has been reviewed and approved by Architect.

PART 2 - PRODUCTS

2.01 INSTRUCTION PROGRAM

A. Program Structure: Develop an instruction program that includes individual training modules for each system and for equipment not part of a system, as required by individual Specification Sections.

B. Training Modules: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following as applicable to the system, equipment, or component:

1. Basis of System Design, Operational Requirements, and Criteria: Include the following:
   a. System, subsystem, and equipment descriptions.
   b. Performance and design criteria if Contractor is delegated design responsibility.
   c. Operating standards.
   d. Regulatory requirements.
   e. Equipment function.
   f. Operating characteristics.
   g. Limiting conditions.
   h. Performance curves.

2. Documentation: Review the following items in detail:
   a. Emergency manuals.
   b. Operations manuals.
   c. Maintenance manuals.
   d. Project record documents.
   e. Identification systems.
   f. Warranties and bonds.
   g. Maintenance service agreements and similar continuing commitments.

3. Emergencies: Include the following, as applicable:
a. Instructions on meaning of warnings, trouble indications, and error messages.
b. Instructions on stopping.
c. Shutdown instructions for each type of emergency.
d. Operating instructions for conditions outside of normal operating limits.
e. Sequences for electric or electronic systems.
f. Special operating instructions and procedures.

4. Operations: Include the following, as applicable:

a. Startup procedures.
b. Equipment or system break-in procedures.
c. Routine and normal operating instructions.
d. Regulation and control procedures.
e. Control sequences.
f. Safety procedures.
g. Instructions on stopping.
h. Normal shutdown instructions.
i. Operating procedures for emergencies.
j. Operating procedures for system, subsystem, or equipment failure.
k. Seasonal and weekend operating instructions.
l. Required sequences for electric or electronic systems.
m. Special operating instructions and procedures.

5. Adjustments: Include the following:

a. Alignments.
b. Checking adjustments.
c. Noise and vibration adjustments.
d. Economy and efficiency adjustments.

6. Troubleshooting: Include the following:

a. Diagnostic instructions.
b. Test and inspection procedures.

7. Maintenance: Include the following:

a. Inspection procedures.
b. Types of cleaning agents to be used and methods of cleaning.
c. List of cleaning agents and methods of cleaning detrimental to product.
d. Procedures for routine cleaning.
e. Procedures for preventive maintenance.
f. Procedures for routine maintenance.
g. Instruction on use of special tools.

8. Repairs: Include the following:

a. Diagnosis instructions.
b. Repair instructions.
c. Disassembly; component removal, repair, and replacement; and reassembly instructions.
d. Instructions for identifying parts and components.
e. Review of spare parts needed for operation and maintenance.
PART 3 - EXECUTION

3.01 PREPARATION

A. Assemble educational materials necessary for instruction, including documentation and training module. Assemble training modules into a training manual organized in coordination with requirements in Division 01 Section "Operations and Maintenance Data."

3.02 INSTRUCTION

A. Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and Owner for number of participants, instruction times, and location.

B. Engage qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.

1. Architect will furnish an instructor to describe basis of system design, operational requirements, criteria, and regulatory requirements.

2. Owner will furnish an instructor to describe Owner's operational philosophy.

3. Owner will furnish Contractor with names and positions of participants.

C. Scheduling: Provide instruction at mutually agreed on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.

1. Schedule training with Owner with at least seven days' advance notice.

2. Provide minimum four (4) hours training on systems in at least two (2) separate segments. In addition provide separately minimum eight (8) hours training on control systems in at least four (4) separate segments.

3. Provide additional four (4) hour training sessions at 6 month after substantial completion and 11 months after substantial completion.

3.03 DEMONSTRATION AND TRAINING VIDEO RECORDINGS

A. General: Engage a qualified videographer to record demonstration and training video recordings. Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids, but not student practice.

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 Architect.

C. Narration: Describe scenes on video recording by audio narration by microphone while or dubbing audio narration off-site after video recording is recorded. Include description of items being viewed.

D. Pre-Produced Video Recordings: Provide video recordings used as a component of training modules in same format as recordings of live training.

END OF SECTION 01 79 00
SECTION 22 05 29
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

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

1.02 SUMMARY
   A. The work covered under this Section of the Specifications is intended to include the
      furnishing of all equipment, materials and labor or reasonably incidental to the complete
      operating installation of systems as shown on the plan and of related equipment all as
      indicated on the drawings, as hereinbefore specified under Division 22 and as hereinafter
      specified in this Section.
   B. Section Includes:
      1. Metal pipe hangers and supports.
      2. Trapeze pipe hangers.
      3. Thermal-hanger shield inserts.
      4. Fastener systems.
      5. Pipe positioning systems.
      6. Equipment supports.

1.03 PERFORMANCE REQUIREMENTS
   A. Delegated Design: Design trapeze pipe hangers and equipment supports, including
      comprehensive engineering analysis by a qualified professional engineer, using
      performance requirements and design criteria indicated.
   B. Structural Performance: Hangers and supports for plumbing piping and equipment shall
      withstand the effects of gravity loads and stresses within limits.
      1. Design equipment and piping supports for multiple pipes capable of supporting
         combined weight of supported systems, system contents, and test water.

1.04 ACTION SUBMITTALS
   A. Product Data: For each type of product indicated.

1.05 INFORMATIONAL SUBMITTALS
   A. Welding certificates.

1.06 QUALITY ASSURANCE
   A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to
      AWS D1.1/D1.1M, "Structural Welding Code - Steel."
   B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler
      and Pressure Vessel Code.
PART 2 - PRODUCTS

2.01 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
   3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

B. Stainless-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

C. Copper Pipe Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.

2.02 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.03 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: wood blocking with vapor barrier intact.

B. Insulation-Insert Material for Hot Piping: wood blocking with vapor barrier intact.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.04 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.05 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.06 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.07 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
E. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.


H. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.

6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.02 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.03 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.04 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods flush with support.

C. Provide close cell insulation protection on all sharp edges of supports within 7'-6" of finished floor.

3.05 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
   4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
   5. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
   6. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
   7. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
   8. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
   9. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

   1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
   2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with barjoist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.
8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.

P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
R. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 22 05 29
SECTION 22 05 53
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 22 and as hereinafter specified in this Section.

1.03 ACTION SUBMITTAL

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

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch Stainless steel, 0.025-inch Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.


5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

2. Letter Color: Black.


4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Make, Model, Capacities & Characteristics (example: CFM, GPM, BTU/H...).

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Red. Background Color: White

C. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

F. Fasteners: Stainless-steel rivets or self-tapping screws.

G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

H. Label Content: Include caution and warning information, plus emergency notification instructions.

2.03 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2. Siphonic roof drain system’s labels shall say “Siphonic Roof Drain, Section length __”, Pipe dia. __”, do not modify without consulting engineer.” The actual dimensions and pipe sizes must be filled in per section, they can be noted with a permanent means.
3. Lettering Size: At least 1-1/2 inches high.

2.04 VALVE TAGS

A. General Requirements for Manufactured valve tags: 1-1/2” diameter brass disc with stamped black filled character whose size are between 1/4”-1/2”. Tags shall be painted to match the pipe label color and be connected to the valve with 12” long copper chains. Tag shall include a unique valve number. Do not use pipe tags for bare pipes conveying fluids at temperatures of 125 deg F or higher.

PART 3 - EXECUTION

3.01 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.02 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.03 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 20 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
7. Install labels longitudinally along top of painted or publically exposed ducts.

B. Pipe Label Color Schedule:

1. Coordinate all colors with Owner/Engineer prior to ordering, the following are default colors.

3.04 VALVE TAG INSTALLATION

A. Provide valves tags at all valves in all piping excluding fixture stops. Do not put valve tags on valves that are isolation valves within 5’ of equipment they serve and the function is obvious. A complete log of the tags, valve location, what the valve is serving shall be provided. An acceptable alternate is to label the valve on the tag with what the valve serves.

END OF SECTION 22 05 53
SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 23 and as hereinafter specified in this Section.

B. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Sleeves.
5. Escutcheons.
7. HVAC demolition.
8. Equipment installation requirements common to equipment sections.
9. Concrete bases.
10. Supports and anchorages.

1.03 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.04 SUBMITTALS

A. Welding certificates.
1.05 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

PART 2 - PRODUCTS

2.01 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.02 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.


G. Solvent Cements for Joining Plastic Piping:
   1. CPVC Piping: ASTM F 493.
   2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.03 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

F. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.04 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

B. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

C. Pressure Plates: Carbon steel. Include two for each sealing element.

D. 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.

2.05 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.


G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.
2.06 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.
   1. Finish: Polished chrome-plated and rough brass, verify with Architect.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   1. Finish: Polished chrome-plated and rough brass, verify with Architect.

2.07 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 HVAC DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

   1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
   3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
   4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
   5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.02 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. 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 Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.03 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.


F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
1. Comply with ASTM F 402, for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
   2. Plain-End Pipe and Socket Fittings: Use socket fusion.

M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.04 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

3.05 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

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

C. Install HVAC 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.

D. Install equipment to allow right of way for piping installed at required slope.

3.06 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.

3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

5. Install anchor bolts to elevations required for proper attachment to supported equipment.

6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement.

3.07 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.08 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.09 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 23 05 00
SECTION 23 05 29
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

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

1.02 SUMMARY
A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 23 and as hereinafter specified in this Section.

B. Section Includes:
   1. Metal pipe hangers and supports.
   2. Trapeze pipe hangers.
   3. Thermal-hanger shield inserts.
   4. Fastener systems.
   5. Equipment supports.

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

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits.
   1. Design supports for equipment and multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

1.04 ACTION SUBMITTALS
A. Product Data: For each type of product indicated.

B. Delegated-Design Submittal: For pipe hangers indicated to comply with performance requirements and design criteria, including analysis data.

1.05 INFORMATIONAL SUBMITTALS
A. Welding certificates.
1.06 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.01 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.02 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.03 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier intact for piping with liquids below 40 degrees F. For piping with liquids above 40 degrees F, wood blocking with vapor barrier intact.

B. Insulation-Insert Material for Hot Piping: Wood blocking with vapor barrier intact.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.04 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless-steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.05 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.06 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:

   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured.
Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer’s operating manual.

2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.


G. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

H. Install lateral bracing with pipe hangers and supports to prevent swaying.

I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

L. Insulated Piping:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.

6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.02 EQUIPMENT SUPPORTS
A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.03 METAL FABRICATIONS
A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.04 ADJUSTING
A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
B. Trim excess length of continuous-thread hanger and support rods flush with support.
C. Provide closed cell insulation on sharp edges of all supports within 7'-6" of finished floor.

3.05 HANGER AND SUPPORT SCHEDULE
A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
5. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
6. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
7. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
8. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
9. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb.
   b. Medium (MSS Type 32): 1500 lb.
   c. Heavy (MSS Type 33): 3000 lb.
8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
9. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 23 05 29
SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 23 and as hereinafter specified in this Section.

1.03 ACTION SUBMITTAL

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

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch Stainless steel, 0.025-inch Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment’s Drawing designation or unique equipment number, Make, Model, Capacities & Characteristics (example: CFM, GPM, BTU/H…).

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Red.

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.03 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: At least 1-1/2 inches high.
2.04 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware or semi ridged plastic.

B. Supply Air Duct:
   1. Background Color: Green
   2. Letter Color: White

C. Return and Fresh Air Duct:
   1. Background Color: Blue
   2. Letter Color: White

D. Exhaust and Relief Air Duct:
   1. Background Color: Yellow
   2. Letter Color: Black

E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

H. Fasteners: Stainless-steel rivets or self-tapping screws or self-adhesive.

I. Paint/Stencil: Maintain same color, temperature and size requirements as printed labels. Painted labels to be applied with crisp clean lines.

J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
   1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches high.

2.05 VALVE TAGS

A. General Requirements for Manufactured valve tags: 1-1/2” diameter brass disc with stamped black filled character whose size are between 1/4”-1/2”. Tags shall be painted to match the pipe label color and be connected to the valve with 12” long copper chains. Tag shall include a unique valve number. Do not use pipe tags for bare pipes conveying fluids at temperatures of 125 deg F or higher.
PART 3 - EXECUTION

3.01 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.02 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.03 PIPE LABEL INSTALLATION

A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 20 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
7. Install labels longitudinally along top of painted or publically exposed ducts.

B. Pipe Label Color Schedule:

1. Coordinate colors with Owner/Engineer prior to ordering. The following are shown as default colors only.

3.04 DUCT LABEL INSTALLATION

A. Install plastic-laminated or self-adhesive duct labels with permanent adhesive on air ducts in the following color codes, coordinate color with Owner/Engineer prior to ordering:

1. Blue: For outside air supply ducts. (Cold air supply ducts in dual duct systems)
2. Yellow: For Exhaust ducts. (hot air supply ducts in dual duct systems)
3. Green: For supply air ducts.
4. Blue: For relief-, return-, and mixed-air ducts.
5. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 15 feet in each space where ducts are exposed or concealed by removable ceiling system.

C. Install labels longitudinally along top of painted or publically exposed ducts.
3.05 VALVE TAG INSTALLATION

A. Provide valves tags at all valves in all piping excluding fixture stops. Do not put valve tags on valves that are isolation valves within 5' of equipment they serve and the function is obvious. A complete log of the tags, valve location, what the valve is serving shall be provided. An acceptable alternate is to label the valve on the tag with what the valve serves.

END OF SECTION 23 05 53
SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

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

1.02 SUMMARY
   A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 22 and as hereinafter specified in this Section.
   B. Section Includes:
      1. Balancing Air Systems:
         a. Constant-volume air systems.
         b. Variable-air-volume systems.

1.03 DEFINITIONS
   C. TAB: Testing, adjusting, and balancing.
   D. TABB: Testing, Adjusting, and Balancing Bureau.
   E. TAB Specialist: An entity engaged to perform TAB Work.

1.04 APPROVED CONTRACTORS
   A. Air and Fluid Management, 217 S Wilson St, Wilber, NE 68465
   B. Balcon Air and Water Balancing, 7905 L St, Omaha, NE 68358
   C. Systems Management and Balancing, 925 SE Olson DR, Waukee, IA 50263.
   D. MMC Testing and Balancing, 9751 S 142nd Street, Omaha, NE 68138

1.05 ACTION SUBMITTALS

1.06 INFORMATIONAL SUBMITTALS
B. Certified TAB reports.

1.07 QUALITY ASSURANCE

A. TAB Contractor (Supervisor and Technician) Qualifications: Engage a TAB entity certified by AABC, NEBB or TABB.

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

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

C. TAB Report Forms: Use standard TAB contractor’s forms.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.01 EXAMINATION

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

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

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

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

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 233113 "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

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

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

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

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

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

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

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

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

3.02 PREPARATION

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

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

1. Permanent electrical-power wiring is complete.
2. Automatic temperature-control systems are operational.
3. Equipment and duct access doors are securely closed.
4. Balance, smoke, and fire dampers are open.
5. Isolating and balancing valves are open and control valves are operational.
6. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
7. Windows and doors can be closed so indicated conditions for system operations can be met.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" or ASHRAE 111] NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

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

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," Section 230719 "HVAC Piping Insulation."

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

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

E. Units shall be balanced and tested in all operation modes including but not limited to heating, cooling and dehumidification. Operate units on all stages.

F. All spaces with critical differential pressure requirements being positive or negative to adjoining spaces or the exterior shall be measured initially and at design air flows. If pressure readings are not as they should be, then the engineer shall be consulted on resolving the situation to achieve the proper pressure relationship. All measurements shall be documented in the final report.

G. Overall building pressure shall be measured at all exterior doors initially and at design air flows. If pressure readings are not as they should be, then the engineer shall be consulted on resolving the situation to achieve the proper pressure relationship. All measurements shall be documented in the final report.

3.04 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

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

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

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

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

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

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

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

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

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

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

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."
M. All spaces with critical differential pressure requirements being positive or negative to adjoining spaces or the exterior shall be measured initially and at design air flows. If pressure readings are not as they should be, then the engineer shall be consulted on resolving the situation to achieve the proper pressure relationship. All measurements shall be documented in the final report.

N. Overall building pressure shall be measured at all exterior doors initially and at design air flows. If pressure readings are not as they should be, then the engineer shall be consulted on resolving the situation to achieve the proper pressure relationship. All measurements shall be documented in the final report.

3.05 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.
   a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:
   a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
   b. Measure static pressure directly at the fan outlet or through the flexible connection.
   c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
   d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
   a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.

5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.

6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
1. Measure airflow of submain and branch ducts.
   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.

3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.
   1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
   1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
   2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.06 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
   1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
   2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
   3. Measure total system airflow. Adjust to within indicated airflow.
   4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
   5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
   6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.

8. Record final fan-performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance variable-air-volume systems the same as described for constant-volume air systems.
2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
4. Readjust fan airflow for final maximum readings.
5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
3. Set terminal units at full-airflow condition.
4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
3.07 PROCEDURES FOR MOTORS

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

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

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

3.08 TOLERANCES

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

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 percent or minus 10 percent.
2. Air Outlets and Inlets: Plus 5 percent or minus 10 percent.
3. Heating-Water Flow Rate: Plus 5 percent or minus 10 percent.
4. Cooling-Water Flow Rate: Plus 5 percent or minus 10 percent.

3.09 REPORTING

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

B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.10 FINAL REPORT

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

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

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

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

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

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
   a. Indicated versus final performance.
   b. Notable characteristics of systems.
   c. Description of system operation sequence if it varies from the Contract Documents.
12. Notes to explain why certain final data in the body of reports vary from indicated values.
13. Test conditions for fans and pump performance forms including the following:
   a. Settings for outdoor-, return-, and exhaust-air dampers.
   b. Conditions of filters.
   c. Cooling coil, wet- and dry-bulb conditions.
   d. Face and bypass damper settings at coils.
   e. Fan drive settings including settings and percentage of maximum pitch diameter.
   f. Inlet vane settings for variable-air-volume systems.
   g. Settings for supply-air, static-pressure controller.
   h. Other system operating conditions that affect performance.

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

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
8. Critical Room and building differential pressure relationships.

3.11 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 05 93
SECTION 23 09 00
HVAC DIRECT DIGITAL CONTROLS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Furnish all labor, materials, equipment, and services for the installation of a complete Direct Digital Control System (DDC) as indicated, in accordance with provisions of the Contract Documents. The District shall contract independently for graphic programming and integration related to this project on the Tridium N4 Supervisor.

B. Although such work is not specifically indicated, provide all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation.

1.02 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. The Owner will contract directly with the Commissioning Authority (CxA) for this project. All Contractors shall cooperate with the CxA to complete all required commissioning.

1.03 DESCRIPTION

A. General:

1. Omaha Public Schools is using the Niagara N4 software as the “Front End” interface to all buildings. All EMS equipment installed shall be compatible with Niagara N4. The contractor shall provide all Niagara N4 integration services for Niagara integration. Integration shall follow the OPS EMS standards.

2. All control system equipment, including sensors, transmitters, control modules and communication link wiring between controllers required for the installation shall be provided by the Temperature Control Contractor.

3. Communication wiring shall be tested to demonstrated functional operation.

4. All wiring and control hardware to be installed by the Temperature Control Contractor.

5. Temperature Control Contractor to provide all labor incidental to the Building Automation System including engineering assistance, start-up, check-out and programming.

6. Control valves and dampers to be furnished by the temperature control contractor and installed by Mechanical or Sheet metal contractor.

7. The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and a web-based operator interface.

B. System software shall be based on a server/thin client architecture, designed around the open standards of web technology. The control system server shall be accessed using a Web browser over the control system network, the owner’s local area network, and (at the owner’s discretion) over the Internet. The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a web browser shall be required to access point displays, and trends,
configure trends, configure points and controllers, or to download programming into the controllers.

C. System shall use the BACnet protocol for communication between control modules. I/O points, schedules, setpoints, trends and alarms specified in the Sequence of Operations for HVAC Controls shall be BACnet objects.

1.04 QUALITY ASSURANCE

A. The following are the approved vendors for this project:

1. Schneider Electric
2. Honeywell
3. Trane
4. Alerton
5. Tridium
6. Vykon

B. Other manufacturer’s equipment may be proposed but must comply with the following specifications. To obtain bid approval, a detailed technical proposal shall be required of bidders and shall be furnished along with the bid. The information required shall list of at least 3 similar digital transmission, computer oriented, integrated DDC installations which have been on-line for at least 5 years. The list shall include a synopsis of the type of control strategies being implemented, name of primary contact and phone number along with the local service capability. Technical cut sheets for all non-approved products being proposed shall also be provided. Cut sheets shall provide technical information and network requirements. Also provide cut sheets for any custom editing/programming software required for programming controllers.

C. The BAS shall be installed by competent mechanics and checked out by competent technicians regularly employed by the manufacturer or manufacturer representative of the equipment. All JACE programming shall be done with a Niagara N4 certified programmer also regularly employed by the manufacturer or manufacturer representative.

D. Single source responsibility of the Temperature Control Contractor shall include JACE Programming, Niagara N4 programming and Graphics, installations, calibration, and check out of systems.

E. The Temperature Control Contractor shall have an in-place, local support facility with technical staff, spare parts inventory, and all necessary test diagnostic equipment.

1.05 CODES AND STANDARDS

A. It is the responsibility of the Temperature Control Contractor to be familiar with all codes, rules, ordinances, and regulations of the Authority Having Jurisdiction and their interpretations which are in effect at the site of work.

B. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities’ codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to the receipt of bids of the following codes:

1. Federal Communications Commission (FCC)
2. Electronics Industries Association (EIA)
3. American Society of Mechanical Engineers (ASME)
4. Institute of Electrical and Electronics Engineers (IEEE)
5. National Electrical Manufacturers Association (NEMA)
6. National Fire Protection Association (NFPA)
7. Underwriter's Laboratories (UL)
8. Occupational Safety and Health Administration (OSHA)
10. International Building Code (IBC)

a. Section 719 Ducts and Air Transfer Openings
b. Section 907 Fire Alarm and Detection Systems
c. Chapter 28 Mechanical

11. International Mechanical Code (IMC)
12. American National Standards Institute (ANSI)
13. American Society of Heating, Refrigeration and Air Conditioning Engineers

C. The Temperature Control Contractor shall be solely responsible for compliance with all health and safety regulations, performing the work in a safe and competent manner, and use industry accepted installation procedures required for the work as outlined in this document.

D. All systems equipment, components, accessories, and installation hardware shall be new and free from defects and shall be UL listed where applicable. All components shall be in current production and shall be a standard product of the system or device manufacturer. refurbished or reconditioned components are unacceptable. Each component shall bear the make, model number, device tag number (if any), and the UL label as applicable. All System components of a given type shall be the product of the same manufacturer.

1.06 SUBMITTALS

A. Product Data and Shop Drawings: Meet requirements of Section 01 30 00 on Shop Drawings, Product Data, and Samples. In addition, the contractor shall provide an electronic copy of all shop drawings or other submittals on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD 2013 (or newer) compatible files on magnetic or optical disk (file format: .DWG, .DXF, or comparable) and three 11” x 17” prints of each drawing. When manufacturer’s cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Submittals shall be provided within 3 weeks of contract award. Submittals shall include:

1. DDC System Hardware

a. A complete bill of materials to be used indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.

b. Manufacturer’s description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:
1) Direct digital controllers (controller panels)
2) Transducers and transmitters
3) Sensors (including accuracy data)
4) Actuators
5) Valves
6) Relays and switches
7) Control panels
8) Power supplies
9) Batteries
10) Operator interface equipment
11) Wiring

c. Wiring diagrams and layouts for each control panel. Show termination numbers.
d. Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.

2. Controlled Systems

a. Riser diagrams showing control network layout, communication protocol, and wire types. System architecture drawing shall identify the exact order in which devices are to be wired for communication, including equipment with packaged controls.
b. A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system. Locations of controllers, JACE, pressure transmitters etc. shall be provided.
c. A schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
d. An instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
e. A mounting, wiring, and routing plan-view drawing. The design shall take into account HVAC, electrical, and other systems’ design and elevation requirements. The drawing shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work.
f. A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.
g. A point list for each control system. List I/O points and software points specified in the Sequence of Operation. Indicate alarmed and trended points.

3. Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.

4. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.

B. Project Record Documents. Upon completion of installation, submit three copies of record (as-built) documents of the documents shall be submitted for approval prior to final completion and shall include:
1. Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD 2013 (or newer) compatible files on magnetic or optical media (file format: .DWG, .DXF, or comparable) and as 11" x 17" prints.


3. As-built versions of submittal product data.

4. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.

5. Operator’s manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.

6. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

7. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.

8. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.

9. Graphic files, programs, and database on magnetic or optical media.

10. List of recommended spare parts with part numbers and suppliers.

11. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

12. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.

13. Floor plan drawings identifying communication cable pathways through the building, controller locations and concealed sensor locations. Additionally, sensors that are installed in concealed locations shall have a photograph included that shows the location.

14. Licenses, guarantees, and warranty documents for equipment and systems.

15. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

C. Training Materials: Provide course outline and materials for each class before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training.

1.07 WORK BY OTHERS

A. Automatic Control Valves: Furnished by the Controls Contractor, installed by Mechanical under the supervision of the Temperature Control Contractor. All reducers and fittings necessary to install smaller than pipe size valves shall be furnished and installed under applicable piping sections.

B. Automatic Control Dampers: Furnished by the Controls Contractor, installed by Mechanical under the supervision of the Temperature Control Contractor. All sheet metal and duct modifications required to support the installation shall be provided by the Mechanical Contractor.
C. Piping Penetration: Water pressure and differential taps, valve manifolds, flow switches, thermal wells; installed by Mechanical under the supervision of the Temperature Control Contractor.

D. Power Source Wiring; and all 120 volts A.C. power source wiring: Furnished and installed under Division 26: Electrical:

E. The District shall contract independently for graphic programming and integration related to this project on the Tridium N4 Supervisor.

1.08 WARRANTY

A. Warrant work as follows:

1. At completion of final test of installation and acceptance by the District, provide any service incidental to proper performance for a period of one year. Provide one year in warranty service with minimum of 2 maintenance/calibration inspections. Unlimited telephone technical support for OPS employees shall also be provided during the warranty period. Telephone support shall be available Monday through Friday, 8:00 AM to 5:00 PM.

2. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner’s warranty service request.

3. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer’s acceptance.

1.09 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become Owner’s property. This includes, but is not limited to:

1. Graphics
2. Record drawings
3. Database
4. Application programming code
5. Documentation

PART 2 - PRODUCTS

2.01 GENERAL

A. The Direct Digital Control System shall consist of the following:

1. Standalone DDC panels (JACE).
2. Application specific controllers.
3. Local Display Devices.

B. JACE 8000 - The School District has standardized on Niagara N4 as the main system software and architecture. All JACES installed must have the same point capacity. Point capacity shall not exceed 250 points per JACE. When point count becomes 80% of the JACE capacity (200 Points) additional JACE’s are required.
C. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, standalone DDC panels, and operator devices.

D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

E. Standalone DDC panels shall be able to access any data from or send control commands and alarm reports directly to any other DDC panel or combination of panels on the network without dependence upon a central processing device, such as a central file server. Standalone DDC panels shall also be able to send alarm reports to multiple operator workstations, terminals, and printers without dependence upon a central processing device or File Server.

2.02 MATERIALS

A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.03 NETWORKING/COMMUNICATION

A. Design of the DDC shall network operator workstations and Standalone DDC Panels as indicated on drawings. Inherent in the system's design shall be the ability to expand or modify the network via a local network.

1. Local Area Network:
   a. Dynamic Data Access: All operator devices shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the local area network.
   b. Access to system data shall not be restricted by the hardware configuration of the DDC. Hardware configuration of the DDC network shall be transparent to user when accessing data or developing control programs.
   c. General Network Design: Network design shall include the following provisions:
      1) High speed data transfer rates for alarm reporting, quick report generation from multiple controllers, and upload/download efficiency between network devices.
      2) Support of any combination of controllers directly connected to the local area network.
      3) Detection and accommodation of single or multiple failures of either DDC panels or the network media. The network shall include provisions for automatically re-configuring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.
      4) Message and alarm buffering to prevent information from being lost.
      5) Error detection, correction, and re-transmission to guarantee data integrity.
6) Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.

7) Commonly available, multiple sourced, networking components shall be used to allow the DDC to coexist with other networking applications. The following are acceptable technologies: BACNET or ETHERNET.

8) Communications must be that of a deterministic nature to assure calculable performance under worst case network loading. When a collision-based network is proposed, Contractor shall provide detailed calculations indicating worse-case network response times.

9) Automatic synchronization of the real-time clocks in all DDC panels shall be provided.

B. System Software.

1. System Graphics. This contract requires the creation of all system graphics on the Building Control System Server.

2. Integration and central system graphics shall be provided by an independent third party on the District-Wide Niagara Tridium N4 Supervisor.

3. The operator interface on the Building Control System Server shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.

   a. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.

   b. Animation. Graphics shall be able to animate by displaying different image files for changed object status.

   c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.

   d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Adobe Flash).

C. System Applications. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.

1. Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.

2. Manual Controller Memory Download. Operators shall be able to download memory from the system database to each controller.
3. System Configuration. The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection. Operators shall be able to configure the system.

4. On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.

5. Security. Each operator shall be required to log on to the system with username and password in order to view, edit, add, or delete data. The Tridum N4 Supervisor and all connected DDC Control Systems shall utilize the District’s Active Directory for Single Source Login.

   a. Operator Access. The username and password combination shall define accessible viewing, editing, adding, and deleting privileges for that operator. Users with system administrator rights shall be able to create new users and edit the privileges of all existing users.

   b. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time shall be user adjustable.


6. System Diagnostics. The system shall automatically monitor the operation of all building management panels and controllers. The failure of any device shall be annunciated to the operator.

7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in the Sequences of Operation. Alarms shall be BACnet alarm objects and shall use BACnet alarm services.

8. Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying on acronyms.

9. Alarm Reactions. Operator shall be able to configure (by object) what, if any actions are to be taken during an alarm. As a minimum, the workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.

10. Alarm and Event log. Operators shall be able to view all system alarms and changes of state from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and delete alarms and archive closed alarms to the workstation or web server hard disk.

11. Trend Logs. The operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified in the Sequences of Operation. Trends shall be BACnet trend objects.

12. Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object or property in the system. The status shall be available by menu, on graphics, or through custom programs.

13. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
14. Standard Reports. Furnish the following standard system reports:

a. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.


c. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:

1) Alarm History.
2) Trend Data. Operator shall be able to select trends to be logged.
3) Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

15. Energy Reports. System shall include an easily configured energy reporting tool that provides the capabilities described in this section.

a. The energy reporting tool shall be accessible through the same user interface (operator workstation software) as is used to manage the BAS.

b. The energy reporting tool shall be preconfigured by the Contractor to gather and store energy demand and consumption data from each energy source that provides metered data to the BAS. Analog meter data shall be stored at 5 minute intervals unless otherwise specified in the Sequence of Operation. Binary or multiple-state meter data shall be stored at change of value (CoV) rate unless otherwise specified in the Sequence of Operation. This data shall be maintained in an industry standard SQL database for a period of not less than five years.

c. The energy reporting tool shall allow the operator to select an energy source and a time period of interest (day, week, month, year, or date range) and shall provide options to view the data in a table, line graph, bar graph, or pie chart. The tool shall also allow the operator to select two or more data sources and display a comparison of the energy used over this period in any of the listed graph formats, or to total the energy used by the selected sources and display that data in the supported formats.

d. The energy reporting tool shall allow the operator to select and energy source and two time periods of interest (day, week, month, year, or date range) and display a graph that compares the energy use over the two time periods in any of the graph formats listed in the previous paragraph. The tool shall also allow the operator to select multiple energy sources and display a graph that compares the total energy used by these sources over the two time periods.

e. The energy reporting tool shall allow the operator to easily generate the previously described graphs "on the fly," and shall provide an option to store the report format so the operator can select that format to regenerate the graph at a future date. The tool shall also allow the user to schedule these reports to run on a recurring basis using relative time periods, such as automatically generating a consumption report on the first Monday of each month showing consumption over the previous month. Automatically generated reports shall be archived on the server in a common industry format such as Adobe PDF or Microsoft Excel with copies e-mailed to a user editable list of recipients.
f. The energy reporting tool shall be capable of collecting and displaying data from the following types of meters:

1) Gas
2) Potable Water
3) Electricity

g. The user shall have the option of using Btu/hr (Btu) as the units for demand and consumption reports. Multiples of these units (MWH, kBtu, etc.) shall be used as appropriate. All selected sources shall be automatically converted to the selected units. The user shall similarly have the option of entering facility area and occupancy hours and creating reports that are normalized on an area basis, an annual use basis, or an occupied hour basis.

h. The user shall have the option of entering benchmark data for an individual facility or a group of facilities.

i. The user shall have the option of displaying any or all of the following data on any chart, line, or bar graph generated by the energy reporting tool:

1) Low/High/Average value of the metered value being displayed.
2) Heating and/or Cooling Degree Days for the time period(s) being displayed.

D. Workstation Application Editors. Each PC or browser workstation shall support editing of all system applications via password protected web access. The applications shall be downloaded and executed at one or more of the controller panels.

1. Controller. Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.

2. Scheduling. An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and schedule type. Exception schedules and holidays shall be shown clearly on the calendar. The start and stop times for each object shall be adjustable from this interface. All schedules shall be BACnet schedule objects.

3. Custom Application Programming. Provide the tools to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

a. Language. Language shall be graphically based or English language oriented. If graphically based, language shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks. Any ancillary software required to support function block programming shall be supplied with the control system. If English language oriented, language shall be based on the syntax of BASIC, FORTRAN, C, or PASCAL, and shall allow for free-form programming that is not column-oriented or "fill-in-the-blanks."

b. A full-screen character editor programming environment shall be provided. The editor shall be cursor/mouse-driven and allow the user to insert, add, modify, and delete custom programming code. It also shall incorporate features such as cut/paste and find.
c. The programming language shall allow independently executing program modules to be developed. Each module shall be able to independently enable and disable other modules.

d. The editor/programming environment shall have a debugging/simulation capability that allows the user to step through the program and observe any intermediate values and/or results.

e. The programming language shall support conditional statements (IF/THEN/ELSE/ ELSE-IF) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

f. The programming language shall support floating-point arithmetic using the following operators: +, -, ÷, ×, and square root. The following mathematical functions also shall be provided: absolute value and minimum/maximum value.

g. The programming language shall have predefined variables that represent time of day, day of the week, month of the year, and the date. Other predefined variables shall provide elapsed time in seconds, minutes, hours, and days. These elapsed time variables shall be able to be reset by the language so that interval-timing functions can be stopped and started within a program. Values from all of the above variables shall be readable by the language so that they can be used in a program for such purposes as IF/ THEN comparisons, calculations, etc.

h. The language shall be able to read the values of the variables and use them in programming statement logic, comparisons, and calculations.

i. The programming language shall have predefined variables representing the status and results of the system software and shall be able to enable, disable, and change the setpoints of the system software described below.

1) Portable Operator's Provide one Microsoft Surface 7 Laptop with all controller service software installed. The controller software shall allow the technician to manually control all output points, read values of all input points and virtual points for all provided controllers. The Service software shall allow OPS to edit, develop new or delete any custom programming. Laptop shall be provided with all required cabling to interface to all provided field controllers including JACE.

2.04 CONTROLLER SOFTWARE

A. Furnish the following applications for building and energy management. All software application shall reside and operate in the system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.

B. Provide one Microsoft Surface 7 Laptop with all controller service software installed. The controller software shall allow the technician to manually control all output points, read values of all input points and virtual points for all provided controllers. The Service software shall allow OPS to edit, develop new or delete any custom programming. Laptop shall be provided with all required cabling to interface to all provided field controllers.


D. Scheduling. Provide the capability to execute control functions according to a user created or edited schedule. Each schedule shall provide the following schedule options as a minimum:
1. Weekly Schedule. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events). Initial schedules shall provide for Optimal start of the equipment 2 hours before occupancy. Start time is 7:40 and stop time is 5:00.

2. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule has executed, the system shall discard and replace the exception schedule with the standard schedule for that day of the week.

3. Holiday Schedules. Provide the capability for the operator to define up to 24 special or holiday schedules. These schedules will be repeated each year. The operator shall be able to define the length of each holiday period.

4. All schedules shall be BACnet schedule objects.

E. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

F. Binary Alarms. Each binary object shall have the capability to be configured to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

G. Analog Alarms. Each analog object shall have both high and low alarm limits. The operator shall be able to enable or disable these alarms.

H. Alarm Reporting. The operator shall be able to determine the action to be taken in the event of an alarm. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display on graphics.

I. Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms.

J. Demand Limiting.

1. The demand-limiting program shall monitor building power consumption from a building power meter (provided by others) which generates pulse signals or a BACnet communications interface. An acceptable alternative is for the system to monitor a watt transducer or current transformer attached to the building feeder lines.

2. When power consumption exceeds adjustable levels, system shall automatically adjust setpoints, de-energize low-priority equipment, and take other programmatic actions to reduce demand as specified in the Sequence of Operation. When demand drops below adjustable levels, system shall restore loads as specified.

K. Maintenance Management. The system shall be capable of generating maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in the Sequence of Operation.

L. Sequencing. Application software shall sequence chillers, boilers, and pumps as specified in Section the Sequence of Operation.

M. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog
value that can be used to position an output or to stage a series of outputs. The calculation
interval, PID gains, and other tuning parameters shall be adjustable by a user with the correct
security level.

N. Staggered Start. System shall startup by time schedules and restart after power outage. All
HVAC contained within an area or zone shall stagger the startup of the equipment. Operator shall
be able to adjust equipment restart order and time delay between equipment restarts.

O. Energy Calculations.

1. The system shall accumulate and convert instantaneous power (kW) or flow rates (gpm)
to energy usage data.
2. The system shall calculate a sliding-window average (rolling average). Operator shall be
able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.

P. Anti-Short Cycling. All binary output objects shall be protected from short cycling by means of
adjustable minimum on-time and off-time settings.

Q. On and Off Control with Differential. Provide an algorithm that allows a binary output to be cycled
based on a controlled variable and a setpoint. The algorithm shall be direct-acting or reverse-
acting.

R. Runtime Totalization. Provide software to totalize runtime for each binary input and output.
Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit.
Configure and enable runtime totalization and alarms as specified in the Sequence of Operation.

2.05 CONTROLLERS

A. General. Provide an adequate number of JACE Building Controllers (BC), Advanced Application
Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart
Sensors (SS) as required to achieve performance specified. Every device in the system which
executes control logic and directly controls HVAC equipment must conform to a standard BACnet
Device profile as specified in ANSI/ASHRAE 135, BACnet Annex L. Unless otherwise specified,
hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart
Sensors. Building controllers shall be JACE8000.

B. BACnet.

1. Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B- BC)
device profile as specified in ANSI/ASHRAE 135, BACnet Annex L, and shall be listed
as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet
Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE
135, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing
Laboratories (BTL) Product Listing.
3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application
Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135, BACnet
Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories
(BTL) Product Listing.
4. Smart Sensors (SSs). Each SS shall conform to BACnet Smart Sensor (B-SS) device
profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be
listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.

5. BACnet Communication.
   a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
   b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
   c. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
   d. Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
   e. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
   f. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.

C. Communication
   1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator’s Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
   2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
   3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
   4. Stand-Alone Operation. Each piece of equipment specified shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.

D. Environment. Controller hardware shall be suitable for anticipated ambient conditions.
   1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).
   2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

E. Keypad. Provide a laptop and software and any interface cabling needed to use a laptop computer as a Portable Operator's Terminal for the system.

F. Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.

G. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal
operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

H. Memory.

1. Controller memory shall support operating system, database, and programming requirements.
2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

I. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m.

J. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.06 INPUT AND OUTPUT INTERFACE

A. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

B. Protection. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground shall cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no controller damage.

C. Space Setpoints. Space setpoints will be controllable from the space thermostat or from the BAS system. Operator will have the ability to choose if the setpoint used comes from the thermostat or BAS. On new installation the default shall be -Thermostat adjustments disabled and BAS enabled. Setpoints, both BAS and Local shall be limited to the following:

1. Cooling High Limit = 78
2. Cooling low limit = 70
3. Heating High Limit = 75
4. Cooling low limit = 68

D. Binary Inputs. Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

E. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall also accumulate up to 10 pulses per second.

F. Analog Inputs. Analog inputs shall monitor low-voltage (0–10 Vdc), current (4–20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.
G. Binary Outputs. Binary outputs shall provide for ON/OFF operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on Building Controllers shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

H. Analog Outputs. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0–10 Vdc or a 4–20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

I. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

J. System Object Capacity. The system size shall be expandable to at least twice the number of input/output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.07 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

   a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
   b. Line voltage units shall be UL recognized and CSA listed.

B. Power Line Filtering.

1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:

   a. Dielectric strength of 1000 V minimum
   b. Response time of 10 nanoseconds or less
   c. Transverse mode noise attenuation of 65 dB or greater
   d. Common mode noise attenuation of 150 dB or greater at 40–100 Hz

2.08 AUXILIARY CONTROL DEVICES

A. Motorized Control Dampers, unless otherwise specified elsewhere, shall be as follow:
1. Type. Control dampers shall be the parallel or opposed-blade type as specified below or as scheduled on drawings.
   a. Outdoor and return air mixing dampers and face-and-bypass dampers shall be parallel-blade and shall direct airstreams toward each other.
   b. Other modulating dampers shall be opposed-blade.
   c. Two-position shutoff dampers shall be parallel- or opposed-blade with blade and side seals.

2. Frame. Damper frames shall be 2.38 mm (13 gauge) galvanized steel channel or 3.175 mm (⅛ in.) extruded aluminum with reinforced corner bracing.

3. Blades. Damper blades shall not exceed 20 cm (8 in.) in width or 125 cm (48 in.) in length. Blades shall be suitable for medium velocity (10 m/s [2000 fpm]) performance. Blades shall be not less than 1.5875 mm (16 gauge).

4. Shaft Bearings. Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze, or better.

5. Seals. Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Side seals shall be spring-loaded stainless steel. Blade seals shall leak no more than 50 L/s·m² (10 cfm per ft²) at 1000 Pa (4 in. w.g.) differential pressure. Blades shall be airfoil type suitable for wide-open face velocity of 7.5 m/s (1500 fpm).

6. Sections. Individual damper sections shall not exceed 125 cm × 150 cm (48 in. × 60 in.). Each section shall have at least one damper actuator.

7. Modulating dampers shall provide a linear flow characteristic where possible.

8. Linkages. Dampers shall have exposed linkages.

B. Electric Damper and Valve Actuators.

1. Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.

2. Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).

3. Signal and Range. Proportional actuators shall accept a 0–10 Vdc or a 0–20 mA control signal and shall have a 2–10 Vdc or 4–20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as described in paragraph 2.6H.). Outdoor Dampers and Heating Valves values shall be 0% for open and 100% for closed. Chilled water valves shall be 0% wide open and 100% closed.

4. Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.

5. Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank.

6. All Damper and Valve Actuators shall be by Belimo.

C. Control Valves.

1. Control valves shall be two-way or three-way type for two-position or modulating service as shown.

2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
   a. Water Valves:
      1) Two-way: 150% of total system (pump) head.
2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

   a. Body and trim style and materials shall be in accordance with manufacturer’s recommendations for design conditions and service shown, with equal percentage ports for modulating service.
   b. Sizing Criteria:
      1) Two-position service: Line size.
      2) Two-way modulating service: Valve CV shall be calculated based on design parameters and resulting calculation provided with the valve submittal. Pressure drop across the control valve shall not exceed 3 PSI.
      3) Three-way modulating service: Valve CV shall be calculated based on design parameters and resulting calculation provided with the valve submittal. Pressure drop across the control valve shall not exceed 3 PSI.
      4) Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.
      5) Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
   c. Water valves shall fail normally open or closed, as scheduled on plans, or as follows:
      1) Water zone valves—normally open preferred.
      2) Heating coils in air handlers—normally open.
      3) Chilled water control valves—normally closed.
      4) Other applications—as scheduled or as required by sequences of operation.

D. Binary Temperature Devices.
   1. Low-Voltage Space Thermostats. Low-voltage space thermostats shall be 24 V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C–30°C (55°F–85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
   2. Line-Voltage Space Thermostats. Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 13°C–30°C (55°F–85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
   3. Low-Limit Thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 6 m (20 ft) long. Element shall sense temperature in each 30 cm (1 ft) section and shall respond to lowest sensed temperature. Provide a minimum of 1.5 m (5 ft) of element length per 1 m2 (10 ft2) of duct cross-section. Low-limit thermostat shall be manual reset only.

E. Temperature Sensors.
1. Type. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.

2. Duct Sensors. Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m² (10 ft²) of duct cross-section.

3. Immersion Sensors. Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.

4. Space Sensors. Space sensors shall have an adjustable setpoint adjustment and include space temperature, space humidity and space CO₂. The space adjustment shall be disabled and control of the setpoint through the BAS.


F. Humidity Sensors.

1. Duct and room sensors shall have a sensing range of 20%–80%.
2. Duct sensors shall have a sampling chamber.
3. Outdoor air humidity sensors shall have a sensing range of 20%–95% RH and shall be suitable for ambient conditions of -40°C–75°C (-40°F–170°F).
4. Humidity sensors shall not drift more than 1% of full scale annually.

G. Flow Switches. Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).

1. Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.
2. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

H. CO₂ Sensors

1. CO₂ Sensors shall use non-dispersive infrared (NDIR) and equipped with automatic background calibration.
2. The CO₂ sensor have a range of 200 ppm to 2000 ppm or greater.
3. CO₂ sensors shall be certified by the manufacturer to be accurate within plus or minus 75 ppm at a 600 and 1000 ppm concentration. The sensors shall be factory or field calibrated and certified by the manufacturer to require calibration no more frequently than once every 5 years.
4. CO₂ sensors must be located in the room between 3 ft and 6 ft above the floor or at the anticipated height of the occupants’ heads.

I. Relays.

1. Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
2. Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

J. Override Timers.
1. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0–6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

K. Current Transmitters.

1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4–20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.

3. Unit shall be split-core type for clamp-on installation on existing wiring.

L. Current Transformers.

1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.

2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.

3. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

M. Voltage Transmitters.

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4–20 mA output with zero and span adjustment.

2. Adjustable full-scale unit ranges shall be 100–130 Vac, 200–250 Vac, 250–330 Vac, and 400–600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

N. Voltage Transformers.

1. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.

2. Transformers shall be suitable for ambient temperatures of 4°C–55°C (40°F–130°F) and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.

3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

O. Power Monitors.

1. Selectable rate pulse output for kWh reading, 4–20 mA output for kW reading, N.O. alarm contact, and ability to operate with 5.0 amp current inputs or 0–0.33 volt inputs.

2. 1.0% full-scale true RMS power accuracy, ±0.5 Hz, voltage input range 120–600 V, and auto range select.


4. NEMA 1 enclosure.
5. Current transformers having a 0.5% FS accuracy, 600 VAC isolation voltage with 0–0.33 V output. If 0–5 A current transformers are provided, a three-phase disconnect/shorting switch assembly is required.

P. Hydronic Flowmeters

1. Insertion-Type Turbine Meter
   a. Dual 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. Single turbine for piping 2 inches and smaller. Flow sensing turbine rotors shall be non-metallic and not impaired by magnetic drag.
   b. Insertion type complete with 'hot-tap' isolation valves to enable sensor removal without water supply system shutdown.
   c. Sensing method shall be impedance sensing (nonmagnetic and non-photoelectric)
   d. Volumetric accuracy
      
      1) ± 0.5% of reading at calibrated velocity
      2) ± 1% of reading from 3 to 30 ft/s (10:1 range)
      3) ± 2% of reading from 0.4 to 20 ft/s (50:1 range)

   e. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).
   f. Maximum operating pressure of 400 psi and maximum operating temperature of 200°F continuous (220°F peak).
   g. All wetted metal parts shall be constructed of 316 stainless steel.
   h. Analog outputs shall consist of non-interactive zero and span adjustments, a DC linearly of 0.1% of span, voltage output of 0-10 Vdc, and current output of 4-20 mA.

2. Magnetic Flow-Tube Type Flowmeter
   a. Sensor shall be a magnetic flowmeter, which utilizes Faraday’s Law to measure volumetric fluid flow through a pipe. The flowmeter shall consist of two elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.
   b. Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).
   c. Four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used provided accuracy is as specified.
   d. Flow Tube:
      
      1) ANSI class 150 psig steel
      2) ANSI flanges
      3) Protected with PTFE, PFA, or ETFE liner rated for 245°F minimum fluid temperature
e. Electrode and grounding material

1) 316L Stainless steel or Hastelloy C
2) Electrodes shall be fused to ceramic liner and not require o-rings.

f. Electrical Enclosure: NEMA 4, 7

g. Approvals:

1) UL or CSA
2) NSF Drinking Water approval for domestic water applications

h. Performance

1) Accuracy shall be ±0.5% of actual reading from 3 to 30 ft/s flow velocities, and 0.015 ft/s from 0.04 to 3 ft/s.
2) Stability: 0.1% of rate over six months.
3) Meter repeatability shall be ±0.1% of rate at velocities > 3 ft/s.

3. Magnetic Insertion-Type Flowmeter

a. Magnetic Faraday point velocity measuring device.
b. Insertion type complete with hot-tap isolation valves to enable sensor removal without water supply system shutdown.
c. 4-20 mA transmitter proportional to flow or velocity.
d. Accuracy: larger of 1% of reading and 0.2 ft/s.
e. Flow range: 0.2 to 20 ft/s, bidirectional.
f. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).

4. Vortex Shedding Flowmeter

a. Output: 4-20 mA, 0-10 Vdc, 0-5 Vdc.
c. Wetted Parts: Stainless Steel.
d. Housing: NEMA 4X.
e. Turndown: 25:1 minimum.
f. Accuracy: 0.5% of calibrated span for liquids, 1% of calibrated span for steam and gases.
g. Body: Wafer style or ANSI flanged to match piping specification.

5. Transit-Time Ultrasonic Flowmeter

a. Clamp-On transit-time ultrasonic flowmeter
b. Wide-Beam transducer technology
c. 4-20 mA transmitter proportional to flow or velocity.
d. Accuracy: 0.5% of reading in range 1 to 30 ft/s, 0.001 ft/s sensitivity.

Q. Thermal Energy Meters

1. Matched RTD, solid state, or thermistor temperature sensors with a differential temperature accuracy of ±0.15°F.
2. Flow meter: See "Hydronic Flowmeters" section.
3. Unit accuracy of ±1% factory calibrated, traceable to NIST with certification.
4. NEMA 1 enclosure.
5. Panel mounted display.
6. UL listed.
7. Isolated 4–20 ma signals for energy rate and supply and return temperatures and flow.

R. Current Switches.
1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

S. Pressure Transducers.
1. Transducers shall have linear output signal and field-adjustable zero and span.
2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
3. Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducer shall have 4–20 mA output, suitable mounting provisions, and block and bleed valves.
4. Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300 psi). Transducer shall have 4–20 mA output, suitable mounting provisions, and 5-valve manifold.

T. Differential Pressure Switches. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified. Differential pressure switches designated for High Limit functions shall be provided with Manual Reset if specified.

U. Pressure-Electric (PE) Switches.
1. Shall be metal or neoprene diaphragm actuated, operating pressure rated for 0–175 kPa (0–25 psig), with calibrated scale minimum setpoint range of 14–125 kPa (2–18 psig) minimum, UL listed.
2. Provide one- or two-stage switch action (SPDT, DPST, or DPDT) as required by application Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.
3. Switches shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.
4. Each pneumatic signal line to PE switches shall have permanent indicating gauge.

V. Occupancy Sensors. Occupancy sensors shall utilize Passive Infrared (PIR) and/or Microphonic Passive technology to detect the presence of people within a room. Sensors shall be mounted as indicated on the approved drawings. The sensor output shall be accessible by any lighting and/or HVAC controller in the system. Occupancy sensors shall be capable of being powered from the lighting or HVAC control panel, as shown on the drawings. Occupancy sensor delay shall be software adjustable through the user interface and shall not require manual adjustment at the sensor.

W. Local Control Panels.
1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.

2. Interconnections between internal and face-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.

3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

2.09 WIRING AND RACEWAYS

A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.

B. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

PART 3 - EXECUTION

3.01 EXAMINATION

A. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.

B. The contractor shall examine the drawings and specifications for other parts of the work. If headroom or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor’s work and the plans and the work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor’s work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by—and at the expense of—this contractor.

3.02 PROTECTION

A. The contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.

B. The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.03 COORDINATION

A. Site

1. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with
work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.

2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Submittals. See Specifications for submittal requirements.

C. Test and Balance.

1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
2. The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
3. In addition, the contractor shall provide a qualified technician to coordinate and assist in the test and balance process as needed.
4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.

D. Life Safety.

1. Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown as specified in the Sequence of Operation.
2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as specified in the Sequence of Operation.
3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 28.

E. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

1. All communication media and equipment shall be provided as specified.
2. Each supplier of a controls product is responsible for the configuration, programming, start up, and testing of that product to meet the sequences of operation.
3. The contractor shall coordinate and resolve any incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
4. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
5. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.04 GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
C. Install equipment in readily accessible locations as defined by Chapter 1 Article 100 Part A of the National Electrical Code (NEC).

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.05 FIELD QUALITY CONTROL

A. All work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances.

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

C. Contractor shall have work inspection by local and/or state authorities having jurisdiction over the work.

3.06 EXISTING EQUIPMENT

A. Wiring. Interconnecting control wiring shall be removed and shall become the property of the contractor unless specifically noted or shown to be reused.

B. Local Control Panels. Remove and deliver existing control panels to Owner.

C. Repair. Unless otherwise directed, the contractor is not responsible for repair or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the engineer is to be notified immediately.

D. Indicator Gauges. Where these devices remain and are not removed, they must be made operational and recalibrated to ensure reasonable accuracy.

E. Room Thermostats. Remove and deliver existing room thermostats to Owner unless otherwise noted. Patch and finish holes and marks left by removal to match existing walls.

F. Electronic Sensors and Transmitters. Remove and deliver existing sensors and transmitters to Owner.

G. Controllers and Auxiliary Electronic Devices. Remove and deliver existing controllers and auxiliary electronic devices to Owner.

H. Damper Actuators, Linkages, and Appurtenances. Remove and deliver existing damper actuators, linkages and appurtenances to Owner.

I. Control Valves. Replace existing control valves with new. Deliver removed control valves to Owner.

J. Control Compressed Air Systems. Replace existing control compressed air systems with new unless otherwise noted. Deliver removed systems to Owner.
K. Existing System Operating Schedule. Existing mechanical system may be disabled during this work.

L. The scheduling of fans through existing or temporary time clocks or control system shall be maintained throughout the DDC system installation.

M. Install control panels where shown.

N. Modify existing starter control circuits, if necessary, to provide hand-off-auto control of each controlled starter. If new starters or starter control packages are required, these shall be included as part of this contract.

O. Patch holes and finish to match existing walls.

3.07 WIRING

A. Contractor shall provide and install EMS LAN connections. MAC address of new equipment shall be provided to Omaha Public Schools so reservations can be made. If additional LAN connections are required, the contractor is responsible to install LAN wiring as needed.

B. Contractor shall provide and install Systimax Cat6A from the BAS System to the appropriate OPS network switch. This needs to be completed by a Systimax certified installer per OPS standards. Contractor shall test and verify the Systimax cable is terminated and communicating properly. After communication is verified contractor is to contact OPS Energy Manager, Tony Zimmerman at 531-299-0180 to verify the Jace is communicating and verify network connections.

C. All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification, Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.

D. All NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements.

E. All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be subfused when required to meet Class 2 current limit.

F. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for the intended application.

G. All wiring in mechanical, electrical, or service rooms – or where subject to mechanical damage – shall be installed in raceway.

H. Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

I. Do not install wiring in raceway containing tubing.

J. Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and supported per the requirements of the NEC.
K. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

L. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

M. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

N. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.

O. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

P. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

Q. Size of raceway and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer’s recommendations and NEC requirements, except as noted elsewhere.

R. Include one pull string in each raceway 1 in. or larger.

S. Use color-coded conductors throughout with conductors of different colors.

T. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

U. Conceal all raceways except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 in. from high-temperature equipment (e.g. steam pipes or flues).

V. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

W. Adhere to this specification’s Division 26 requirement where raceway crosses building expansion joints.

X. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of vertical raceways.

Y. The contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

Z. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 3 ft. in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

AA. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings.
(according to code). Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.

3.08 COMMUNICATION WIRING

A. The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

C. Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.

D. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.

F. When a cable enters or exits a building, a lightning arrester must be installed between the lines and ground. The lighting arrester shall be installed according to manufacturer's instructions.

G. All runs of communication wiring shall be un-spliced length when that length is commercially available.

H. All communication wiring shall be labeled to indicate origination and destination data.

I. All communication wiring pathways shall be documented on the Controls As-Built drawings.

J. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

K. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:

   1. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 30 pF per foot.

   2. The maximum length of an MS/TP segment is 4000 ft. with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.

   3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated using repeaters.

   4. An MS/TP EIA-485 network shall have no T connections.

3.09 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for environment within which the sensor operates.
C. Room temperature sensors shall be installed on concealed junction boxes properly supported by wall framing.

D. All wires attached to sensors shall be sealed in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.

E. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1 ft. of sensing element for each 1 ft² of coil area.

G. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 10 ft. downstream.

H. All pipe-mounted temperature sensors shall be installed in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

I. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

J. Differential Air Static Pressure.

1. Supply Duct Static Pressure. Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the height-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.

2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.

3. Building Static Pressure. Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.

4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.

5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.

6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shut-off valves installed before the tee.

K. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

L. Install humidity sensors for duct mounted humidifiers at least 10 ft. downstream of the humidifier. Do not install filters between the humidifier and the sensor.
3.10 FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.
B. Adjust flow switch according to manufacturer's instructions.

3.11 ACTUATORS

A. General. Mount and link control damper actuators according to manufacturer’s instructions.
   1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
   2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
   3. Provide all mounting hardware and linkages for actuator installation.

B. Electric/Electronic
   1. Dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° travel available for tightening the damper seal. Actuators shall be mounted following manufacturer’s recommendations.
   2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer’s recommendations.

3.12 WARNING LABELS

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the control system.
   1. Labels shall use white lettering (12-point type or larger) on a red background.
   2. Warning labels shall read as follows.

   **CAUTION**
   This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to “Off” position before servicing.

B. Permanent warning labels shall be affixed to all motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.
   1. Labels shall use white lettering (12-point type or larger) on a red background.
   2. Warning labels shall read as follows.

   **CAUTION**
   This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.
3.13 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 2 in. of termination with control system address or termination number.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum ½ in. letters on laminated plastic nameplates.

D. Identify all other control components with permanent labels. All plug-in components shall be labeled such that label removal of the component does not remove the label.

E. Identify room sensors related to terminal boxes or valves with nameplates.

F. Manufacturers’ nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

G. Identifiers shall match record documents.

3.14 CONTROLLERS

A. Provide a separate controller for each AHU or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

B. Building Controllers and Custom Application Controllers shall be selected to provide the required I/O point capacity required to monitor all of the hardware points listed in the Sequence of Operation.

3.15 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging.

B. Point Naming. Name points in accordance with the Project Haystack Open Source Data Modeling Standard. Contractor shall submit a complete Points List containing the Description, Point Name (Acronym), Tag, Point Type, Unit of Measure and Trend Properties, for approval prior to the start of any programming.

C. Software Programming.

1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:

a. Text-based:

1) Must provide actions for all possible situations.

2) Must be modular and structured.
3) Must be commented.

b. Graphic-based:
   1) Must provide actions for all possible situations.
   2) Must be documented.

c. Parameter-based:
   1) Must provide actions for all possible situations.
   2) Must be documented.

2. Provide one Microsoft Surface 7 Laptop with all controller service software installed. The controller software shall allow the technician to manually control all output points, read values of all input points and virtual points for all provided controllers. The Service software shall allow OPS to edit, develop new or delete any custom programming. Laptop shall be provided with all required cabling in order to interface to all provided field controllers.

3.16 CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing. All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner’s representative is notified that the system is ready for Commissioning.

1. The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.

2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers’ recommendations.

4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.

6. Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops.

7. Alarms and Interlocks:
   a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
   b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
   c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.
3.17 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration.

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.

2. The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The engineer will be present to observe and review these tests. The engineer shall be notified at least 10 days in advance of the start of the testing procedures.

3. The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.

4. The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.

5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.


7. Demonstrate compliance with sequences of operation through all modes of operation.

8. Demonstrate complete operation of operator interface.

9. Additionally, the following items shall be demonstrated:

   a. DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.

   b. Demand limiting. The contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.

   c. Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started equipment, as well as temperature sensor inputs of affected areas. Only optimum start is required.

   d. Interface to the building fire alarm system.

   e. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer. These logs shall cover three 48-hour periods.
and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.

10. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance.

1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner, or owner’s representative, prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.

2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."

3.18 CLEANING

A. The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.19 TRAINING

A. Provide training for a designated staff of Owner’s representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.

B. Provide course outline and materials according to the "Submittals" article in Part 1 of this specification. Provide one copy of training material per student.

C. The instructor(s) shall be factory-trained and experienced in presenting this material.

D. Classroom training shall be done using a network of working controllers representative of installed hardware.

3.20 CONTROL VALVE INSTALLATION

A. Valve submittals shall be coordinated for type, quantity, size, calculated Cv, pressure drop and piping configuration to ensure compatibility with pipe design.
B. Slip-stem control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position. Ball type control valves shall be installed with the stem in the horizontal position.

C. Valves shall be installed in accordance with the manufacturer's recommendations.

D. Control valves shall be installed so that they are accessible and serviceable and so that actuators may be serviced and removed without interference from structure or other pipes and/or equipment.

E. Isolation valves shall be installed so that the control valve body may be serviced without draining the supply/return side piping system. Unions shall be installed at all connections to screw-type control valves.

F. Provide tags for all control valves indicating service and number. Tags shall be brass, 1.5 inch in diameter, with ¼ inch high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

3.21 CONTROL DAMPER INSTALLATION

A. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.

B. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure ¼ in. larger than damper dimensions and shall be square, straight, and level.

C. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 1/8 in. of each other.

D. Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.

E. Install extended shaft or jackshaft according to manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)

F. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.

G. Provide a visible and accessible indication of damper position on the drive shaft end.

H. Support ductwork in area of damper when required to prevent sagging due to damper weight.

I. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.
3.22 DUCT SMOKE DETECTION

A. Submit data for coordination of duct smoke detector interface to HVAC systems as required in Part 1, "Submittals."

B. This Contractor shall provide a dry-contact alarm output in the same room as the HVAC equipment to be controlled.

3.23 CONTROLS COMMUNICATION PROTOCOL

A. General. The electronic controls packaged with this equipment shall communicate with the building energy management system (DDC). The DDC shall communicate with these controls to read the information and change the control setpoints as shown in the points list, sequences of operation, and control schematics. The information to be communicated between the DDC and these controls shall be in the standard object format as defined in ANSI/ASHRAE Standard 135 (BACnet). Controllers shall communicate with other BACnet objects on the internetwork using the Read (Execute) Property service as defined in Clause 15.5 of Standard 135.

B. Distributed Processing. The controller shall be capable of stand-alone operation and shall continue to provide control functions if the network connection is lost.

C. I/O Capacity. The controller shall contain sufficient I/O capacity to control the target system.

D. The Controller shall have a physical connection for a laptop computer or a portable operator’s tool.

E. Environment. The hardware shall be suitable for the anticipated ambient conditions.

   1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 40 °F to 140 °F.
   2. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 32 °F to 120 °F.

F. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field removable, modular terminal strips or to a termination card connected by a ribbon cable.

G. Memory. The Controller shall maintain all BIOS and programming information in the event of a power loss for at least 30 days.

H. Power. Controller shall be able to operate at 90% to 110% of nominal voltage rating.

I. Transformer. Power supply for the Controller must be rated at minimum of 125% of ASC power consumption and shall be fused or current limiting type.

3.24 START-UP AND CHECKOUT PROCEDURES

A. Start up, check out, and test all hardware and software and verify communication between all components.

   1. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
   2. Verify that all analog and binary input/output points read properly.
3. Verify alarms and interlocks.
4. Verify operation of the integrated system.
5. Verify that all adjustable room temperature setpoints for cooling and heating have software High/Low setpoint limits in place. Limits are 70 Deg (LOW) to 75 Deg (HIGH). Wrestling rooms shall have 70 deg LOW, 80 Deg HIGH. Limits shall be adjustable only by administrator password level.

END OF SECTION 23 09 00
SECTION 23 11 23
FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 23 and as hereinafter specified in this Section.

B. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.

1.03 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 100 psig minimum unless otherwise indicated.

1.04 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.05 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.06 QUALITY ASSURANCE

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

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
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.

PART 2 - PRODUCTS

2.01 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   4. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
      a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

B. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.
   2. Coating: PE with flame retardant.
      a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
         1) Flame-Spread Index: 25 or less.
         2) Smoke-Developed Index: 50 or less.
   3. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
   4. Striker Plates: Steel, designed to protect tubing from penetrations.
   5. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
   6. Operating-Pressure Rating: 5 psig.

C. Annealed-Temper Copper Tube: Comply with ASTM B 88, Type K.
      a. Copper fittings with long nuts.
      b. Metal-to-metal compression seal without gasket.
      c. Dryseal threads complying with ASME B1.20.3.
   3. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of 0.022 inch thick.

D. PE Pipe: ASTM D 2513, SDR 11.
1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.
   c. Aboveground Portion: PE transition fitting.
   d. Outlet shall be threaded or suitable for welded connection.
   e. Tracer wire connection.
   f. Ultraviolet shield.
   g. Stake supports with factory finish to match steel pipe casing or carrier pipe.
   a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
   b. Outlet shall be threaded or suitable for welded connection.
   c. Bridging sleeve over mechanical coupling.
   d. Factory-connected anode.
   e. Tracer wire connection.
   f. Ultraviolet shield.
   g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

2.02 PIPING SPECIALTIES

A. Appliance Flexible Connectors:
   4. Corrugated stainless-steel tubing with polymer coating.
   5. Operating-Pressure Rating: 0.5 psig.

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.
   1. Copper-alloy convenience outlet and matching plug connector.
   2. Nitrile seals.
   3. Hand operated with automatic shutoff when disconnected.
   4. For indoor or outdoor applications.
   5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:
1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller.
3. Strainer Screen: 40 mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

D. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.03 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.
C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.04 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
   1. CWP Rating: 125 psig.
   3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
   5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
   6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
C. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
   2. Ball: Chrome-plated brass.
   3. Stem: Bronze; blowout proof.
   4. Seats: Reinforced TFE; blowout proof.
   5. Packing: Separate packnut with adjustable-stem packing threaded ends.
   7. CWP Rating: 600 psig.
   8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.
5. Packing: Threaded-body packnut design with adjustable-stem packing.
7. CWP Rating: 600 psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

E. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.

2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE.
5. Packing: Threaded-body packnut design with adjustable-stem packing.
7. CWP Rating: 600 psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

F. Bronze Plug Valves: MSS SP-78.

2. Plug: Bronze.
4. Operator: Square head or lug type with tamperproof feature where indicated.
5. Pressure Class: 125 psig.
6. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. PE Ball Valves: Comply with ASME B16.40.

1. Body: PE.
2. Ball: PE.
5. Ends: Plain or fusible to match piping.
7. Operating Temperature: Minus 20 to plus 140 deg F.
8. Operator: Nut or flat head for key operation.
9. Include plastic valve extension.
10. Include tamperproof locking feature for valves where indicated on Drawings.

H. Valve Boxes:
1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.05 MOTORIZED GAS VALVES

A. Electrically Operated Valves: Comply with UL 429.
   1. Pilot operated.
   2. Body: Brass or aluminum.
   5. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
   6. NEMA ICS 6, Type 4, coil enclosure.
   7. Normally closed.

2.06 PRESSURE REGULATORS

A. General Requirements:
   1. Single stage and suitable for natural gas.
   2. Steel jacket and corrosion-resistant components.
   3. Elevation compensator.

   1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
   2. Springs: Zinc-plated steel; interchangeable.
   4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
   5. Orifice: Aluminum; interchangeable.
   7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
   8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
   10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
   11. Maximum Inlet Pressure: See plans.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.
   2. Springs: Zinc-plated steel; interchangeable.
7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.

2.07 DIELECTRIC UNIONS

A. Dielectric Unions:

1. Description:
   b. Pressure Rating: 125 psig minimum at 180 deg F.
   c. End Connections: Solder-joint copper alloy and threaded ferrous.

2.08 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.01 OUTDOOR PIPING INSTALLATION


B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

E. Copper Tubing with Protective Coating:

1. Apply joint cover kits over tubing to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

F. Install fittings for changes in direction and branch connections.
3.02 INDOOR PIPING INSTALLATION


B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

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

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. 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.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
   1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

Q. Connect branch piping from top or side of horizontal piping.
R. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment.

S. Do not use natural-gas piping as grounding electrode.

T. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

U. Install sleeves for piping penetrations of walls, ceilings, and floors.

3.03 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install anode for metallic valves in underground PE piping.

3.04 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:
   1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
   2. Cut threads full and clean using sharp dies.
   3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
   4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
   5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:
   2. Bevel plain ends of steel pipe.
   3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.
G. **PE Piping Heat-Fusion Joints**: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

### 3.05 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. See schedule on plans.

### 3.06 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches from each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

### 3.07 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

### 3.08 FIELD QUALITY CONTROL

A. Test, inspect, and purge natural gas according to NFPA 54 and the International Fuel Gas Code and authorities having jurisdiction.

B. Natural-gas piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

### 3.09 OUTDOOR PIPING SCHEDULE

A. See schedule on plans.

### 3.10 INDOOR PIPING SCHEDULE

A. See schedule on plans.
3.11 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility’s gas mains and listed by an NRTL per local code.

3.12 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be one of the following:
   1. One-piece, bronze ball valve with bronze trim.
   2. Two-piece, full-port, bronze ball valves with bronze trim.

B. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:
   1. One-piece, bronze ball valve with bronze trim.
   2. Two-piece, full-port, bronze ball valves with bronze trim.

C. Valves in branch piping for single appliance shall be one of the following:
   1. One-piece, bronze ball valve with bronze trim.
   2. Two-piece, full-port, bronze ball valves with bronze trim.

END OF SECTION 23 11 23
SECTION 23 31 13
METAL DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 23 and as hereinafter specified in this Section.

B. Section Includes:

1. Rectangular ducts and fittings.
2. Round ducts and fittings.
4. Sealants and gaskets.
5. Hangers and supports.

1.03 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article. All ducts shall be a minimum of thickness of 26 gage.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

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

1.04 ACTION SUBMITTALS

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

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated-Design Submittal:
1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.

1.05 INFORMATIONAL SUBMITTALS
A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Perimeter moldings.

B. Welding certificates.

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

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

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
PART 2 - PRODUCTS

2.01 RECTANGULAR DUCTS AND FITTINGS

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

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

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

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.02 ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.03 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct
construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G60.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.04 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:
   1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   2. Tape Width: 3 inches.
   5. Mold and mildew resistant.
   6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
   7. Service: Indoor and outdoor.
   8. Service Temperature: Minus 40 to plus 200 deg F.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
   10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

D. Flanged Joint Sealant: Comply with ASTM C 920.
2. Type: S.
3. Grade: NS.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

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

2.05 HANGERS AND SUPPORTS

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

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

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

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

E. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:

PART 3 - EXECUTION

3.01 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.


3.02 INSTALLATION OF EXPOSED DUCTWORK

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

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

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.03 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.04 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
3.05 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

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

3.06 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.07 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Underground Ducts: Concrete-encased, PVC-coated, galvanized sheet steel with thicker coating on duct exterior.

B. See schedule on plans.

C. Intermediate Reinforcement:

2. PVC-Coated Ducts:
   a. Exposed to Airstream: Match duct material.
   b. Not Exposed to Airstream: Match duct material.

D. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Velocity 1000 fpm or Lower:
      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.
   b. Velocity 1000 to 1500 fpm:
      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
   c. Velocity 1500 fpm or Higher:
      1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

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

E. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.

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

END OF SECTION 23 31 13
SECTION 23 33 00
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
3. Control dampers.
4. Fire dampers.
5. Smoke dampers.
6. Flange connectors.
7. Turning vanes.
8. Duct-mounted access doors.
10. Flexible ducts.
11. Duct accessory hardware.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

   a. Special fittings.
   c. Control-damper installations.
   d. Fire-damper and smoke-damper installations, including sleeves; and duct-mounted access doors.
   e. Wiring Diagrams: For power, signal, and control wiring.

1.03 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTION


B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless
otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

### 2.02 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G60, with G90 for all outdoor and high moisture areas including shower areas, locker rooms, etc.
   2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No.3 finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

### 2.03 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Description: Gravity balanced.

B. Maximum Air Velocity: 2000 fpm

C. Maximum System Pressure: 2-inch wg.

D. Frame: Hat-shaped, 0.05-inch- thick, galvanized sheet steel, mechanically attached and mounting flange.

E. Blades: Multiple single-piece blades, end pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum with sealed edges.

F. Blade Action: Parallel.

G. Blade Seals: Extruded vinyl or Neoprene, mechanically locked.

H. Blade Axles:
   1. Material: Stainless steel

I. Tie Bars and Brackets: Aluminum

J. Return Spring: Adjustable tension.

K. Accessories:
   1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.
   a. Sleeve Thickness: 20 gage minimum.
   b. Sleeve Length: 6 inches minimum.
6. Screen Mounting: Rear mounted.
7. Screen Material: Aluminum.
8. Screen Type: Insect.
9. 90-degree stops.

2.04 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Standard leakage rating, with linkage outside airstream.
   2. Suitable for horizontal or vertical applications.
   3. Frames:
      a. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel or 0.05-
         inch- thick stainless steel.
      b. Mitered and welded corners.
      c. Flanges for attaching to walls and flangeless frames for installing in
         ducts.
   4. Blades:
      a. Multiple or single blade.
      b. Parallel- or opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Galvanized or Stainless-steel, 0.064 inch thick.
   5. Blade Axles: Galvanized steel or Stainless steel.
      a. Dampers in ducts with pressure classes of 3-inch wg or less shall have
         axles full length of damper blades and bearings at both ends of operating
         shaft.
   6. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:
   1. Standard leakage rating, with linkage outside airstream.
   2. Suitable for horizontal or vertical applications.
   3. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with
      flanges for attaching to walls and flangeless frames for installing in ducts.
   4. Blades:
      a. Multiple or single blade.
      b. Parallel- or opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
      e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
5. **Blade Axles:** Nonferrous metal.
   
a. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

6. **Tie Bars and Brackets:** Aluminum.

C. **Jackshaft:**
   
1. **Size:** 0.5-inch or 1-inch diameter.
2. **Material:** Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. **Length and Number of Mountings:** As required to connect linkage of each damper in multiple-damper assembly.

D. **Damper Hardware:**
   
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

### 2.05 CONTROL DAMPERS

A. **Frames:**
   
1. Material to match duct material.
2. Interlocking, gusseted corners.

B. **Blades:**
   
1. Multiple blade with maximum blade width of 8 inches.
2. Parallel- and opposed-blade design.
3. Galvanized-steel or Stainless steel or Aluminum.
4. Blade Edging: Closed-cell neoprene or PVC.
5. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

C. **Blade Axles:** 1/2-inch-diameter; same material as damper; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
   
1. Operating Temperature Range: From minus 40 to plus 200 deg F.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

### 2.06 FIRE DAMPERS

A. **Type:** Dynamic rated and labeled according to UL 555 by an NRTL. Material shall match connecting duct.

B. **Closing rating in ducts up to 2-inch wg static pressure class and minimum 2000-fpm velocity.** All dampers shall be rated to close in vertical or horizontal applications.

C. **Fire Rating:** 1-1/2 hours.
D. Frame: Curtain type with blades outside airstream or Multiple-blade type; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners without welded joints.

E. Mounting Sleeve: Factory- or field-installed, material to match ductwork.
   1. Minimum Thickness: As required by manufacturer to suit application.
   2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated. All dampers shall be rated to close in vertical or horizontal applications.

G. Blades: Roll-formed, with material to match ductwork.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Heat-Responsive Device: Replaceable (or resettable), 165 deg F rated, fusible links. If immediately downstream of a heating coil / heater then coordinate as 212 may be required.

2.07 SMOKE DAMPERS

A. General Requirements: Label according to UL 555S by an NRTL. Material shall match connecting duct.

B. Smoke Detector: Integral, factory wired for single-point connection.

C. Frame:
   1. Material to match duct material
   2. Mechanically attached corners and mounting flange.

D. Blades: Roll-formed, horizontal blades with material to match ductwork.
   1. Blade seals shall be silicone and rated to 350 degrees F.

E. Leakage: Class I

F. Rated pressure and velocity to exceed design airflow conditions.

G. Mounting Sleeve: Factory- or field-installed, material to match ductwork.

H. Damper Motors: two-position action. Dampers shall be fail close unless indicated otherwise.

I. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 “Common Motor Requirements for HVAC Equipment.”
   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."

3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.

5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.

6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.

7. Electrical Connection: 115 V, single phase, 60 Hz.

J. Accessories:

1. Auxiliary switches for position indication.
2. Momentary test switch mounted.

2.08 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components. Foam tape and plastic cleats are not acceptable.

B. Material: Galvanized steel.

C. Gage and Shape: Match connecting ductwork.

2.09 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.


B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vaners and Vane Runners," and 4-4, "Vane Support in Elbows."

D. Vane Construction: Double wall.

2.10 DUCT-MOUNTED ACCESS DOORS

1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
   e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Two hinges or continuous hinge and two sash locks.
   c. Access Doors up to 24 by 48 Inches: Three hinges or Continuous hinge and two compression latches with outside handles.
   d. Access Doors Larger Than 24 by 48 Inches: Four hinges or Continuous hinge and two compression latches with outside and inside handles.

B. Pressure Relief Access Door:
   1. Door and Frame Material: Galvanized sheet steel.
   2. Door: Single wall or Double wall with insulation fill with metal thickness applicable for duct pressure class.
   3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
   4. Factory set at 3.0- to 8.0-inch wg
   5. Doors close when pressures are within set-point range.
   6. Hinge: Continuous piano.
   7. Latches: Cam.
   8. Seal: Neoprene or foam rubber.

2.11 DUCT ACCESS PANEL ASSEMBLIES

A. Labeled according to UL 1978 by an NRTL.

B. Panel and Frame: Minimum thickness 0.0528-inch carbon or 0.0428-inch stainless steel.

C. Fasteners: Carbon Steel with Stainless steel used in all aluminum and stainless steel ducts. Panel fasteners shall not penetrate duct wall.

D. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

E. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.12 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.
C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches or 5-3/4 inches wide attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.

   1. Minimum Weight: 26 oz./sq. yd.
   2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F.

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

2.13 FLEXIBLE DUCTS

A. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   3. Temperature Range: Minus 10 to plus 160 deg F.

B. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor-barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   3. Temperature Range: Minus 20 to plus 210 deg F.
   4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

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

2.14 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.
PART 3 - EXECUTION

3.01 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft or control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

   1. Install steel volume dampers in steel ducts.
   2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire dampers according to UL listing and manufacturers recommendations.

H. Install duct access and smoke doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

   1. On both sides of duct coils.
   2. At outdoor-air intakes and mixed-air plenums.
   3. At drain pans and seals.
   4. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
   5. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
   6. Upstream or downstream from duct silencers.
   7. Control devices requiring inspection.
   8. Elsewhere as indicated.

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

J. Access Door Sizes:

   1. One-Hand or Inspection Access: 8 by 5 inches.
   2. Two-Hand Access: 12 by 6 inches.

K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. Connect terminal units to supply ducts with maximum 36-inch lengths of flexible duct. Do not use flexible ducts to change directions.

N. Connect diffusers or to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place. Hard elbow shall be installed directly on diffuser.

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

3.02 FIELD QUALITY CONTROL

A. Tests and Inspections:

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

END OF SECTION 23 33 00
SECTION 23 74 13
PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

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

1.02 SUMMARY
A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 23 and as hereinafter specified in this Section.

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

1. Direct-expansion cooling.
2. Gas furnace.
3. Economizer outdoor- and return-air damper section.
4. Integral, space temperature controls.
5. Roof curbs.

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

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

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

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

E. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
1.04 ACTION SUBMITTALS

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

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

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data – Include materials such as:
   1. Title Page listing contact information of installing contractor(s) and supplier(s)
   2. Operation and Repair Manuals
   3. Wiring Diagrams
   4. Troubleshooting Guide
   5. Shop Drawings do not count as O&M data by themselves but can be included with it.

B. Warranty – Include manufacturer's / Contractor’s warranty terms clearly stating that warranty period begins on the date of substantial completion and specifies warranty duration and covered items including materials and labor (if specified).

C. Field quality-control test reports.

1.06 QUALITY ASSURANCE

A. ARI Compliance:
   1. Comply with ARI 203/110 and ARI 303/110 for testing and rating energy efficiencies for RTUs.
   2. Comply with ARI 270 for testing and rating sound performance for RTUs.

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

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

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

E. UL Compliance: Comply with UL 1995.

F. 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.
1.07 WARRANTY

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

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from substantial completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than 10 years from substantial completion
3. Whole unit warranty – 1 year from substantial completion to include parts and labor.

PART 2 - PRODUCTS

2.01 CASING

A. General Fabrication Requirements for Casings: Unit casing shall be constructed of zinc coated, 20 gauge galvanized steel. Exterior surfaces shall be cleaned, phosphatized, and painted with a weather resistant baked enamel finish. Cabinet construction shall allow for all maintenance on one side of the unit. Hinged service panels shall be used for servicing.

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

1. Exterior Casing 20 gauge.

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

1. Materials: ASTM C 1071, Type I.
2. Thickness: 1/2 inch foil faced insulation.

D. Condensate Drain Pans: Formed sections of plastic, dual sloped and complying with ASHRAE 62.1.

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

2.02 FANS

A. Direct-Driven Plenum Supply-Air Fan with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

B. Provide VFD for supply fan as noted on schedule.

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

D. Relief-Air Fan: Forward curved shaft mounted on permanently lubricated motor.

2.03 COILS

A. Supply-Air Refrigerant Coil:
1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
4. Condensate Drain Pan: Plastic with dual sloping or stainless steel.

B. Outdoor-Air Refrigerant Coil:

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

2.04 REFRIGERANT CIRCUIT COMPONENTS

A. Number of Refrigerant Circuits: per schedule on drawing.

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

C. Refrigeration Specialties:

1. Refrigerant: R-407C or R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
5. Automatic-reset low-pressure safety switch.
8. Brass service valves installed in compressor suction and liquid lines.

D. Units to be provided with on/off hot gas reheat and room humidistat

2.05 AIR FILTRATION

A. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Pleated: Minimum 90 percent arrestance, and MERV 10.

2.06 GAS FURNACE

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54.

1. CSA Approval: Designed and certified by and bearing label of CSA.

B. Burners: Stainless steel.

1. Fuel: Natural gas.
2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.

C. Heat-Exchanger and Drain Pan: Stainless steel.
D. Venting: Gravity vented.

E. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.

F. Safety Controls:
   1. Gas Control Valve: Modulating multi stage per schedule.

2.07 DAMPERS

A. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Do not interlock dampers so they may be able to operate independently. System shall be capable of 100% economizer mode.
   1. Damper Motor: Modulating with adjustable minimum position.
   2. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IESNA 90.1, with bird screen and hood.

2.08 ELECTRICAL POWER CONNECTION

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

2.09 CONTROLS

A. Unit controls with a central building control system:
   1. Unit shall be provided with a BACnet communication card to interface to the control system. All points shall be readable with all setpoints writeable. See sequence on plans. Manufacturer responsible to provide sequence and points list on plans.
   2. Unit shall retain all factory safety sequences and alarms.

B. BACnet RTU Controls and Diagnostics
   1. Integration to the existing OPS Niagara N4 system:
      a. Integration of all units shall be performed by the temperature control contractor. All of the existing points and data for the old rooftops shall be removed from the JACE and Supervisor. The contractor shall provide one graphic per RTU with all required BacNet points. The new rooftop units shall be hard wired comm to the existing JACE located in the mechanical room B-20.
   2. Smoke detectors connection:
      a. Provide Smoke Detector terminals for connection to unit controller or a terminal strip in the electrical compartment for field wiring of the smoke detector(s) to the unit. RTU Long V1.2 8.
      b. Smoke Purge: RTU shall have the capability for an EMS, other network application, or external device to start supply fan, deactivate cooling and heating systems, open outside and relief dampers, close return dampers, and activate power exhaust fan(s).
   3. RTU shall have a stand-alone Direct Digital Control (DDC) Bacnet based unit control system.
a. DDC unit control system shall include all required, input/output boards, main microprocessor, software and operator interface for stand-alone operation and for communication with an external third-party device, network or EMS.

b. The temperature sensors shall have an accuracy of ±1 deg F, relative humidity sensors shall have an accuracy of ±5%, dew-point sensors shall have an accuracy of ±1 deg F, pressure transducers shall have an accuracy of ±1% FS and power measurements shall be ±5%.

c. DDC unit control system shall perform all unit control functions including unit safeties and either zone sensor control mode or thermostat control mode.

d. All boards shall be individually replaceable for ease of service. All microprocessors, boards, and sensors shall be factory mounted and tested.

e. The DDC controller shall be stand-alone, not dependent on communications with any on-site or remote master control panel when operating in either a zone sensor control or a thermostat control mode.

f. DDC controller shall accept virtual thermostat inputs from the existing OPS BACnet JACE. The OPS Energy Management System (EMS) when operating in zone space temperature control mode. DDC controller shall be capable of switching from external EMS (or other) control mode to zone sensor or thermostat or non-EMS-based zone sensor or thermostat control mode.

g. DDC controller shall support full communication with external compatible third-party devices, networks, or EMS using standard BACnet open protocol, that is, the DDC controller shall have communication capability with an external BACnet compliant third-party device (e.g., an EMS) to read all sensor data and all signal and status information (damper signal, status of both supply and outdoor fans, status of compressor and any protection limits). If additional sensors are installed to support the diagnostic functions, those sensor values also shall be readable from the external BACnet compliant third-party device or network (e.g., an EMS). In addition, the controller shall allow for reading the fault codes and messages.

4. The microprocessor memory shall be protected from voltage fluctuations and power failures. All factory and user set control points, control algorithms and schedules shall be maintained in nonvolatile memory. No settings shall be lost, even during extended power shutdowns.

a. Compressor protections and delays shall be no greater than the following:
   a. Minimum On time of 120 seconds
   b. Minimum Off time of 300 seconds.

b. Minimum outside air damper position setpoint used during occupied periods if network communications are lost.

5. The user interface shall consist of a keypad/display device with characters of a size and font that is clearly visible for service personnel on a rooftop. Password protection from changes to writable properties by unauthorized personnel shall be one easily remembered default that is the same for all RTU’s. Read only properties shall be available without 1. Some EMS systems are also referred to as Energy Management and Control Systems or Building Automation Systems. RTU Long V1.2 9 password requirements. The service technician shall be able to scroll through to read the sensor values and fault codes and messages. In addition to the diagnostic fault codes and messages, it shall provide possible cause(s) for each fault condition.

6. BACnet Communications:
a. A BACnet communications port shall be provided for direct communication to the existing JACE and shall be compliant with the BACnet protocol.

b. All BACnet features shall be implemented per the latest version of the ANSI/ASHRAE 135 industry recognized BACnet standard.

c. Dip switches or digital display shall be available for setting MAC addresses on individual RTUs in the field.

d. Dip switches or keypad display shall be capable of setting a unique BACnet Device Instance on each RTU in the field.

e. BACnet communications hardware and software shall be configured and available when the RTU arrives from the factory with no additional software, hardware, or peripheral (e.g., laptop computer) device connections required to initiate communication between RTU and external third-party network or device (e.g., an EMS).

f. All required BACnet objects and properties shall be open protocol, non-proprietary type. 7. BACnet implementation shall include (but not be limited to) the following features to assure satisfactory communication speed.

1) BAUD rate shall be BACnet MS/TP 76800 BPS or faster.
2) ReadPropertyMultiple service for accessing more than one data point per request message in addition to the ReadProperty service.
3) WritePropertyMultiple service for changing more than one data point per request message in addition to the WriteProperty service.
4) BACnet MS/TP implementations shall provide the ability to adjust the Max_Masters property of the Device Object through BACnet network communications interface.
5) BACnet MS/TP implementations shall not respond with BACnet Reply Postponed frames to all Confirmed Service Requests.

g. The DDC unit control system shall have the ability to communicate with an external third-party network or device through a direct wired BACnet communication connection. Multiple units shall communicate on the BACnet communication network. The RTU DDC unit shall enable such external third-party devices to both read and write to properties of the following BACnet objects on the individual rooftop DDC unit controllers.

1) BACnet Binary Objects:

a) Supply Fan and Start/stop the supply fan.
b) Cool 1 (Y1) Start/stop first stage cooling.
c) Cool 2 (Y2): Start/stop second stage cooling. Cool stages shall directly follow these control inputs.
d) Cool 3 (Y3): Start/stop third stage cooling on units with three stages. Cool stages shall directly follow these control inputs. The third stage may be defined by combinations of Y1 and Y2.
e) Heat 1 (W1) Start/stop first stage heating.
g) Smoke Alarm: Controller shall allow external BACnet systems (such as EMS) to monitor this BACnet binary input object for alarm purposes.
h) Diagnostic Alarm: Controller shall allow external BACnet systems (such as EMS) to monitor this BACnet binary input object for alarm purposes.
i) Compressor On/Off Status: Controller shall allow external BACnet systems (such as EMS) to monitor the binary input. RTU Long V1.2 10.
j) Indoor Fan Status: Controller shall allow external BACnet systems (such as EMS) to monitor this binary input.

k) Outdoor Fan Status: Controller shall allow external BACnet systems (such as EMS) to monitor this binary input.

2) BACnet Analog Input Objects:
   a) Zone Temperature Analog Input. EMS shall monitor and use this value to provide thermostat type staging of RTU heating and cooling.
   b) Discharge Air Temperature Analog Input. EMS shall monitor.
   c) Return Air Temperature Analog Input for monitoring thru EMS.
   d) Zone Relative Humidity Analog Input. On units with a field mounted zone humidity sensor, EMS shall monitor and provide dehumidification control.
   e) Carbon Dioxide (CO2) Analog Input. On units with a field-mounted zone CO2 sensor, EMS shall monitor and vary the OA damper for demand controlled ventilation.
   f) If any additional sensors are installed to support diagnostics, all those sensor values shall be available as BACnet objects for EMS to monitor.

3) Commandable BACnet Analog Output Objects:
   a) Outside Air Damper Actuator: The EMS shall write to this output at priority level 9 to achieve direct control of the outside air damper position (overriding the DDC unit controller's ability to control the damper). If damper control resides on an auxiliary control board other than the main processor, the physical analog output of the auxiliary board shall also be directly under EMS control through the same BACnet object.

4) Commandable BACnet Binary Outputs:
   a) Power Exhaust 1 Units with economizer shall have this output which the EMS shall write to at priority level 9 when exhaust is required.

5) All fault codes shall be presented to the EMS as BACnet multi-state value object. The state text property shall be implemented and contain English language descriptions of the associated fault codes.

6) Alarm/Alert Information:
   a) Current alarms and alerts (if these are different from diagnostic information above) shall be presented to the EMS as BACnet multi-state value object. The optional state text property shall be implemented and contain English language descriptions of the associated alarms and alerts.

7) Remote alarm reset:
   a) A commandable BACnet value object shall be available which allows reset of RTU lockouts to be performed over the EMS network. If conditions which caused the lockout still exist, RTU shall again lock out operations. Local alarm reset at the unit shall also be available. After clearing an alarm by setting the present value to “true”, the priority array entry used to clear the alarm shall be reset to “auto” by the DDC unit controller so clearing...
alarms can be done again at any priority (this guarantees local clearing abilities at the unit after remote clearing). Relinquish default property of this object shall equal “false”.

8) The present value property of all BACnet Binary Inputs shall be writable when the object’s “out of service” property has been set to true by the EMS.

9) DDC unit controller shall support the BACnet Time Synchronization service. EMS will automatically set the unit controllers time properties for scheduling purposes. RTU Long V1.2 11

10) 10. Watchdog Timer (Heartbeat): DDC controller shall accept a watchdog timer signal from EMS network building controller into a BACnet analog value object. EMS will write the value of 300 every 90 seconds at priority level 9. This present value shall be reduced by 1 (at priority level 9) each second by the DDC controller until it reaches zero. If DDC controller’s watchdog timer counts down to zero, the DDC controller shall know that EMS network communication has been lost.

11) On all commandable BACnet objects, the DDC unit controller shall write to the present value property at any priority level higher than 9, preferably 16. Normal EMS control shall override the DDC unit controller at the command priority level 9. Manual EMS control shall write at command priority level 8.

12) If EMS network communications fail (indicated through the watchdog timer), the DDC unit controller shall assume command in the zone temperature control mode, overriding control of all commandable objects at priority level 8 and 9 from the noncommunicating EMS. When communications is restored and the watchdog timer is restored, the controller shall automatically switch back to thermostat control mode. Priority levels less than 8 (manual life safety, automatic life safety, etc) shall not be overridden after communications loss.

h. RTU controls shall have an available power source to supply loop power through the following optional field installed sensors and back to the associated analog inputs:

1) One Relative Humidity sensor at: a. 18-30 VDC b. 1 VA maximum power.

2) One CO2 sensor at: a. 18-30 VDC b. 3 VA maximum power H.

RTU manufacturer shall provide discharge air temperature (DAT), outdoor air temperature, return air temperature (RAT) and humidity sensors wired to DDC unit controller inputs and presented to the external third-party device or network (e.g., an EMS) as BACnet Analog inputs. DAT sensor shall be mounted downstream of the coil, fan and heat source and measure a well mixed air stream. RAT sensor shall be mounted in direct line of sight from the return air duct to the lowest visible spot on the cooling coil. RAT sensor shall not be subjected to air from the OA damper or OA pulled backwards through a closed relief air damper.

i. In the event of a zone temperature sensor failure open-circuit, short-circuit, or otherwise defined to have failed by RTU manufacturer), the DDC unit controller shall switch to return air temperature as the control input in zone temperature control mode. The zone temperature sensor failure code shall be set, so the OPS EMS can read the code and issue an alarm. This condition, along with the provision to operate the RTU in
zone temperature control mode when network communication fails, shall enable units shipped from the factory to condition the space upon startup (before the zone sensor and external third-party devices or network (e.g., EMS) are installed).

j. DDC unit controller must support enthalpy and outdoor dry bulb economizer controls.

k. DDC unit controller in zone temperature control mode shall provide the following economizer control based on outside air temperature when EMS network communications are lost:
   1) Low OA temp lockout = 35 deg F
   2) High OA temp lockout = 65 deg F
   3) DDC controller shall support integrated economizer operation, i.e., the unit shall be able to economize while also providing mechanical cooling, if economizer can’t fully satisfy the zone cooling load. RTU Long V1.2 12.
   4) If economizer is available, and the zone is in the cooling mode, and no compressors are running, the OA damper shall modulate to supply discharge air temperature control (setpoint = 55 deg F)
   5) If an economizer is available and any compressor is running, the OA damper shall be fully (100%) open.
   6) If the economizer is not available, the OA damper shall be at Minimum Position during occupied times and fully closed during unoccupied times. DDC unit controller shall provide a service test mode. This operating mode shall allow a service contractor to force RTU into cool, heat, economizer, fan, dehumidification for local troubleshooting control and for independent testing and verification of the unit in the field during start-up commissioning.
   7) A BACnet Binary Value object shall indicate to the EMS when the unit is in service test mode.

l. Communication from unit controller to the existing JACE shall use BACnet MS/TP (Master-Slave/Token-Passing) or BACnet/IP. N. All operational capabilities described in previous sections A-M shall be automatically executed at equipment start-up to ensure proper operation and assist in commissioning.

2.10 ECONOMIZER
   A. Provide enthalpy based economizer with all required controls and powered exhaust. Shall be capable of 100% of air flow.

2.11 ACCESSORIES
   A. Duplex, unpowered 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.
   B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
   C. Hail guards of galvanized steel, painted to match casing.

2.12 ROOF CURBS
   A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
   a. Materials: ASTM C 1071, Type I or II.
   b. Thickness: 1 inch.
2. Vibration isolation.
3. Provide structural curb if required. Verify with structural drawings.
4. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
   a. Liner Adhesive: Comply with ASTM C 916, Type I.
   b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
   c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
   d. Liner Adhesive: Comply with ASTM C 916, Type I.

2.13 CAPACITIES AND CHARACTERISTICS

A. See schedule on plans:

PART 3 - EXECUTION

3.01 INSTALLATION

A. Equipment Mounting:
   1. Install RTUs on cast-in-place concrete equipment base(s).

B. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." ARI Guideline B. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction. Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

C. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

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

E. Install piping adjacent to RTUs to allow service and maintenance.
   1. Gas Piping: Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

F. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
   1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Install return-air duct continuously through roof structure.

3.02 FIELD QUALITY CONTROL

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

B. Perform tests and inspections and prepare test reports.

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

C. Tests and Inspections:

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

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

3.03 CLEANING AND ADJUSTING

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

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

END OF SECTION 23 74 13
SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 26 and as hereinafter specified in this Section.

B. Section Includes:

1. Sleeves for raceways and cables.
2. Sleeve seals.
4. Common electrical installation requirements.

C. Commissioning: Reference the pre-functional and functional check list inserts out the end of the specification book for sample forms that will be required to be completed by each/all responsible contractor.

1.03 SUBMITTALS

A. Product Data: For sleeve seals.

PART 2 - PRODUCTS

2.01 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. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.

b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.
2.02 SLEEVE SEALS
A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
   1. 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.
   2. Pressure Plates: Plastic. Include two for each sealing element.
   3. 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.

2.03 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
3.01 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.

3.02 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 above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.03 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.

3.04 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 26 05 00
SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 26 and as hereinafter specified in this Section.

B. This Section includes the following:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.
   3. Sleeves and sleeve seals for cables.

1.03 SUBMITTALS

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

B. Field quality-control test reports.

1.04 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

2.01 CONDUCTORS AND CABLES

A. Copper Conductors: Comply with NEMA WC 70.

B. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN.

C. Multiconductor Cable: Comply with NEMA WC 70 for armored cable, Type AC with ground wire.

2.02 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.
2.03 SLEEVES FOR CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated “wall pipe,” equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section “Penetration Firestopping.”

2.04 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
   1. 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.
   2. Pressure Plates: Plastic. Include two for each sealing element.
   3. 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.

PART 3 - EXECUTION

3.01 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.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

G. Class 1 Control Circuits: Type THHN-THWN, in raceway.

H. Class 2 Control Circuits: Type THHN-THWN, in raceway.
3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Sections "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

G. 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.

H. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

I. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.04 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

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. 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.

D. Cut sleeves to length for mounting flush with both wall surfaces.

E. Extend sleeves installed in floors 2 inches above finished floor level.

F. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and cable unless sleeve seal is to be installed.

G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

J. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

K. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

L. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.05 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.06 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.07 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. 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 following critical equipment and services for compliance with requirements.


C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

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

END OF SECTION 26 05 19
SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

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

1.02 SUMMARY
A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 26 and as hereinafter specified in this Section.

B. This Section includes methods and materials for grounding systems and equipment.

1.03 SUBMITTALS
A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

1.04 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 UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.01 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:
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
2.02 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory 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, bolted pressure-type, with at least two bolts.
   1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.03 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet in diameter.

PART 3 - EXECUTION

3.01 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum. Bury at least 24 inches below grade.

C. 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.

3.02 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1. Feeders and branch circuits.
   2. Lighting circuits.
   3. Receptacle circuits.
   5. Three-phase motor and appliance branch circuits.
   6. Flexible raceway runs.
   7. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.03 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 below finished floor or final grade, unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. 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 so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

D. 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, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, 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.
E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.
   
   a. Measure ground resistance not less 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.

B. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.

2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.

3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.

4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26
SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the
furnishing of all equipment, materials and labor or reasonably incidental to the complete
operating installation of systems as shown on the plan and of related equipment all as
indicated on the drawings, as hereinbefore specified under Division 26 and as hereinafter
specified in this Section.

B. Section includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.03 PERFORMANCE REQUIREMENTS

A. Delegated Design:  Design supports for multiple raceways, including comprehensive
engineering analysis by a qualified professional engineer, using performance
requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of
supported systems and its contents.

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

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads
calculated or imposed for this Project, with a minimum structural safety factor of five
times the applied force.

1.04 SUBMITTALS

A. Product Data: For steel slotted support systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication
and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Equipment supports.

C. Welding certificates.
1.05 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   1. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
   2. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating 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 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.
   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.
   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.
2.02 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.01 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted 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.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.02 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, as permitted in NFPA 70.

C. 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.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-acted driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4
inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.

7. To Light Steel: Sheet metal screws.

8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.03 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.

3.04 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

2. Install anchor bolts to elevations required for proper attachment to supported equipment.

3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.05 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29
SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

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

1.02 SUMMARY
A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 26 and as hereinafter specified in this Section.
B. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
C. See Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks and manholes, and underground handholes, boxes, and utility construction.

1.03 SUBMITTALS
A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, details, and attachments to other work.

1.04 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

2.01 METAL CONDUIT AND TUBING
A. Rigid Steel Conduit: ANSI C80.1.
B. IMC: ANSI C80.6.
C. EMT: ANSI C80.3.
D. FMC: Zinc-coated steel.
E. LFMC: Flexible steel conduit with PVC jacket.

F. 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.

2. Fittings for EMT: Steel, type.

2.02 NONMETALLIC CONDUIT AND TUBING


B. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

C. LFNC: UL 1660.

D. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

E. Fittings for LFNC: UL 514B.

2.03 METAL WIREWAYS

A. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.

B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

C. Wireway Covers: Hinged type.

D. Finish: Manufacturer's standard enamel finish.

2.04 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.

2.05 BOXES, ENCLOSURES, AND CABINETS

A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

C. Metal Floor Boxes: Cast metal, rectangular.

D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

E. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.

F. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
G. 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

3.01 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.
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. Mechanical rooms.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: Rigid steel conduit.
7. Raceways for Optical Fiber or Communications Cable: EMT.
8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3.02 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 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 finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceways Embedded in Slabs:
   1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
   2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
   3. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.

I. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

J. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

K. Raceways for Optical Fiber and Communications Cable: Install as follows:
   1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
   2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
   3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

L. 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.

M. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet.
1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:

   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
   c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F temperature change.

2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change.

3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

N. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

   1. Use LFMC in damp or wet locations subject to severe physical damage.
   2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

O. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

P. Set metal floor boxes level and flush with finished floor surface.

Q. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.03 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

   1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches in nominal diameter.
   2. Install backfill as specified in Division 31 Section "Earth Moving."
   3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
   4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
   5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits, placing them 24 inches o.c. Align planks along the width and along the centerline of conduit.

3.04 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 26 05 33
SECTION 26 05 44

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLEING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
   2. Sleeve-seal systems.
   5. Silicone sealants.

B. Related Requirements:
   1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 SLEEVES

A. Wall Sleeves:
   2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:
   2. Minimum Metal Thickness:
      a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
      b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.
2.02 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

   1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   2. Pressure Plates: Carbon steel.
   3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.03 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

2.04 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.


C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.05 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

   1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.01 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

   1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."

b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.02 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install 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.

3.03 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.
D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 26 05 44
SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. The work covered under this Section of the Specifications is intended to include the furnishing of all equipment, materials and labor or reasonably incidental to the complete operating installation of systems as shown on the plan and of related equipment all as indicated on the drawings, as hereinbefore specified under Division 26 and as hereinafter specified in this Section.

B. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.03 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.04 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

B. Comply with NFPA 70.


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.

PART 2 - PRODUCTS

2.01 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.
   2. Legend: Indicate voltage and system or service type.

C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.02 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.03 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.04 FLOOR MARKING TAPE

A. 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.05 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.

2.06 WARNING LABELS AND SIGNS

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.07 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.08 EQUIPMENT IDENTIFICATION LABELS

A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

2.09 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Apply identification devices to surfaces that require finish after completing finish work.

C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
D. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

E. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

G. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.02 IDENTIFICATION SCHEDULE

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Install labels at 30-foot 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. Power.
2. UPS.

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. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
E. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

F. 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.

G. 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.

H. 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.

I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.
   2. Identify system voltage with black letters on an orange background.
   3. Apply to exterior of door, cover, or other access.

J. 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.

K. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch high letters for emergency instructions at equipment used for power transfer.

L. 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: Adhesive film label. Unless otherwise indicated, provide a single line of text with 1/2-inch high letters on 1-1/2-inch high label; where two lines of text are required, use labels 2 inches high.
      b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
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.

END OF SECTION 26 05 53
SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.

1.02 DEFINITIONS

A. MCCB: Molded-case circuit breaker.
B. SPD: Surge protective device.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.
B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details.
   2. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
   3. Detail bus configuration, current, and voltage ratings.
   4. Short-circuit current rating of panelboards and overcurrent protective devices.
   5. Include evidence of NRTL listing for series rating of installed devices.
   6. Include evidence of NRTL listing for SPD as installed in panelboard.
   7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   8. Include wiring diagrams for power, signal, and control wiring.
   9. Key interlock scheme drawing and sequence of operations.
   10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

1.04 INFORMATIONAL SUBMITTALS

A. Panelboard schedules for installation in panelboards.

1.05 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.06 FIELD CONDITIONS

A. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.
1.07 WARRANTY

A. Manufacturer’s Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PANELBOARDS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 “Seismic Controls for Electrical Systems.”

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 PB 1.

D. Comply with NFPA 70.

E. Enclosures: Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.

b. Outdoor Locations: NEMA 250, Type 3R.


d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5 or Type 12.

2. Height: 84 inches maximum.

3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.

4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.

F. Incoming Mains Location: Convertible between top and bottom

G. Phase, Neutral, and Ground Buses: Hard-drawn copper, 98 percent conductivity

H. Conductor Connectors: Suitable for use with conductor material and sizes.


2. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.

3. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.

4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

I. NRTL Label: Panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

J. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

K. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.

L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

2.02 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards 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."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1

2.03 POWER PANELBOARDS

A. Panelboards: NEMA PB 1, distribution type.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

C. Mains: Circuit breaker

D. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Branch Overcurrent Protective Devices: Fused switches.

2.04 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:
   a. Inverse time-current element for low-level overloads.
   b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.


3. Electronic Trip Circuit Breakers:
   a. RMS sensing.
   b. Field-replaceable rating plug or electronic trip.
   c. Digital display of settings, trip targets, and indicated metering displays.
   d. Multi-button keypad to access programmable functions and monitored data.
   e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
   f. Integral test jack for connection to portable test set or laptop computer.
   g. Field-Adjustable Settings:
      1) Instantaneous trip.
      2) Long- and short-time pickup levels.
      3) Long and short time adjustments.
      4) Ground-fault pickup level, time delay, and I squared T response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).

6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).


9. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Breaker handle indicates tripped status.
   c. UL listed for reverse connection without restrictive line or load ratings.
   d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
   e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
   f. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
   g. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

B. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."

2.05 IDENTIFICATION

A. Panelboard Label: Manufacturer’s name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.


2.06 ACCESSORY COMPONENTS AND FEATURES

A. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1.

B. Install panelboards and accessories according to NECA 407 and NEMA PB 1.1.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Mount top of trim 90 inches above finished floor unless otherwise indicated.

E. Mount panelboard cabinet plumb and rigid without distortion of box.

F. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges.

H. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

I. Install filler plates in unused spaces.

J. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

K. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.02 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.03 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each panelboard bus, 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 for low-voltage air circuit breakers stated in NETA ATS. 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.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 26 24 16