08100 Metal Doors And Frames
08710 Door Hardware

DIVISION 9 - FINISHES

09250 Gypsum Board (Referenced from paints and coatings 09900)
09510 Acoustical Ceilings
09900 Paints and Coatings

DIVISION 14 - CONVEYING SYSTEMS

14205 General Elevator Requirements
14210 Vertical Reciprocating Conveyor
14630 Bridge Cranes

DIVISION 15 - MECHANICAL

15010 Mechanical General Provisions
15060 Pipe And Pipe Fittings - General
15061 Carbon Steel Piping Systems
15062 Cast Iron Piping Systems
15064 Copper Pipe Systems
15065 Nonmetallic Pipe, Fittings, And Valves
15066 Grooved Pipe, Fittings, And Valves
15070 Mechanical Seismic Control
15072 Mechanical Pipe Flexibility, Expansion Joints, and Connectors
15075 Mechanical Identification
15080 Mechanical Insulation
15090 Hangers and Supports
15120 Piping Specialties
15190 Air And Water Systems Balancing
15195 Cleanroom Certification
15210 Vibration Isolation - Commercial
15325 General Purity Copper Piping System
15368 Double Contained Stainless Steel Piping Systems
15369 Stainless Steel Piping System
15371 Thermoplastic Piping System
15380 UPW and HUPW System Validation
15383 Ultra High Purity Water System
15410 Plumbing Fixtures
15430 Plumbing Specialties
15510 Sprinkler System
15840 HVAC Sheet Metal Ductwork
15841 HVAC Flexible Ductwork
15860 Duct Accessories
15870 Air Devices
15880 Air Filters
15910 Control System - General Requirements
15913 Control Devices
DIVISION 8 - DOORS AND WINDOWS

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DIVISION 9 - FINISHES

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DIVISION 15 - MECHANICAL

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15870  Air Devices
15880  Air Filters
15910  Control System - General Requirements
15913  Control Devices
15951  Leak Detection System

DIVISION 16 - ELECTRICAL

16050  Basic Materials
16060  Grounding
16071  Seismic Controls
16140  Wiring Devices
16145  Lighting Controls
16410  Enclosed Safety Switches
16420  Enclosed Controllers
16421  Exterior Lighting
16442  Panelboards
16461  Dry Type Transformers
16491  Fuses
16511  Interior Lighting

END OF TABLE OF CONTENTS
PART 1 – GENERAL

1.1 SUMMARY OF WORK

A. Work covered by Contract Documents comprises preparation for a new Spectrograph provided by NOAO.

B. Project is located in Terminus of Arizona State Route 386, approx. 40 miles west of Tucson, Arizona.

C. Work consists of providing labor, materials, equipment, services, and administration required in conjunction with or properly incidental to Project construction.

D. Drawings and Project Manuals indicate basic quality of materials and quality of construction.

E. Provide items required for complete operating systems, including items not necessarily specified or shown in these documents, but that can be reasonably inferred as being necessary.

1.2 CONSTRUCTION CONTRACT

1. Refer to Owner Contract Terms and Conditions.

1.3 CONSTRUCTION SEQUENCE

1. Provide per Owner requirements and drawings whichever is more stringent. In the event of conflict contact Owner and Architect immediately and attain resolution prior to imitating the related work.

B. Coordinate use of premises with Owner.

C. Assume responsibility for protection and safekeeping of products stored on site under this Contract.

D. Move stored products that interfere with operations of Owner or separate contractors.

E. Conduct operations to ensure least inconvenience to public and to occupied areas.

F. Obtain and pay for use of additional storage or staging areas needed for operations.

G. Do not load structure with weight that would jeopardize its safety.

H. Should it be necessary to use portions of existing streets, sidewalks or right of ways for operations, obtain approval and pay for use of such areas in accordance with requirements of authorities having jurisdiction.

I. Owner Occupancy:

1. Owner will fully occupy premises during entire construction period.
2. Cooperate with Owner during construction operations to minimize conflicts and to facilitate Owner usage.
3. Perform Work to avoid interference and to minimize inconvenience with Owner operations.

PART 2 - PRODUCTS
NOT USED

PART 3 - EXECUTION
NOT USED

END OF SECTION
SECTION 01250

CONTRACT MODIFICATION PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Provide per Owner Contract Terms and Conditions.
B. Provide per the following for items that the Owner Contract Terms and Conditions does not cover.

1.2 SUBMITTALS

A. General: Submit names of individuals authorized to receive Contract modification documents.
B. Submit names of individuals responsible for informing Contractor's employees and affected subcontractors of Contract clarifications and modifications.

1.3 CHANGE PROCEDURES

A. General: Change procedures are written instructions issued after execution of Contract Agreement.

B. Minor Changes in the Work:
   1. Description: Written instructions, clarifications, or interpretations of Contract Documents not involving adjustment to Contract Sum or Contract Time. Instructions or interpretations are binding on Owner and Contractor.
   2. Procedure: Document is prepared and signed by Architect and distributed to Owner and Contractor. Architect’s Supplemental Instructions are effective upon receipt.

C. Proposal Request:
   1. Description: Written proposed change of Work within Contract scope consisting of additions, deletions, and other revisions. Proposal Request is for information only and does not authorize changes in Contract Sum or Contract Time. Contractor evaluates proposal for pricing and scheduling impact.
   2. Procedure:
      a. Document is prepared and signed by Architect. Copies are sent to Owner and Contractor.
      b. Contractor shall review Proposal Request and submit Change Order Request and Proposal Worksheet Detail and Summary Forms with proposed changes in Contract Sum and Contract Time.
      c. Prepare and submit Change Order Request and Proposal Worksheet Detail and Summary Forms to Architect within 10 days of Proposal Request receipt. Proposed Contract Sum and Contract Time changes quoted by Contractor shall remain valid for 30 days from receipt by Architect.

D. Change Order Request:
1. Attached Forms:
   a. Change Order Request: Describes and summarizes Contractor’s proposed changes. Indicates changes in Contract Sum and Contract Time.
   b. Proposal Worksheet Summary: Summarizes labor, materials, overhead and profit, bonds, insurance, and tax of proposed Contract additions and deductions.
   c. Proposal Worksheet Detail: Summarizes labor and material costs of each subcontractor involved in proposed change.


3. Procedure:
   a. Proposed changes are documented by Contractor on Change Order Request, Proposal Worksheet Summary, and Proposal Worksheet Detail forms. Documents include description of proposed changes and summary of changes in Contract Sum and Contract Time are prepared and signed by Contractor. Send copies to Owner and Architect.
   b. Comply with requirements of Section 01630 - Product Substitution Procedures for proposed changes in Work which include products or systems not contained in Contract Documents.
   c. Architect and Owner will review Change Order Request and evaluate proposed changes. Architect and Owner may accept or reject Change Order Request. Upon acceptance Architect will prepare Change Order to document Contract change.

E. Change Order:
1. Description: Written change of Work within Contract scope consisting of additions, deletions, and other revisions, including proposed basis for adjustment to Contract Sum and Contract Time. Change Orders are signed by Owner, Contractor, and Architect. Owner’s signature authorizes change.
2. Procedure: Document is prepared and signed by Architect; sent to Contractor for acceptance and signature; approved and signed by Owner; distributed to Architect and Contractor. Contractor shall perform changes upon receipt.

F. Construction Change Directive:
1. Description: Written change of Work within Contract scope consisting of additions, deletions, and other revisions, including a proposed basis for adjustment to Contract Sum and Contract Time. Document is used in absence of agreement on terms of Change Orders.
2. Procedure:
   a. Document is prepared and signed by Architect and Owner. Contractor shall perform changes upon receipt.
   b. Adjustments to Contract Sum should be one of following:
      1) Lump sum.
      2) Unit price.
      3) Mutually accepted method.
      4) As provided in AIA Document A201 Subparagraph 7.3.6; maintain detailed records on time and material basis of Construction Change Directive Work.
c. Architect will determine proposed method, time, and amount of Contract adjustment based on reasonable expenditures, and allowance for overhead, profit, and time.
d. Contractor’s signing of Construction Change Directive acknowledges agreement with proposed method for adjusting Contract Sum and Contract Time and is recorded as Change Order.
e. Contractor disagreement or no response to proposed method for adjusting Contract Sum or Contract Time does not relieve Contractor from responsibility to perform Work.
f. Payment for Construction Change Directives will be made in accordance with AIA Document A201 Subparagraph 9.3.1.1.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION

Attachments:
  Request for Change
  Proposal Worksheet Summary
  Proposal Worksheet Detail
CHANGE ORDER REQUEST (PROPOSAL)

Project: ___________________________ COR Number: ___________________________

To: ___________________________ Date: ___________________________

RE: ___________________________ Contract For: ___________________________

This Change Order Request (COR) contains an itemized quotation for changes in the Contract Sum and/or Time in response to proposed modifications to the Contract Documents based on Proposal Request Number ___________________________

Description of Proposed Change:

- Attachment

Reason For Change:

- Does Proposed Change involve a change in Contract Sum or Contract Time?  o  Yes  o  No

  If Yes: Proposed Change in Contract Sum

  Proposed Change in Contract Time

  Attached Pages: Proposed Worksheet Summary

  Proposed Worksheet Detail(s)

Signed by: ___________________________

- Attached is supporting information from  o  Subcontractor  o  Supplier  o  ______  o  ________
PROPOSAL WORKSHEET SUMMARY

Project: ____________________________  COR Number: ____________________________

__________________________  From (Contractor): ____________________________

To: ____________________________  Date: ____________________________

Proposal Request Number: ____________________________  A/E Project Number: ____________________________

Complete and attach Proposal Worksheet Detail for each Subcontractor. Enter Work Sheet Information below.

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Sub-Total

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Sub-Total

Subcontractors’ Net: ___________
Subcontractors’ OH&P: ___________
Subcontractors’ Bond: ___________
Subcontractors’ Total: ___________
General Contractor OH&P: ___________
General Contractor Bond: ___________
Insurance: ___________
## PROPOSAL WORKSHEET DETAIL

Project Name: ____________________________  COR Number: ____________________________

Project Number: ____________________________  Detail Sheet Number: ____________________________

Subcontractor Name: ____________________________  Date: ____________________________

Phone Number/Contact Person: ____________________________  DO NOT MARK IN SHADED AREAS.

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Sub-Total (Enter this number on Work Sheet Summary.)
PART 1 - GENERAL

1.1 UNIT PRICE REQUIREMENTS

A. General:
   1. Perform Work required in accordance with Contract Documents.
   2. Unit prices cover portions of Work added to or deducted from quantities indicated by
      Contract Documents.
   3. Unit prices are for work in place, except where indicated otherwise.
   4. Acceptance or rejection of unit prices, partially or completely, will be declared at time of
      Contract award.

B. Unit Prices for Additions or Deletions Include:
   1. Materials.
   2. Delivery to site.
   3. Supervision and labor.
   4. Installation, including associated accessories.
   5. Insurance.
   6. Applicable taxes.
   7. Overhead and profit.
   8. Handling, including receiving, unloading, uncrating, storage, and distribution.
   9. Protection from damage and from elements.
   10. Submittal and processing of product data, shop drawings, samples, and other required
       submittals.
   11. Other expenses required to complete installation.

C. Schedule of Unit Prices: Requirements for specific unit prices are indicated on Bid Form and
    in individual specification sections.

D. Adjustment of Costs: If actual quantities differ from those indicated for bidding purposes,
    submit difference between actual and bid quantities with unit price extensions for adjustment to
    Contract Sum by Change Order.

PART 2 - PRODUCTS
NOT USED

PART 3 - EXECUTION
NOT USED

END OF SECTION
SECTION 01290
PAYMENT PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Provide per Owner Contract Terms and Conditions.
B. Provide per the following for items that the Owner Contract Terms and Conditions does not cover.
C. Coordinate Schedule of Values and Applications for Payment with Construction Progress Schedule, Submittal Schedule, and List of Subcontracts.

1.2 TAXES

A. Per Owner Contract Terms and Conditions

1.3 SCHEDULE OF VALUES

A. General:
   1. Submit at least 10 days prior to submitting first Application for Payment.
   2. Upon request of Architect, submit additional data to substantiate accuracy of given values.
   3. Approved schedule will be used as basis for reviewing applications for payment.

B. Format:
   2. Contractor’s standard form or electronic media printout will be considered on request.
   3. Follow 16 Division format established in Table of Contents of Project Manual for listing of categories. Identify each line item by number and title of respective Specification sections.
   4. Identify Schedule of Values with following information:
      a. Project name and location.
      b. Name of the Architect.
      c. Project number.
      d. Contractor's name and address.
      e. Date of submittal.

C. Content:
   1. List installed value of each item of Work and each subcontracted item of Work as separate line item to serve as basis for computing values for Progress Payments. Round off values to nearest dollar.
   2. For each major subcontract, list products and operations of that subcontract as separate line items.
3. Include in each line item, as applicable, amount specified for allowances. For unit cost allowances, identify quantities taken from Contract Documents multiplied by unit cost to achieve total for item.

4. Itemize separate line costs for performance and payment bonds, field supervision, field layout, temporary facilities and controls, and overhead and profit.

5. For items on which payments will be requested for stored products, list sub-values for cost of materials, delivered and unloaded, with taxes paid.

6. Sum of listed values shall equal total Contract Sum.

D. Review and Resubmittals:
   1. After Architect’s initial review, revise and resubmit as necessary.
   2. Revise and resubmit whenever Change Order is issued. Show each Change Order as new line item. Submit revised schedule with next application for payment.

1.4 APPLICATIONS FOR PAYMENT

A. General:
   1. Maintain consistency with previous applications for payments as certified by Architect and paid by Owner.
   2. Initial Application for Payment, Application for Payment at time of Substantial Completion, and final Application for Payment involve additional requirements.
   3. Payment application times:
      a. Each progress payment date is as indicated in Agreement 15th day of each month.
      b. Work covered by each Application for Payment is as indicated in Agreement starts on the day following the end of the preceding period and ends 15 days prior to the date for each progress payment.

B. Application Preparation:
   1. Complete every entry on form, including notarization and execution by person authorized to sign legal documents on behalf of Contractor.
   2. Incomplete applications will be returned without action.
   3. Match data entries on Schedule of Values and Construction Progress Schedule. Use updated schedules if revisions have been made.
   4. Include amounts of Change Orders and Construction Change Directives issued prior to last day of construction period covered by application.

C. Transmittal:
   1. Submit 3 executed copies of each Application for Payment to Architect by date required for receipt; include waivers of lien and similar attachments with one copy.
   2. Transmit each copy with transmittal form listing attachments, and recording appropriate information related to application in manner acceptable to Architect.

D. Waivers of Mechanics Lien:
   1. With each Application for Payment submit waivers of mechanics liens from subcontractors and suppliers for construction period covered by previous application.
   2. Submit partial waivers on each item for amount requested, prior to deduction for retainage, on each item.
3. When application shows completion of item, submit final or full waivers.
4. Owner reserves right to designate which entities involved in Work must submit waivers.

E. Initial Application for Payment: Administrative actions and submittals that must precede or coincide with submittal of first Application for Payment include following:
   1. List of subcontractors.
   2. List of principal suppliers and fabricators.
   3. Schedule of Values.
   4. Construction Progress Schedule (preliminary if not final).
   5. Submittal schedule.
   7. Schedule of unit prices.
   8. List of Contractor’s staff assignments.
   9. List of Contractor’s principal consultants.
  12. Initial progress report.
  14. Certificates of insurance and insurance policies.
  15. Performance and payment bonds (if required).

F. Application for Payment at Substantial Completion:
   1. Following issuance of Certificate of Substantial Completion, submit Application for Payment reflecting Certificates of Partial Substantial Completion issued previously for Owner occupancy of designated portions of Work.
   2. Required administrative actions and submittals that precede or coincide with this application include:
      a. Occupancy permits and similar approvals.
      b. Warranties and maintenance agreements (dated to commence on date of Substantial Completion).
      c. Test/adjust/balance records.
      d. Maintenance instructions.
      e. Meter readings.
      f. Start-up performance reports.
      g. Change-over information related to Owner’s occupancy, use, operation, and maintenance.
      h. Application for reduction of retainage, and consent of surety, AIA Document G707A, Consent of Surety to Reduction in or Partial Release of Retainage.
      i. Advice on shifting insurance coverages.
      j. Final progress photographs.
      k. Comprehensive list of incomplete or non-complying Work (initial punch list).

G. Final Payment Application: Required administrative actions and submittals which precede or coincide with submittal of final payment Application for Payment include following:
   1. Completion of Project Closeout requirements.
   2. Completion of items specified for completion after Substantial Completion.
3. Assurance that unsettled claims will be settled.
5. Assurance that Work not complete and accepted will be completed without undue delay.
6. Final cleaning.
7. Transmittal of required Project construction records to Owner.
8. Certified property survey.
9. Proof that taxes, fees and similar obligations have been paid.
10. Removal of temporary facilities and services.
12. Change of door locks to Owner’s access.

PART 2 - PRODUCTS
NOT USED

PART 3 - EXECUTION
NOT USED

END OF SECTION
SECTION 01310
PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.1 GENERAL COORDINATION PROVISIONS

A. Carefully study and compare Contract Documents before proceeding with fabrication and installation of Work. Promptly advise Architect of any error, inconsistency, omission, or apparent discrepancy discovered.

B. Allot time in construction scheduling for liaison with Architect; establish procedures for handling queries and clarifications. Use "Request for Interpretation" form for requesting information. Copy of form is found after last page of this Section. Remove form for making additional copies or request an original copy from Architect.

C. If Architect is able to respond to a request for interpretation by making specific reference to Drawing sheet or Specification Section, Contractor shall reimburse Owner for charges of Architect and Architect’s Consultants for performing review services for the Contractor.

D. In addition to other specified meetings, hold coordination meetings and conferences with personnel and subcontractors to ensure coordination of Work.

E. Coordinate scheduling, submittals, and Work of various Specification sections to avoid conflicts and ensure efficient and orderly sequence of installation of interdependent construction elements.

F. Coordinate Work of various Specification sections having interdependent responsibilities for installation, connection, and operation.

G. Verify that characteristics of operating equipment are compatible with building utilities and services.

H. Except as otherwise indicated, conceal pipes, ducts, conduit and wiring in construction. Coordinate locations of fixtures and outlets with finish elements.

I. Make provision to accommodate items scheduled for later installation.

1.2 COORDINATION DRAWINGS AND LAYOUTS

A. General:
   1. Coordination drawings are not shop drawings and are not to be submitted to Architect for approval.
   2. Coordination drawings show relationship and integration of different construction elements that require careful coordination during fabrication or installation to fit in space provided or to function as intended.
3. Except as otherwise specified, prepare composite coordination drawings to scale of 1/4"=1'-0" or larger; detailing major elements, components, and systems of site utilities, architectural, structural, mechanical, and electrical equipment and materials in relationship with each other, installations, and building components. Include dimensions.

4. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to efficient flow of Work affecting one or more trades.

5. Indicate scheduling, sequencing, movement, and positioning of large equipment into building during construction.

6. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

7. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communications systems components, sprinklers, and other ceiling-mounted devices.

8. Show interrelationship of components to be shown on separate Shop Drawings.

9. Indicate required installation sequences.

B. Site Utilities: Include, but not necessarily limited to following:

1. Water Distribution: Pipe sizes, valve and meter locations, underground structures, connections, anchors, and reaction backing. Indicate spatial relationship between piping and other piping in same trench, and proximate structures.

2. Sanitary Sewerage: Pipe sizes, manholes, locations and elevations, underground structures, and connections. Indicate spatial relationship between piping and other piping in same trench, and proximate structures.

   a. Match scale of project utility plans. Prepare based on field verified data including test hole results, to identify/verify elevations of existing utilities to be crossed. Show utility vaults and other structures, pipe sizes, valves, specialties, control coordinates, locations and elevations at changes of direction, branch connections, anchors, points of connection to services inside vaults and buildings, and crossings of other underground utilities. Include details of wall penetrations, anchors, underground structures, and connections. Show other piping in same trench and clearances from hydronic system piping. Indicate interface and spatial relationship between piping and proximate structures.

   b. Profile Drawings: Show system piping in elevation. Prepare profiles at horizontal scale of not less than 1 inch equals 50 feet ratio and vertical scale of not less than 1 inch equals 5 feet ratio. Indicate underground structures and pipe. Show types, sizes, materials, and elevations of other utilities that cross system piping.

4. Drainage and Containment:
   a. Manholes and other structures, pipe sizes, locations, and elevations. Include details of underground structures and connections. Indicate spatial relationship between piping other piping in same trench, and proximate structures.

   b. Profile Drawings: Show systems piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet and vertical scale of not less than 1 inch equals 5 feet. Indicate underground structures and pipe. Show types, sizes, materials, and elevations of other utilities that cross system piping.
5. **Storm Drainage:***
   a. Pipe sizes, manholes and catch basins locations and elevations. Include details of underground structures and connections. Show other piping in the same trench and clearances from storm sewerage system piping. Indicate interface and spatial relationship between piping and proximate structures.
   b. Profile Drawings: Show storm sewerage system piping in elevation. Draw profiles at a horizontal scale of not less than 1 inch equals 50 feet and a vertical scale of not less than 1 inch equals 5 feet. Indicate pipe and underground structures. Show types, sizes, materials, and elevations of other utilities crossing sewerage system piping.

C. **Structural Systems:** Include, but do not necessarily limit to following:
   1. Structural frame showing interface with exterior cladding.
   2. Location of openings in relation to structure.
   3. Show attachments to decking, structural elements, and other systems.

D. **Mechanical Systems:** Include, but do not necessarily limit to following:
   1. Proposed locations of piping, ductwork, equipment, and materials.
   2. Proposed locations for access panels and doors.
   3. Clearances for installing and maintaining insulation.
   4. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance. Show access locations.
   5. Equipment connections and support details.
   7. Fire-rated wall and floor penetrations.
   8. Sizes and location of required concrete pads and bases.

E. **Electrical Systems:** Include, but do not necessarily limit to following:
   1. Proposed locations of major raceway systems, equipment, and materials.
   2. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance. Show access locations.
   3. Exterior wall and foundation penetrations.
   4. Fire-rated wall and floor penetrations.
   5. Equipment connections and support details.
   6. Sizes and location of required concrete pads and bases.

F. Coordinate in field with affected trades for proper relationship to Work based on Project conditions.

G. Notify Architect of conflicts and other coordination issues requiring resolution prior to commencing construction in each affected area.

H. Submit Contractor’s certification to Architect that coordination documents have been completed and coordination issues have been identified and resolved prior to commencing construction in each affected area.
I. Make coordination documents available in field office for review by Architect and Owner during entire period of construction.

1.3 COORDINATION OF SPACE

A. Coordinate use of Project space and sequence of installation of plumbing, fire protection, mechanical and electrical Work. Follow routings shown for pipes, ducts, and conduits as closely as practicable, with due allowance for available physical space; make runs parallel with building lines. Utilize space efficiency to maximize accessibility for other installations, for maintenance, and for repairs.

B. Layout of plumbing, fire protection, mechanical, and electrical systems, equipment, fixtures, piping, ductwork, conduit, specialty items, and accessories indicated on Drawings is diagrammatic. Variations in alignment, elevation, and details required to avoid interference and satisfy architectural and structural limitations are not necessarily shown.

C. Prior to installation of material and equipment, review and coordinate Work with Architectural and Structural Drawings to establish exact space conditions. Where available space is inadequate or where reasonable modifications are not possible, request information from Architect before proceeding.

D. Coordinate installation to prevent conflicts and cooperate in making, without extra charge, reasonable modifications in layout as needed.

E. Provide clear access to control points, valves, strainers, control devices, and specialty items of every nature related to such systems and equipment to obtain maximum head room. Provide adequate clearances as necessary for operation and maintenance.

1.4 COORDINATION OF CONTRACT CLOSEOUT

A. Coordinate completion and clean up of Work in preparation for Substantial Completion [and for portions of Work designated for partial occupancy as indicated in Section 01100 - Summary.

B. To minimize disruption of Owner’s activities after occupancy of premises, coordinate access to site by various trades for correction of defective Work and for correction of Work not in accordance with Contract Documents.

1.5 GENERAL MEETING REQUIREMENTS

A. Schedule meetings and conferences throughout progress of Work; each session scheduled, administered, and presided by entity indicated. Requirements for meetings and conferences include:
   1. Prepare agenda for each conference and meeting.
   2. Distribute written notice to participants 7 days in advance of scheduled date.
   3. Make physical arrangements.
   4. Record minutes and attendees; include significant proceedings and decisions.
   5. Reproduce and distribute copies of minutes within 5 days after each meeting.
6. Distribute one copy of minutes to each participant and to entities affected by decisions made at meeting.
7. Distribute one copy of minutes to Architect and Owner.
8. Maintain in field office one copy of agenda and minutes for each conference and meeting.

B. Representatives attending meetings shall be qualified and authorized to act on behalf of entity each represents.

C. Architect and professional consultants may attend meetings to ascertain that Work is consistent with Contract Documents.

D. Owner may be present at meetings and may propose agenda items.

1.6 PRECONSTRUCTION CONFERENCES

A. Schedule preconstruction conferences no later than 42 days prior to commencement of Work. Convene at Project site.

B. Attendees:
1. Architect
2. Owner.
3. Contractor.
4. Major subcontractors.
5. Others as appropriate.
6. General Contractor presides over meeting and is responsible for minutes.

C. Minimum Agenda:
1. Administrative and procedural issues:
   a. Designation of key personnel.
   b. Review and clarify responsibilities of parties to contract.
   c. Communications procedures.
   d. Review of proposed subcontractors, materials, equipment, and products.
   e. Application for payment procedures; schedule of values, proposal requests, change orders.
   f. Critical work sequencing; long lead time items.
   g. Submittal and construction progress schedules.
   h. Submittal requirements; complete, correct, and timely submittals; scheduled dates.
   i. Procedures for submitting product data, shop drawings, samples, and other submittals.
   j. Product options and substitutions procedures.
   k. Procedures for requests for interpretations (RFI), minor changes, field decisions, construction change directives, proposal requests, change orders, and filing claims.
   l. Procedures for testing and inspection, including timely notification.
   m. Responsibilities and limitations of authority of testing laboratories; distribution of reports.
   n. Procedures for maintaining Project Record Documents.
   o. Schedule for progress meetings.
2. Site mobilization and utilization:
   a. Use of premises; office and storage areas, Owner’s requirements.
b. Temporary utilities and services.

1.7 PROGRESS MEETINGS

A. Schedule periodic meetings as necessary by progress of Work; day, location, and time to be determined. Convene at Project site.

B. Attendees:
   1. Contractor; presides over meeting and is responsible for minutes.
   2. Subcontractors as appropriate.
   3. Owner, and Architect may attend as appropriate.
   4. Others as appropriate to agenda.

C. Minimum Agenda:
   1. Approval of minutes of previous meeting.
   2. Work progress since previous meeting:
      a. Current activities.
      b. Critical activities.
      c. Deviations from schedule.
   3. Field observations, problems, conflicts, and decisions.
   4. Deficiencies:
      a. Identification of items.
      b. Status of correction.
   5. Requests for Interpretations (RFIs):
      a. Status of clarification.
      b. Status of proposal requests.
   6. Changes and modifications:
      a. Status of change orders.
      b. Pending changes.
      c. Pending claims and disputes.
      d. Clarification decisions of Architect or Owner.
   7. Problems and conflicts which impede planned progress.
   8. Construction Progress and Submittal Schedules:
      a. Off-site fabrication and delivery schedules.
      b. Effect of proposed changes on construction progress schedule and coordination.
      c. Submittal schedules, status of submittals, and effect on construction progress schedule.
      d. Corrective measures to regain projected schedule.
   9. Planned progress during succeeding Work period.
10. Adequacy of work forces.
11. Coordination between elements of Work.
12. Maintenance of Project Record Documents.
13. Other business relating to progress of Work.

D. Meeting Minutes:
   1. Include column to indicate who is required to take action and date action is to be completed. Each of these items requiring action will be carried in subsequent minutes of meeting as "old business" until noted as "resolved."
   2. As minimum, separate into following categories:
      a. Old business.
b. New business.
c. Work progress.
d. Deficiencies.
e. RFIs.
f. Proposed changes.
g. Schedules.
h. Submittals.
i. Other business, including events to be accomplished by next meeting.

1.8 PREINSTALLATION CONFERENCES

A. Schedule preinstallation conferences required in individual Specification sections. Convene at Project site prior to commencing Work of the section.

B. Attendees:
   1. Project superintendent; presides over meeting and is responsible for minutes.
   2. Subcontractor (installer, applicator, or erector).
   3. Material or equipment supplier.
   5. Others directly affecting, or affected by the work.
   6. Testing agency (if necessary).
   7. Subcontractors as appropriate.
   8. Owner, Architect, and professional consultants may attend as appropriate.
   9. Others as appropriate to agenda.

C. Minimum Agenda:
   1. Access to work and conditions of proper installation.
   2. Conditions of installation, such as substrates, existing and surrounding conditions, and environmental conditions.
   3. Conditions detrimental to installation.
   4. Preparation procedures, including protection of adjacent work.
   5. Verify installers’ receipt and understanding of installation instructions.
   6. Review submittals, installation procedures, and sequence.
   7. Review coordination with other work.
   8. Evaluate delivery schedule and Construction Progress Schedule.
   10. Required protection procedures.
   11. Observe actual installation areas.

1.9 CLOSEOUT CONFERENCE

A. Schedule Project Closeout conference prior to requesting Substantial Completion.

B. Attendees:
   1. Contractor; presides over meeting and is responsible for minutes.
   2. Major subcontractors.
   3. Owner. Architect, and professional consultants may attend as appropriate.
   4. Others as appropriate to agenda.

C. Minimum Agenda:
   1. Start-up of facilities and systems.
2. Testing, adjusting, and balancing.
3. System demonstration and observation.
4. Operation and maintenance instructions for the owner’s personnel.
5. Contractor’s inspection of work.
6. Contractor’s preparation of an initial "punch list."
7. Procedure to request Architect inspection to determine date of substantial completion.
8. Completion time for correcting deficiencies.
9. Inspections by authorities having jurisdiction.
10. Certificate of occupancy and transfer of insurance responsibilities.
11. Partial release of retainage.
12. Preparation for final inspection.
13. Closeout submittals:
   a. Project Record Documents.
   b. Operating and maintenance documents.
   c. Operating and maintenance materials.
   d. Warranties and bonds.
   e. Affidavits.
14. Final application for payment.
15. Final cleaning.
16. Contractor’s demobilization of site.
17. Maintenance.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION

Attachment: Request for Interpretation
REQUEST FOR INTERPRETATION

Contractor: __________________________ Project: __________________________

Question to: __________________________ Date: __________________________

From: __________________________ Signed: __________________________ RFI Number: ___

RE:

Specification Section No. ________ Paragraph No. ____ Drawing Ref. ________ Details ____

____________________________________________________________________________________

Response:

____________________________________________________________________________________

Response Above From: ADPM To: Contractor Date Transmitted: _______ Dated Rec’d: _______

Copies: 0 Owner 0 0 0 0

ADPM

01310-9 PROJECT MGMT. AND COORDINATION

NOAO Spectrograph

KITT Peak WIYN

Revision 0 – July 11, 2017

Advantech Facility Design Inc

11607.00
PART 1 - GENERAL

1.1 CONSTRUCTION PROGRESS SCHEDULE

A. Submit initial preliminary schedule 10 days prior to first Application for Payment. Within 7 days after return of reviewed submittal, resubmit revised data.

B. Prepare schedule as horizontal bar chart Critical Path Method with separate bar for each major portion of Work or operation, identifying first work day of each week.

C. Content:
   1. Show complete sequence of construction by activity, with dates for beginning and completion of each major element of construction.
   2. Identify Work of separate stages or phases, separate floors, or other logically grouped activities.
   3. Show accumulated percentage of completion of each item, and total percentage of Work completed as of first day of each month.
   4. Indicate delivery dates for Owner furnished products.
   5. Provide sub-schedules to define critical portions of entire schedule.

D. Submittal Schedule:
   1. Provide separate sub-schedule to construction progress schedule indicating submittal dates for shop drawings, product data, samples and other similar data including Owner furnished products.
   2. Submit schedule submittal 10 days prior to first Application for Payment.
   3. Indicate dates reviewed submittals will be required from Architect taking into consideration the quantity of days specified for Architect’s review.
   4. Allow sufficient time in schedule for resubmittal of disapproved submittals with causing construction delay.
   5. Indicate decision dates for selection of finishes and colors.

E. Progress Revisions:
   1. Identify activities modified since previous submittal, major changes in scope, changes in dates, and other identifiable changes.
   2. Provide narrative report as necessary to define problem areas, anticipated delays, and impact on schedule.
   3. Report corrective action taken, or proposed, and its effect

F. Progress Submittals:
   1. Submit revised schedule with each application for payment.
   2. Submit in quantity required for distribution, plus 2 copies to be retained by Architect.
G. Distribute copies of reviewed schedule to project site file, subcontractors, suppliers, and other concerned parties.

1.2 PROPOSED PRODUCTS LIST

A. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation, and reference standards.

B. Listing may be combined with submittal of subcontractor listing required by subparagraph 5.2.1 of General Conditions.

C. Architect will reply in writing within 15 days stating whether there is reasonable objection to listed items. Failure to object to a listed item shall not constitute waiver of requirements of Contract Documents.

1.3 PROPOSED SUBCONTRACTORS AND MANUFACTURERS

A. Submit in writing with bid, a complete listing of all subcontractors and manufacturers proposed for Project. Follow specification table of contents for subcontractor and manufacturer listing.

B. Any and all deviation shall be clearly identified within Bid. Alternates shall not be considered after award if not noted in bid and not formally approved by owner in writing.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION
SECTION 01330

SUBMITTAL PROCEDURES

PART 1 – GENERAL

1.1 SUBMITTAL PROCEDURES

A. Schedule submittals to expedite Project in accordance with approved Construction Progress Schedules and in such sequence as to cause no delay in the Work or in the activities of Owner or of separate contractors.

B. Deliver submittals to Architect’s office. Submittals accepted only from Contractor. Submittals may be emailed, however emailed submittals shall include "Submittal Transmittal" sheet and shall be copied to Architect, and Owner at the same time.

C. Submittal shall be recorded on Submittal log. Submittal log shall be maintained and updated by Contractor.

D. Submit product data, shop drawings, samples, calculations, certificates, manufacturer’s instructions, and other items required by each specification section.
   1. Do not combine submittals for 2 or more Sections into one submittal. Submit a separate package for each Section.

E. Transmit each submittal using form attached to this Section. Number submittals using Specification section number and unique numeric reference number. Indicate reference number of previous submission for resubmittals. For example; Specification Section - 07410; Reference Number - 02; previous Reference Number - 01.

F. Identify Project, Contractor, subcontractor or supplier, pertinent Drawing sheets and detail numbers, and Specification section number, as appropriate.

G. Example of Architect’s submittal review stamp is located at end of this section for information.

H. Contractor shall make stamp to be used for this Project. Example is located at end of this section for information.

I. Apply Contractor’s stamp, sign or initial and date certifying that review, verification of products, field dimensions, adjacent construction Work, and coordination of information, is in accordance with requirements of Work and Contract Documents.

J. Submittals will be returned without processing if they have not been reviewed and stamped by Contractor for coordination of work and conformance with the Drawings and Specifications prior to submission to Architect; if they are not initialed or signed by authorized person; if they are not dated; or if it becomes evident that they have not been properly reviewed. Delays resulting therefrom are not responsibility of Architect.
K. Clearly identify on submittals, or in writing at time of submission, deviations in submittals from requirements of Contract Documents.

L. Do not perform Work on any element requiring submittal and review of shop drawings, product data, samples, or other similar submittals until respective submittal has been approved by Architect.

M. Maintain in field office a copy of submittal schedule and log of submittals indicating current status of each item.

N. Prepare submittals using the same units of measurement system (metric or inch-pound) in compliance with requirements stated in Section 01400. Use ASTM E380 and E621 for establishing metric measurements used in submittals.

1.2 PRODUCT DATA

A. Submit quantity of copies required by Contractor, plus 1 copy to be retained by Architect.

B. Mark each copy to identify applicable products, models, options, and other data.
   1. Supplement manufacturers’ standard data to provide information unique to Project.
   2. Delete inapplicable data.
   3. Place applicable Specification Section paragraph number on each sheet of product data.

1.3 SHOP DRAWINGS

A. Submit one reproducible and 2 copies. Only reproducible will be returned to Contractor.

B. Bind in complete sets. Transmit reproducible transparencies in roll form to eliminate folding. Folding of prints is acceptable.

C. Present in clear and thorough manner. Title each drawing with Project name and number; identify each element of drawings by reference to sheet number and detail, schedule, or room number of Contract Documents.

D. Check and coordinate shop drawings of any section or trade with requirements of other sections or trades and as necessary for proper coordination and complete installation of Work.

E. Do not use Contract Drawings for shop drawings. Provide original shop drawings with changes from Contract Drawings clearly indicated.

F. Show layout, details, materials, dimensions, thicknesses, methods of assembly, attachments, relation to adjoining Work, wiring diagrams, rough-in requirements, and other pertinent data and information.

G. Verify dimensions and field conditions. Clearly indicate field dimensions and field conditions.
H. Submit detail drawings of special accessory components not included in manufacturer’s product data.

I. Existing Conditions:
   1. Show locations of existing conditions which affect installation of new Work.
   2. Show details of existing conditions and proposed modifications as requested by Architect.

1.4 SAMPLES

A. Submit where required.
B. Submit quantity required by Contractor, plus 1 set, except where indicated otherwise in Specification sections, to be retained by Architect.
C. Include identification on each sample with full Project information.
D. Submit samples to illustrate functional and aesthetic characteristics of product, including integral parts and attachment devices. Coordinate sample submittals for interfacing Work.
E. Except where specified otherwise, submit samples from full range of manufacturer’s standard colors illustrating textures, patterns, and finishes for Architect selection.
F. Where custom colors are specified, submit samples illustrating colors, textures, patterns, and finishes for Architect’s review. Architect will advise colors required or furnish samples for color matching.

1.5 CALCULATIONS

A. When specified in individual Sections, submit calculations.
B. Submit engineering calculations for component sizes, deflections, and connections.
C. Submit calculations bearing seal and signature of registered professional engineer responsible for design.
D. Where existing conditions deviate from Contract Documents or shop drawings, submit calculations for existing condition, including calculations for anticipated corrective action required, and changes to loads transferred to "base building" structure.

1.6 INFORMATIONAL SUBMITTALS

A. Informational submittals upon which Architect is not expected to take responsive action may be so identified in Contract Documents. When professional certification of performance criteria of materials, systems, or equipment is required by Contract Documents, Architect shall be entitled to rely upon accuracy and completeness of such certifications.

B. Types of Informational Submittals:
1. Design data: Submit with shop drawings.
2. Test reports: Submit within two weeks of testing.
3. Certifications:
   a. Submit certifications when specified in individual Specification sections.
   b. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.
   c. Certifications may be recent or previous test results on material or product, but must be acceptable to Architect.
   d. Submit welder certifications 2 weeks prior to commencement of welding operations.
   e. Submit manufacturer or fabricator certifications with product data.
   f. Submit certificates of compliance within two weeks following approval or acceptance by authority having jurisdiction.
   g. Submit installation certifications within two weeks following completion of product installation.
4. Engineering Certifications:
   a. Submit certified statement, signed and sealed by professional engineer responsible for design attesting to the following:
      1) Conformity to applicable governing codes.
      2) Conformity to criteria in Contract Documents.
      3) Component parts were designed or selected for locale and application intended.
   b. Submit with shop drawings. Submit prior to fabrication if individual specification sections do not require shop drawings.
5. Qualification Data:
   a. When specified in individual Sections, submit manufacturer’s, fabricator’s, and installer’s qualifications verifying years of experience.
   b. Include list of completed projects having similar scope of Work identified by name, location, date, reference names, and phone numbers.
   c. Submit manufacturer qualification data with proposed products list.
   d. Submit fabricator or installer qualification data with list of subcontractors at least 15 [_____] days prior to submitting first Application for Payment.
6. Manufacturer’s Instructions:
   a. Refer to Section 01600 for requirements.
   b. When specified in individual Specification sections, submit manufacturer’s printed instructions for delivery, storage, assembly, installation, adjusting, finishing, and other pertinent data.
   c. Identify conflicts between manufacturer’s instructions and Contract Documents.
   d. Submit with product data.
7. Manufacturer’s Field Reports:
   a. Refer to Section 01400 for requirements.
   b. When specified in individual Specification sections, submit written results and findings of manufacturer’s field services specified as part of Field Quality Control.
   c. Submit within two weeks following completion of field services covered in individual reports.
C. Quantity: Submit in quantities specified for product data.

1.7 INCOMPLETE AND PARTIAL SUBMITTALS

A. Incomplete Submittal: Submittal not complying with specified submittal requirements.

B. Partial Submittal: Submittal subdivided into components as indicated in submittal schedule and each component submitted separately.

C. Architect will not review incomplete submittals. Complete submittals for each item are required. Submittal will not be considered official until it is complete in every respect. Delays resulting from incomplete submittals are not responsibility of Architect.

1.8 CONTRACTOR REVIEW

A. Review and approve submittals prior to transmittal to Architect; determine and verify field measurements, field construction criteria, manufacturer’s catalog numbers, and conformance of submittal with requirements of Contract Documents.

B. Coordinate submittals with requirements of Work and of Contract Documents.

C. Stamp, sign or initial, and date each submittal to certify compliance with requirements of Contract Documents.

D. Do not fabricate products or begin Work which require submittals until approved submittals have been received from Architect.

1.9 ARCHITECT REVIEW

A. Architect will review construction progress schedules, submittal schedules, product lists, shop drawings, product data, and samples and return within 10 working days of receipt.

B. Do not make "Mass" submittals (6 or more submittals) to Architect at one time. If Mass submittals are received, Architect’s review time stated above will be extended as necessary to perform proper review. Architect will review Mass submittals based upon priority determined by Architect after consultation with Owner and Contractor.

C. Informational submittals and other similar data are for Architect’s information and do not require Architect’s responsive action.

D. Architect’s review of submittals is for limited purpose of checking for conformance with information given and design concept expressed in Contract Documents. Architect’s review is not conducted for purpose of determining accuracy and completeness of items such as dimensions and quantities, which remain responsibility of Contractor.

E. Architect’s review and approval of submittals does not relieve Contractor of responsibility for deviations from Contract Document requirements, unless Architect is informed in writing of deviations and approval is received in writing from Architect for such deviation.
F. Architect’s review and acceptance of submittals does not indicate acceptance of changes in Contract time or cost.

G. Submittals made by Contractor which are not required by Contract Documents may be returned without action.

H. Submittals Stamped "No Exception Noted: Work covered by submittal may proceed, provided it complies with Contract Documents. Final payment depends on that compliance.

I. Submittals Stamped "Exceptions Noted As Indicated": Work covered by submittal may proceed, provided it complies with notations or corrections on submittal and with Contract Documents. Final payment depends on that compliance.

1. If for any reason noted corrections and modifications cannot be fully complied with, resubmit for review requesting clarification; do not proceed with affected Work.

J. Submittals Stamped "Revise and Resubmit": Do not proceed with Work covered by submittal. Revise submittal in accordance with notations, and resubmit without delay to obtain a different action marking.

K. Submittals Stamped "Unacceptable" Do not proceed with work covered by submittal. Revise submittal to comply with contract documents, and resubmit without delay to obtain a different action marking.

L. Submittal approval does not authorize changes to Contract requirements unless accompanied by a Change Order, Architect’s Supplemental Instruction, or Construction Change Directive.

M. Submittals which are unsolicited will be returned without action taken.

1.10 RESUBMITTEDS

A. Make resubmittals under procedures specified for initial submittals; identify changes made since previous submittal.

B. Architect will record time required to review resubmittals after original submittal and first resubmittal. Contractor shall reimburse Owner for charges of Architect and Architect’s Consultants for reviewing submittal more than 2 times.

1.11 DISTRIBUTION

A. Duplicate and distribute reproductions of shop drawings, product data, samples, and other submittals which bear Architect’s stamp of approval, to Project site file, subcontractors, suppliers, other affected contractors, and other entities requiring information.

B. Provide each testing and inspection agency one set of approved submittals for their exclusive use in providing specified quality control testing and inspection services; refer to Section 01450.
C. Provide additional set of approved submittals for Project record documents file; refer to Section 01780.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED
A. No exception noted  
   (resubmittal not required)
B. Exceptions noted as indicated  
   (resubmittal not required)
C. Correct as shown in red  
   (resubmittal required)
D. Unacceptable (submit new drawings and 
   information in compliance with plans and 
   specifications)

Checking is only for conformance with the design concept of the project 
and compliance with the information given in the Contract Documents. 
Contractor is responsible for dimensions to be confirmed and correlated 
at the job site for information that pertains solely to the fabrication 
processes or to techniques or construction and for coordination of the 
work of all trades.

By: ______________________  Date: __________________

ADVANTECH FACILITY DESIGN

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Contractor Review

Contractor has determined and verified materials, field measurements, 
and field construction criteria related thereto, and has checked and 
coordinated the information contained within submittal with the 
requirements of the Work and the Contract Documents.

○ NO EXCEPTION TAKEN    ○ EXCEPTIONS NOTED

○ REJECTED, REVISE AND RETURN

By__________________________ Date_____________

Contractor Name
## SUBMITTAL TRANSMITTAL (Submit separate form for each product)

### Contractor: Project:

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<th>To: Contractor</th>
<th>Date:</th>
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<td>From: Subcontractor</td>
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<tr>
<th>Quantity Reference Number</th>
<th>Title/Description/Manufacturer</th>
<th>Specification Section Title, Paragraph / Drawing Detail Reference</th>
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- O Submitted for Review and Approval
- O Resubmitted for Review and Approval
- O Complies with Contract Requirements
- O Will be available to meet construction schedule
- O A/E Review Time included in construction schedule

Other remarks on above submission:

- O Substitution Involved - Substitution Request Attached
- O If Substitution involved, Submission includes full point by point comparative data or Preliminary details
- O Items included in Submission will be ordered immediately upon receipt of approval

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<th>TRANSMITTAL</th>
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Reviewed, Coordinated, and Approved by Contractor

Remarks on above submission: One copy retained by sender

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- O No Exception Taken
- O Exceptions Noted
- O Revise and Return
- O Rejected
- O Full point by point comparative data required to complete approval process

Remarks on above submission: One copy retained by sender

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<td><strong>D</strong></td>
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Copies

- O Owner
- O

One copy retained by sender

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END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY
A. Provide per the requirements of, and in coordination with Owner for all work.
B. Where Owners requirements cover the items below, this specification shall govern the work.

1.2 OCCUPANCY, ACCESS, AND PROTECTION
A. Areas of existing facilities will be occupied and/or in use during construction for conduct of normal operations.
B. Cooperate with Owner in scheduling operations to minimize conflict and to permit continuous usage. Do not interfere with operations of occupied areas.
C. Existing facilities will remain in full operation during execution of this Work. Exercise precaution to ensure safety and protection for existing facilities, occupants, property, pedestrians, and vehicles.
D. Maintain safe access and egress must be at all times.
E. Prevent damage to facilities, merchandise, and vehicles from dust, water, weather, and other similar harmful elements. Refer to Section 01500 for additional requirements.
F. Maintain exiting from facilities to provide safe passage complying with applicable codes.

1.3 SCHEDULING OF WORK
A. Make arrangements with Owner and schedule Work to avoid interference with normal operations of occupied areas. Submit schedule and summary of applicable Work within occupied areas and obtain Owner approval not less than 5 days prior to commencement of such Work.
B. Requests for use of existing loading docks, passage ways, and other similar spaces outside limits of construction operations will be limited to day-by-day basis and must be approved in advance by Owner.
C. Coordinate access and scheduling of Work within occupied areas with Owner.

1.4 TORCH-CUTTING AND WELDING PROCEDURES
A. Notify Owner in advance of torch-cutting and welding operations performed within occupied areas; obtain approval prior to proceeding with such operations.
B. Prior to beginning open-flame torch-cutting, welding or arc-welding, obtain appropriate permit from Fire Marshal or authority having jurisdiction.

C. Keep portable fire extinguisher of appropriate class within reach during welding or torch-cutting operations.

D. Screen arc-welding from vision of passerbys.

E. Maintain "Fire Watch" for minimum of 30 minutes after completion of each torch-cutting and welding operation.

1.5 UTILITY SERVICE OUTAGES

A. Keep interruptions of existing utility and building services to a minimum; coordinate time and duration of outages with Owner; obtain written approval of Owner.

B. Requests for outages will not be considered unless they include an identification of areas which will be affected by proposed outage.

C. Make requests for outages minimum of 5 working days in advance of proposed outage.

D. Contractor is responsible for investigating utility and service lines to determine effect of outage upon building operations outside of limit of operations. Obtain approval in advance from Owner to execute investigations.

1.6 KEYS

A. When necessary to perform Work in existing mechanical/electrical equipment spaces, Owner will issue keys.

B. Return keys at end of each work day; request keys on succeeding days as necessary.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Type and Quality of Existing Products:
   1. Use products and systems which exist in structure, as needed to patch, extend, or match existing Work.
   2. Generally, Contract Documents do not define products or standards of workmanship present in existing construction.

B. New Materials:
   1. Comply with Specifications for each product involved.
   2. Match existing products and work for patching existing work.
C. Salvaged Materials:
   1. Salvage sufficient quantities of cut or removed material to replace damaged Work of existing construction, when material is not readily obtainable on current market.
   2. Store salvaged items in dry, secure place on site.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Comply with provisions of Section 01700.
   B. Verify that areas are ready for alteration and renovation.

3.2 PREPARATION
   A. Cut, move, or remove items as necessary for access to alteration and renovation Work.
   B. Remove unsuitable material not marked for salvage, such as rotted wood, corroded metals, deteriorated masonry and concrete, and other deteriorated materials. Replace materials as specified for finished Work.
   C. Remove debris and abandoned items from work area and from concealed spaces.
   D. Prepare surface and remove surface finishes as necessary to provide suitable substrate for proper installation of new materials and finishes.
   E. Close openings in exterior surfaces to protect existing Work and salvage items from weather and extremes of temperature and humidity. Insulate ductwork and piping to prevent condensation in exposed areas.
   F. Provide temporary barriers and closures to control operations to prevent spread of dust to occupied portions of building; refer to Section 01500.

3.3 INSTALLATION
   A. Coordinate alteration and renovation work to expedite completion and to accommodate Owner occupancy.
   B. Remove, cut, and patch Work in manner to minimize damage and to provide means for restoring products and finishes to original condition.
   C. Refinish visible existing surfaces to remain in renovated rooms and spaces, to specified condition for each material, with neat transition to adjacent finishes.
   D. Install products as specified in individual Specification sections.
   E. Where new Work abuts or aligns with existing, perform a smooth and even transition to match existing adjacent surface in texture and appearance.
F. When existing surfaces are cut so that smooth transition with new Work is not possible, terminate existing surface along straight line at natural line of division and request instructions from Architect for making transition.

3.4 ADJUSTMENTS

A. Rework floors, walls, and ceilings to provide smooth plane without breaks, steps, or soffits in areas where removal of partitions or walls results in adjacent spaces becoming one.

B. Trim existing doors as necessary to clear new floor finish. Refinish trim as required.

C. Fit Work at surface penetrations as specified in Section 01735.

D. Patch or replace portions of existing surfaces which are damaged, lifted, discolored, or showing other imperfections. Repair substrate prior to application of finishes.

3.5 FINISHES

A. Finish new surfaces as specified in individual Specification sections.

B. Finish patches to produce uniform finish and texture over entire area. When finish cannot be matched, refinish entire surface to nearest intersections.

3.6 CLEANING

A. Thoroughly clean areas and spaces affected by Work. Completely remove paint, mortar, oils, putty, and items of similar nature.

B. Clean Owner-occupied areas daily. Clean spillage, overspray, and heavy collection of dust in Owner-occupied areas immediately.

END OF SECTION
PART 1 - GENERAL

1.1 REGULATORY REQUIREMENTS

A. General: Reference to codes, standards or regulatory requirements made on Drawings or in Specifications are considered an integral part of Contract Documents as minimum requirements. Nothing in Contract Documents should be understood to conflict with laws, by-laws, or regulations of municipal, State, Federal, and other authorities having jurisdiction.

B. Code Requirements:
   1. Provide per the codes and standards adopted by the Authority Having Jurisdiction with amendments and per codes and standards referenced in the construction documents. In the event of a conflict provide per the more stringent and attain owner and Architect approval prior to initiating work for referenced work.
   2. International Code Council (ICC)
      a. International Series Codes with amendments as adopted by the local jurisdiction and as noted on the construction documents.
   3. National Fire Protection Association (NFPA), Quincy, MA.
      a. NFPA 13
      b. NFPA 90
      c. NFPA 101
      d. NFPA 70
      e. NFPA 54

1.2 REFERENCE STANDARDS

A. Comply with association, trade, federal, commercial, standards generating organization (such as ANSI and ASTM), and other similar standards referenced within Specification sections, except where more explicit or stringent requirements are indicated or required by Specification or applicable codes.

B. Reference standards include their associated amendments and supplements.

C. Except where a specific date is indicated, date of standard is latest edition in effect at date of Contract Documents, or date of standard required by code.

D. Reference standards have same force and effect as if bound into or copied directly into Contract Documents; standards are made a part of Contract Documents by reference.

E. Contractual relationship of parties to the Contract shall not be altered from Contract Documents by mention or inference otherwise in reference standards.
F. Names and titles of standards are frequently abbreviated. Where acronyms or abbreviations are used in Specifications, they are defined to mean the recognized name of trade association, standards generating organization, governing authority, or other entity applicable to context of text provision.

G. Should specified reference standards conflict with Contract Documents, request clarification from Architect before proceeding.

H. When indicated by individual Specification section, obtain copy of standard. Maintain copy at Project site during submittals, planning, and progress of specific work, until Substantial Completion.

I. Units of measurements required by specifications govern regardless of units of measurement used in reference standards.

1.3 PROJECT MANUAL CONTENT

A. Language:
1. Imperative mood of sentence structure is generally used which places verb as first word in sentence. Except as otherwise indicated, requirements expressed imperatively are to be performed by Contractor.
2. In certain circumstances, the language of specifications and other contract documents are of abbreviated type. It implies words and meanings that will be appropriately interpreted. Words such as "the," "shall," "shall be," "Contractor shall," "a," "all," "an," "any," and other similar words are eliminated.
3. Singular words will be interpreted as plural and plural words will be interpreted as singular where applicable and where full context of Contract Documents so indicates.
4. The words "shall be" are implied wherever a colon (:) is used within a sentence or phrase.

B. Specialist Assignments:
1. In certain circumstances, Specification text requires or implies that specific elements of Work are to be assigned to specialists who must be engaged to perform that element of Work. Such assignments are special requirements of Contract.
2. Such assignments are intended to establish which party or entity involved in a specific element of Work is considered as being sufficiently experienced in indicated construction processes or operations to be recognized as "expert" in those processes or operations. Nevertheless, ultimate responsibility for fulfilling Contract requirements remains with Contractor.
3. These requirements should not be interpreted to conflict with enforcement of building codes and similar regulations governing the Work. They are also not intended to interfere with local trade union jurisdictional settlements and similar conventions.

C. Minimum Quality/Quantity:
1. Quality level or quantity shown or specified is intended to be minimum for Work to be performed or provided.
2. Except as otherwise specifically indicated, actual Work may either comply exactly with that minimum within specified tolerances, or may exceed that minimum within reasonable limits.
3. In complying with these requirements, indicated numeric values are either minimums or maximums as noted, or as appropriate for context of requirements.
4. Refer instances of uncertainty to Architect for decision before proceeding.

1.4 SYMBOLS

A. List of Symbols:
   # Number.
   % Percent.
   F Degrees Fahrenheit.
   C Degrees Celsius.
   ' Feet.
   " Inches.
   ± Plus to Minus; Plus or Minus.
   +/- Plus to Minus; Plus or Minus.

1.5 DEFINITIONS

A. Basic Contract definitions are included in Conditions of the Contract.
B. And: Conjunction indicating that items in series are to be taken jointly. It may also mean plus or in addition to preceding items in the series.
C. Approved: Where used in conjunction with Architect’s response or action, meaning will be held to limitations of Architect’s responsibilities and duties as specified in General and Supplementary Conditions. In no case will Architect’s approval be interpreted as release of Contractor from responsibilities to fulfill requirements of Contract Documents.
D. Directed, Requested: Terms such as "directed," "requested," "authorized," "selected," "approved," "required," "accepted," and "permitted" mean "directed by Architect," "requested by Architect," and similar phrases. However, no such implied meaning shall be interpreted to extend Architect’s responsibility into area of construction supervision.
E. Finish: The manner or method of completion. The final appearance of a surface, including texture, smoothness, sheen, and color, after finishing operations have been performed. Finishing operations include preparation of substrate and application, curing, and protection of specified finish materials.
F. Furnish: Means to supply, purchase, procure and deliver complete with related accessories, ready for assembly, application, installation, and similar operations, as applicable in each instance.
G. Indicated: Refers to graphic representations, notes, or schedules on Drawings, or other paragraphs or Schedules in Specifications, and similar requirements in Contract Documents.
Terms such as "shown," "noted," "scheduled," and "specified" are used to help reader locate the reference. Location is not limited.

H. Install: Means to construct, assemble, erect, mount, anchor, place, connect, apply and similar operations, complete with related accessories, as applicable in each instance.

I. Installer: Entity (person or firm) engaged to perform a particular unit of Work at Project site, including installation, erection, application, repair, patching, and similar required operations. Such entities must be experienced in operations they are engaged to perform.

J. Or: Used to introduce any of the possibilities in a series. Items in the series are not required to be taken jointly. It does not mean that individual items in the series are optional requirements.

K. Product: Includes natural and manufactured materials, components, machinery, fixtures, equipment, devices, furnishings, systems, and their associated accessories to be incorporated into the Work.

L. Provide: Means to furnish and install, complete and ready for operations and use for purpose intended.

M. Regulations: Includes laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, as well as rules, conventions, and agreements within construction industry that control performance of the Work.

N. Similar: Interpreted in its general sense and not as meaning identical. Elements defined as "similar" shall be coordinated in relationship to their location and connection with other parts of the Work.

O. True To Line, Plumb, Level, and Flat: Install Work within following tolerances, except where indicated otherwise:
   1. True to line: Allowed deviation from straight line within plus or minus 1/16 inch in one foot; plus or minus 1/8 inch in 10 feet; plus or minus 1/4 inch in 20 feet; and plus or minus 3/8 inch in lengths over 20 feet.
   2. Level: Allowed deviation from horizontal plane within plus or minus 1/16 inch in one foot; plus or minus 1/8 inch in 10 feet; plus or minus 1/4 inch in 20 feet; and plus or minus 1/2 inch in lengths over 20 feet.
   3. Plumb: Allowed deviation from vertical plane within plus or minus 1/16 inch in one foot; plus or minus 1/8 inch in 10 feet; plus or minus 1/4 inch in 20 feet; and plus or minus 1/2 inch in lengths over 20 feet.
   4. Flat: Allowed deviation from flat plane in any planar direction within plus or minus 1/16 inch in one foot; plus or minus 1/8 inch in 10 feet; plus or minus 1/4 inch in 20 feet; and plus or minus 3/8 inch in lengths over 20 feet.
   5. Tolerances are not accumulative.

1.6 METRIC MEASUREMENTS
A. Explanation of metric abbreviations is located in ASTM E380 Practice for Use of the International System of Units (SI).

B. Some Specifications contain metric units of measurement.

C. When specifications contain metric and inch-pound measurements, inch-pound measurements are shown in parentheses.

D. Governance of metric and inch-pound measurements, when both appear in individual specification sections:
   1. When Drawings use inch-pound units of measurement, inch-pound measurements govern over metric measurements; metric measurements are for information only.
   2. When Drawings use metric units of measurement, metric measurements govern over inch-pound measurements; inch-pound measurements are for information only.
   3. When metric measurements appear without corresponding inch-pound measurements, metric measurements govern.

1.7 QUALITY ASSURANCE

A. Supervise performance of Work in such manner and by such means to ensure that Work, whether completed or in progress, will not be subjected to harmful, dangerous, damaging, or otherwise deleterious exposure during construction period.

B. Ensure that persons performing Work are qualified to produce workmanship of specified quality.

C. Monitor quality control over products, suppliers, manufacturers, services, site conditions, and workmanship to ensure Work complies with Contract Documents.

D. Comply with specified reference standards for minimum quality of Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

1.8 MANUFACTURER’S FIELD SERVICES AND REPORTS

A. Submit reports in accordance with Section 01330.

B. Submit qualifications of field observer 30 days in advance of required observations; observer is subject to approval of Architect.

C. When specified in individual Specification sections, require material or product suppliers or manufacturers to provide qualified staff personnel to observe site conditions, conditions of surfaces, quality of workmanship, and conditions of installation as applicable, and to initiate instructions when necessary.
D. Report observations and site decisions or instructions given to applicators or installers that are supplemental or contrary to manufacturer’s written instructions.

E. Submit reports within 7 days of observation. Distribute copies to Architect, Owner, Project site file, subcontractor, and other entities requiring information.

PART 2 - PRODUCTS
NOT USED

PART 3 - EXECUTION
NOT USED

END OF SECTION
SECTION 01500

TEMPORARY FACILITIES AND CONTROLS

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

A. Provisions provided by Contractor:
   1. Temporary barriers, barricades, covered walkways, fencing, exterior closures, and interior closures.
   2. Temporary field offices.
   3. Access roads and approaches.
   4. Temporary sanitary facilities.
   5. Temporary telephone service.

B. Each Contractor shall coordinate provisions with Owner and provide following items as necessary for execution of their Work, including associated costs:
   1. Construction aids.
   2. Temporary fire protection, dust control, erosion and sediment control, water control, noise control, and other necessary temporary controls.
   3. Temporary barriers, barricades, and similar devices as necessary for safety and protection of construction personnel and public.
   4. Upon Construction Manager’s approval, may provide temporary field office, including electrical service and temporary telephone.
   5. Temporary tree and plant protection.
   6. Electrical service required in addition to temporary service and distribution provided by Construction Manager.
   7. Temporary provisions for protection of installed work.

1.2 QUALITY ASSURANCE

A. Comply with applicable laws and regulations of authorities having jurisdiction.

B. Obtain approval from authorities having jurisdiction for each temporary utility before use. Obtain required certifications and permits. Pay connection fees.

C. Construction Signs:
   1. Except for specified sign, no other construction signs will be allowed on site.
   2. Finishes, Painting: Adequate to withstand weathering, fading, and chipping for duration of construction.
   3. Permit: Obtain and pay for permit if required to display sign on Project site. Coordinate requirements with authorities having jurisdiction.

1.3 SCHEDULING

A. Prepare schedule indicating dates for implementation and termination of each temporary utility.
B. At earliest feasible time, when acceptable to Owner, change over from use of temporary utility service to use of permanent utility service.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials for temporary facilities may be new or used suitable for intended purpose, but of adequate capacity for required usage, must not create unsafe conditions, and must not violate requirements of applicable codes and standards.

B. Water: Provide potable water approved by local health officials.

2.2 TEMPORARY FIELD OFFICES

A. Field Office:
   1. Structurally sound, weathertight, equipped with heating, air conditioning, ventilation system, electric power outlets, lighting, and telephone.
   2. Temporary Building: Portable or mobile buildings may be used. Floor raised above ground.
   3. When permanent facilities are enclosed with operable utilities, relocate office into building upon written approval of Owner, and remove temporary building.
   4. Size and location: Coordinate with Owner and attain Owner approval.

2.3 CONSTRUCTION AIDS

A. Provide scaffolds, staging, ladders, stairs, ramps, runways, platforms, railings, chutes, and other devices and equipment necessary to facilitate execution and construction contract administration of Work.

B. Provide cranes, hoists, rigging, material lifts, and other conveyances or apparatus as necessary to facilitate execution of Work.

C. Provide storage areas and sheds sized to storage requirements for products of individual Sections, allowing for access and orderly provision for maintenance and inspection of products to requirements of Section 01600.

2.4 VEHICULAR ACCESS AND CONTROLS

A. Provide signs, signals, traffic cones and drums, flares and lights, and flag equipment of types required by authority having jurisdiction.

2.5 TEMPORARY BARRIERS AND ENCLOSURES

A. Partition performance requirements:
   1. Maximum flame spread index of 75 in accordance with ASTM E84.
   2. Minimum fire rating: 1 hour.
B. Partition Framing Options:
   1. Steel stud framing in accordance with ASTM C645.

C. Gypsum Board: ASTM C36; Type X for fire-rated assemblies.

D. Plywood: PS-1; fire-retardant treated in accordance with AWPA C27.

E. Polyethylene: Fire-rated, reinforced, polyethylene sheet.

F. Doors:
   1. Non-fire-rated partitions: Steel doors and frames.
   2. Fire-rated partitions: Steel doors and frames; 1 hour rating.
   3. Hardware:
      a. Provide each door with hinges, lockset, closer, and dust-tight gasketing.
      b. Provide fire-rated hardware on doors in fire-rated partitions.
      c. Construction masterkey locksets.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install, maintain, and operate temporary utilities and services to ensure continuous operation. Modify and extend systems as Work progresses.

B. Install temporary facilities and controls in manner to produce reasonable uniform appearance, structurally adequate for required purposes, and properly maintained.

C. Modify and relocate temporary facilities and controls as necessary to accommodate progress of Work.

3.2 TEMPORARY ELECTRIC POWER AND LIGHTING

A. Provide temporary electrical service required for power and lighting, arrange provisions with utility company, and pay costs for service and energy consumed. Equip service with meter, main disconnect, and over current protection.

B. Complement existing power service capacity and characteristics as required.

C. Provide electrical service sized to provide adequate temporary power and lighting for construction operations.

D. Provide branch distribution system from temporary power source with distribution boxes and outlets located so that power and lighting is available throughout active work areas.

E. Permanent receptacles may be utilized during construction.

F. Replace receptacle plates and wiring devices damaged during construction.
G. Provide lighting to conduct construction operations.

H. Permanent lighting system may be utilized during construction.

I. Restore permanent and existing lighting systems used during construction to original condition. Maintain lighting and provide routine repairs.

3.3 TEMPORARY WATER

A. Connect to existing water service. Owner will pay for water consumed. Exercise measures to conserve water. Monitor usage to prevent interference with Owner’s requirements.

B. Extend branch piping with outlets located so water is available by hoses with threaded connections. Provide temporary pipe insulation to prevent freezing.

C. Wash Facilities: Supply with potable water for personnel to wash-up for sanitary condition. Dispose of drainage properly. Provide cleaning compounds appropriate for each condition.

3.4 TEMPORARY FIELD OFFICE

A. Provide temporary field offices at time of project mobilization. Maintain during progress of Work.

3.5 TEMPORARY BARRIERS AND ENCLOSURES

A. Provide barriers to prevent unauthorized entry to construction areas, to allow for Owner’s use of site, and to protect existing facilities and adjacent properties from damage from construction operations.

B. Protect non-owned vehicular traffic, stored materials, site, and structures from damage.

3.6 TEMPORARY CONTROLS

A. Fire Protection:
   1. Comply with local fire protection code and governing authorities.
   2. Provide and maintain fire protection including, without limitation, fire extinguishers and other appropriate fire-fighting equipment ready for immediate use.
   3. Distribute equipment around site, particularly in immediate vicinity of performance of welding or similar hazardous Work.
   4. Store gasoline and other flammable liquids in Underwriter’s Laboratories listed safety containers in conformance with recommendations of National Board of Fire Underwriters. Do not store gasoline or other flammable liquid within building.
   5. Coordination with permanent fire protection systems:
      a. At earliest feasible date in each area of Project, complete installation of permanent fire protection system, including connected services, and place into operation and use.
      b. Instruct key construction and Owner personnel on use of systems.
B. Dust Control:
   1. Execute Work by methods to minimize raising dust from construction operations.
   2. Provide positive means to prevent air-borne dust from dispersing into atmosphere.
   3. Secure and pay for required permits.

C. Erosion and Sediment Control:
   1. Plan and execute construction by methods to control surface drainage from cuts and fills, from borrow, and from waste disposal areas. Prevent erosion and sedimentation.
   2. Minimize amount of bare soil exposed at one time.
   3. Provide temporary measures such as berms, dikes, silt fences, drains, and other soil and erosion control devices required by authorities having jurisdiction.
   4. Construct fill and waste areas by selective placement to avoid erosive surface silts or clays.
   5. Periodically inspect earthwork to detect evidence of erosion and sedimentation; promptly apply corrective measures.

D. Water Control:
   1. Provide methods to control surface water to prevent damage to site or adjoining properties.
   2. Control fill, grading, and ditching to direct surface drainage away from excavations, pits, tunnels, and other construction areas; and to direct drainage to proper runoff.
   3. Protect site from puddling or running water.
   4. Maintain excavations free of water. Provide, operate, and maintain pumping equipment.

E. Pest and Rodent Control: Provide methods, means, and facilities to prevent pests, insects, and rodents from accessing or invading premises so Project will be free of them at Substantial Completion.

F. Pollution Control: Provide methods, means, and facilities to prevent contamination of soil, water, and atmosphere from discharge of noxious, toxic substances, and pollutants produced by construction operations.

3.7 TEMPORARY USE OF PERMANENT SYSTEMS

A. When allowed by Specifications, certain items of new permanent systems (equipment) may be used prior to Substantial Completion.

B. Prior to operating permanent equipment, notify Architect in writing of intended usage. Verify equipment is approved for operation and equipment is lubricated and ready for operation. Arrange for, obtain, and pay for necessary approvals, manufacturer’s acceptance, inspections, permits, and other provisions necessary for temporary use.

C. Provide and pay for operation, maintenance, and regular replacement of filters, and worn or consumed parts. Use of permanent equipment shall not affect the warranty, which begins at Substantial Completion of Project.

3.8 REMOVAL, CLEANING, AND RESTORATION
A. Remove temporary above grade or buried utilities, equipment, facilities, controls, and materials prior to request for Substantial Completion.

B. Remove temporary paving that is not intended for or acceptable for integration into permanent paving.

C. In areas intended for landscaping, remove soil and aggregate fill that does not comply with requirements for fill or subsoil in landscaped areas.

D. Remove materials contaminated with road oil, asphalt, or other compounds harmful to plant growth.

E. Repair or replace street paving, curbs, and sidewalks at temporary entrances as required by authorities having jurisdiction.

F. Clean and repair evidence or indication of installation or use of temporary Work.

G. Restore existing facilities and equipment used during construction to original condition. Restore permanent facilities and equipment used during construction to specified condition.

END OF SECTION
SECTION 01600

PRODUCT REQUIREMENTS

PART 1 - GENERAL

1.1 BASIC PRODUCT REQUIREMENTS

A. Furnish like products from single manufacturer to greatest extent possible.

B. Provide products complete with accessories, trim, finish, safety guards, and other devices and details needed for complete installation and intended use and effect.

C. Product Identifications: Nameplates, trademarks, logos, and other identifying marks on products are not permitted on surfaces exposed to view in public areas, interior or exterior. Plumbing, mechanical, and electrical equipment not exposed to public view are excluded from foregoing limitation. Required testing laboratory labels (such as UL, FM, or WH) are also excluded from foregoing limitation.

1.2 PRODUCT OPTIONS

A. Products specified by reference standards: Select any product by any manufacturer which can be shown to comply to referenced documents. Evidence of compliance will be required at time of product data or shop drawing submittals.

B. Products specified by naming several products: Select any product named.

C. Acceptable Product: The term as used in these Specifications is to assist the user in locating the specified product and is not intended to denote sole source for product specified. The acceptable product listed denotes a typical product by one of listed acceptable manufacturers. Equivalent products by other listed manufacturers meeting or exceeding listed product or specified criteria may be used without following substitution procedures.

D. Products specified by naming one manufacturer’s model or performance criteria with reference to other acceptable or approved manufacturers: Products of other listed manufacturers must meet or exceed model number or criteria specified. Equivalent products by other listed manufacturers may be used without following substitution procedures.

E. Products specified by naming one product or indicating option of selecting equivalent products by stating “equivalent to,” “or other approved manufacturers,” or other similar language: Submit “Substitution Request Form” in Section01630 for any product or manufacturer not specifically named.

F. Products specified by naming only one product followed by “no substitutions,” or other similar language: There is no option.

1.3 OWNER FURNISHED PRODUCTS
A. OF/CI - Owner Furnished and Contractor Installed Products:
1. Owner responsibilities:
   a. Furnish Contractor with product data, shop drawings, samples, manufacturer’s installation instructions and anchorage requirements, certificates, utility rough-in requirements, and other pertinent data in coordination with Construction Progress Schedule.
   b. Deliver supplier’s bill of materials to Contractor.
   c. Arrange and pay for delivery to site in accordance with Construction Progress Schedule.
   d. Inspect deliveries jointly with Contractor.
   e. Submit claims for transportation damage.
   f. Arrange for replacement of damaged, defective, or missing products.
   g. Arrange for manufacturer’s field services.
   h. Provide testing, calibration, and adjusting of installed products.
2. Contractor responsibilities:
   a. Construction progress schedule:
      1) Establish deadlines for receipt of Owner’s product literature, blocking requirements, and rough-in requirements.
      2) Indicate submittal and delivery dates for each product.
   b. Review product data, shop drawings, samples, and other submittals from Owner. Notify Owner of observed discrepancies or problems anticipated.
   c. Receive and unload products at site.
   d. Inspect deliveries jointly with Owner; record shortages, and damaged or defective products.
   e. Handle products at site, including uncrating and storage.
   f. Protect products from damage and from exposure to elements.
   g. Provide necessary blocking required for proper installation.
   h. Assemble, install, and connect products as required in manufacturer’s written instructions and respective Specification section.
   i. Provide installation inspections required by public authorities.
   j. Repair or replace products damaged or lost by Contractor.

B. CF/CI - Contractor Furnished and Contractor Installed Products: Comply with Contract Documents.

1.4 PRODUCT DELIVERY REQUIREMENTS

A. Arrange deliveries in accordance with construction progress schedules. Schedule deliveries to allow adequate time for product inspection prior to installation. Schedule shall also take into consideration and allow adequate time for reordering of products damaged during delivery or do not meet Contract requirements.

B. Coordinate to avoid conflict with Work and conditions at site.

C. Deliver products in undamaged condition, in manufacturer’s original unopened containers or packaging, with identifying labels intact and legible.
D. Promptly inspect shipments to ensure that products comply with requirements, quantities are correct, and products are undamaged.

1.5 PRODUCT STORAGE, AND HANDLING REQUIREMENTS

A. Storage:
1. Store and protect products in accordance with manufacturer’s instructions with labels intact and legible.
2. Store environmentally sensitive products in weathertight, climate controlled enclosures.
3. Provide off site storage and protection when site does not permit on site storage.
4. Protect and cover products subject to deterioration with impervious sheet covering. Provide ventilation to avoid condensation.
5. Arrange storage to permit access for inspection. Periodically inspect to ensure products are undamaged and are maintained under specified conditions.

B. Handling:
1. Handle products in accordance with manufacturer’s instructions.
2. Do not load structure during construction by storing products with load greater than structure is calculated to safely support.
3. Provide equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage.

C. Do not use products in Work which have deteriorated, become damaged, or are otherwise unfit for use.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION
SECTION 01630

PRODUCT SUBSTITUTION PROCEDURES

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Contract is based upon products and standards established in Contract Documents without consideration of proposed substitutions.

B. Products specified define standard of quality, type, function, dimension, appearance and performance required.

C. Substitution proposals are permitted for specified products, except where specified otherwise.

D. Do not substitute products unless substitution has been accepted and approved in writing by Architect.

1.2 TIME OF SUBSTITUTION REQUESTS

A. Substitution requests must be submitted at time of bid; requests will not be considered if submitted at another time. Refer to Bid Form for provisions of submitting and listing proposed substitutions.

B. After receipt of bid, 3 lowest bidders will be requested to submit supporting data for each proposed substitution. Submit supporting data to Architect within 7 days of receipt of request; comply with specified substitution procedures and use attached "Substitution Request Form."

C. Acceptance or rejection of proposed substitutions will be determined prior to award of Contract. Approved substitutions will be identified in Contract.

D. No additional substitutions will be considered after this initial process unless a substitution is required due to specified product being removed from or unavailable in market place.

1.3 SUBSTITUTION PROCEDURES

A. Limit each request to one proposed substitution.

B. Submit substitution requests on attached form complete with attachments necessary to fully document proposed substitution. Submit in number of copies required for Contractor’s use and distribution, plus one copy to be retained by Architect and one to be retained by Owner.

C. Copy of required form is bound after last page of this Section. Remove form for making additional copies or request an original copy from Architect.
D. Document each request with supporting data substantiating compliance of proposed substitution with Contract Documents, including:

1. Manufacturer’s name and address, product, trade name, model, or catalog number, performance and test data, and reference standards.
2. Itemized point-by-point comparison of proposed substitution with specified product, listing variations in quality, performance and other pertinent characteristics.
3. Reference to article and paragraph numbers in Specification section.
4. Cost data comparing proposed substitution with specified product and amount of net change to Contract Sum.
5. Changes required in other Work.
6. Availability of maintenance service and source of replacement parts, as applicable.
7. Certified test data to show compliance with performance characteristics specified.
8. Samples, when applicable or requested.
9. Other information as necessary to assist Architect’s evaluation.

E. A request for substitution constitutes a representation that Contractor:

1. Has investigated proposed product and determined that it is equal or superior in all respects to specified product.
2. Will provide identical warranty as required for specified product.
3. Will coordinate installation and make changes to other Work which may be required.
4. Waives claims for additional costs or time extension which may subsequently become apparent.
5. Certifies that proposed product will not affect or delay Construction Progress Schedule.
6. Will pay for changes to building design, including architectural or engineering design, detailing, and construction costs caused by the requested substitution.

F. Substitutions will not be considered when:

1. Indicated or implied on shop drawings or product data submittals without formal request submitted in accord with this Section.
2. Submittal for substitution request has not been reviewed and approved by Contractor.
3. Acceptance will require substantial revision of Contract Documents or other items of the Work.
4. Submittal for substitution request does not include point-by-point comparison of proposed substitution with specified product.

1.4 ARCHITECT’S REVIEW

A. Architect will determine acceptability of proposed substitutions and will review requests with reasonable promptness.

B. Considerations for acceptance will be based on conformance with Contract Documents, including following as applicable:

1. Physical dimension and clearance requirements to satisfy space limitations.
2. Static and dynamic weight limitations; structural properties.
3. Audible noise levels.
5. Interchangeability of parts or components.
6. Accessibility for maintenance to allow possible removal or replacement.
7. Design.
8. Colors, textures, and finishes.
9. Compatibility with other materials, products, assemblies, and components.

C. Decision to accept or reject requested substitution will be indicated on "Substitution Request Form."

D. Rejection of proposed substitution requires use of specified product.

PART 2 - PRODUCTS
NOT USED

PART 3 - EXECUTION
NOT USED

END OF SECTION

Attachment:
Substitution Request Form, 2 pages.
**SUBSTITUTION REQUEST FORM**

Note: Limit this Request to one proposed substitution

<table>
<thead>
<tr>
<th>TO:</th>
<th>AFD</th>
<th>Date:</th>
<th>Request Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>FROM:</td>
<td>Contractor</td>
<td>Subcontractor</td>
<td>Supplier</td>
</tr>
</tbody>
</table>

Specified Item: ________________________________

Section: ________________ Page: ________________ Paragraph: ________________

Proposed Substitution: ________________________________

Manufacturer: ____________________ Address: ____________________ Phone Number: ____________________
Trade Name: ____________________ Model Number: ____________________
Installer: ____________________ Address: ____________________ Phone Number: ____________________

History:  
- New product
- 2 to 5 years old
- 5 to 10 years old
- More than 10 years old

Differences between proposed substitution and specified product:

- Point by point comparison data attached - **REQUIRED BY ADVANTECH**

Reason for Not Providing Specified Item:

Similar Installations:

<table>
<thead>
<tr>
<th>Project</th>
<th>Address</th>
<th>Architect</th>
<th>Owner</th>
<th>Date Installed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>Address</td>
<td>Architect</td>
<td>Owner</td>
<td>Date Installed</td>
</tr>
</tbody>
</table>

Proposed substitution affects other parts of Work:  
- No
- Yes; explain

Savings to Owner for accepting substitution: ________________ ($ ________________)

Proposed substitution changes Contract Time:  
- No
- Yes; Add/Deduct ____________ days

Supporting Data Attached:

- Product Data
- Drawings
- Tests
- Reports
- Samples
- Other
Undersigned certifies:

• Proposed substitution has been fully investigated and determined to be equal or superior in all respects to specified product.
• Same warranty will be furnished for proposed substitution as for specified product.
• Same maintenance service and source of replacement parts, as applicable is available.
• Proposed substitution will not affect or delay Construction Progress Schedule.
• Cost data as stated above is complete. Claims for additional costs related to accepted substitution which may subsequently become apparent are to be waived.
• Proposed substitution does not affect dimensions and functional clearances.
• Payment will be made for changes to building design, including architectural or engineering design, detailing, and construction costs caused by the requested substitution.
• Coordination, installation, and changes in the Work as necessary for accepted substitution will be complete in all respects.

Submitted by:

Signature: ____________________________________________________________
Firm: ______________________________________________________________
Address: ____________________________________________________________
Telephone: __________________________________________________________
Attachments: ________________________________________________________

ARCHITECT’S REVIEW AND ACTION

• Substitution approved - Make submittals in accordance with Specification Section 01330.
• Substitution approved as noted - Make submittals in accordance with Specification Section 01330.
• Substitution rejected - Use specified products.
• Substitution Request received too late - Use specified products.

Signed by: ____________________________ Date ____________________________

Additional Comments: o Contractor  o Subcontractor  o Supplier  o Manufacturer  o AFD  o ______

END OF FORM
PART 1 - GENERAL

1.1 EXAMINATION OF CONDITIONS

A. Examine substrates and conditions under which Work is to be performed. Do not commence work over unsatisfactory conditions detrimental to proper and timely execution of Work.

B. Do not proceed with Work until unsatisfactory conditions have been corrected.

C. Commencement of installation constitutes acceptance of conditions and cost of any corrective measures are responsibility of Contractor.

1.2 PREPARATION

A. Require compliance with manufacturer’s printed installation instructions, including each step in sequence. Do not omit preparatory steps or installation procedures unless specifically modified or exempted by Contract Documents.

B. Maintain one set of complete instructions at Project site during installation and until completion.

C. Should Project conditions or specified requirements conflict with manufacturer’s instructions, request clarification in writing from Architect before proceeding.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 PRODUCT EXECUTION

A. Install, erect, connect, condition, use, adjust, and clean products in accordance with manufacturer’s instructions and in conformity with specified requirements.

B. Verify and coordinate clearances, dimensions and installation of adjoining construction, equipment, piping, ducts, conduits, or other mechanical or electrical items or apparatus.

C. Prior to fabrication, field measure actual existing conditions to ensure proper fit.

D. Inspect each item of material or equipment immediately prior to installation. Reject damaged and defective items.
E. Recheck measurements and dimensions of Work, as an integral step of starting each installation. Whenever stock manufactured products are specified, verify actual space requirements for setting or placing into allotted space. No extra cost will be allowed for adjustment of Work to accommodate particular product.

F. Provide attachment and connection devices and methods for securing Work. Secure in place with devices designed and sized to withstand stresses, vibration, physical distortion or disfigurement.

G. Allow for expansion of materials and building movement.

H. Isolate each unit of Work from incompatible Work as necessary to prevent deterioration and electrolytic action.

I. Clean and perform maintenance on installed construction as frequently as necessary through remainder of construction period. Lubricate operable components to ensure operability without damaging effects.

J. Adjust operating products and equipment to ensure smooth and unhindered operation.

3.2 PROTECTION OF INSTALLED CONSTRUCTION

A. Protect installed construction in manner to prevent damage from subsequent construction operations.

B. Provide special protection where specified in individual Specification sections.

C. Provide temporary and removable materials for protection of installed products. Control activity in immediate work area to minimize damage.

D. Ensure materials, systems, and components will be without damage or deterioration at time of Substantial Completion.

E. Protect finished Work from damage, defacements, stains, scratches, and wear.

F. Provide protective coverings at walls, projections, jambs, sills, and soffits of openings.

G. Protect finished floors, stairs, and other surfaces from traffic dirt, wear, damage, or movement of heavy objects, by protecting with durable sheet materials.

H. Prohibit traffic or storage upon waterproofed or roofed surfaces. If traffic or activity is necessary, obtain recommendations for protection from waterproofing or roofing material manufacturer.

I. Prohibit traffic from lawn and landscaped areas.

END OF SECTION
SECTION 01725
FIELD ENGINEERING

PART 1 - GENERAL

1.1 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Submit following informational submittals:
   1. Name, address, and telephone number of Surveyor before starting survey work.
   2. On request, documentation verifying accuracy of survey work.

C. Closeout Submittals:
   1. Submit under provisions of Section 01780.
   2. Project record documents:
      a. Submit copy of surveyor’s log.
      b. Submit 6 copies of final property survey for Owner’s records.

1.2 QUALITY ASSURANCE

A. Employ Land Surveyor registered to perform surveying in State where project is located, acceptable to Owner and Architect.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 SURVEY REFERENCE POINTS

A. Control datum is indicated on Drawings.

B. Establish and maintain minimum of 2 permanent bench marks on site, referenced to established control points. Record locations with horizontal and vertical data on Project Record Documents.

C. Protect survey control points prior to starting site work; preserve permanent reference points during construction.

D. Do not change or relocate benchmarks or control points without prior written approval of Architect.

E. Promptly report to Architect the loss or destruction of any reference point or relocation required because of changes in grades or other reasons.
F. Replace dislocated survey control points based on original survey control. Make no changes without prior written notice to Architect. Base replacements on original survey control points.

G. Existing Utilities and Equipment:
1. Existence and location of indicated existing underground utilities and construction are not guaranteed.
2. Before beginning sitework:
   a. Investigate and verify existence, location, and elevations of underground utilities and other construction.
   b. Verify location and invert elevation at points of connection for sanitary sewer, storm sewer, and water-service piping.
3. Furnish information necessary to adjust, move, or relocate existing utility structures, utility poles, lines, services, or other appurtenances located in or affected by construction.
4. Coordinate with local authorities having jurisdiction.

3.2 SURVEY REQUIREMENTS

A. Establish building location and layout on site. Establish and verify each floor elevation. Establish layout, lines, and elevation of Work based on established datum.

B. Prior to commencement of Work, verify and establish floor elevations of existing facilities to assure that new Work will meet existing elevations in smooth and level alignment, except where specifically detailed or indicated otherwise.

C. Work from lines and levels established by property survey.

D. Establish benchmarks and markers to set lines and levels at each story of construction and elsewhere as needed to locate each element of Project.

E. Calculate and measure required dimensions within indicated or recognized tolerances.

F. Do not scale Drawings to determine dimensions.

G. Advise entities engaged in construction activities of marked lines and levels provided for their use.

H. Establish elevations, lines, and levels. Locate, lay out, and periodically verify layouts, by instrumentation and similar appropriate means:
   1. Site improvements including pavements; stakes for grading, fill and topsoil placement; and utility locations, slopes, and invert elevations;
   2. Grid or axis for structures.
   3. Building foundation, column locations, and ground floor elevations.

I. As construction proceeds, check every major element for line, level, and plumb.

J. Surveyor’s Log:
1. Maintain and make available for references, surveyor’s log of control and other survey work as work progresses. Make this log available for reference.
2. Record deviations from required lines and levels, and advise Architect of deviations exceeding indicated or recognized tolerances.
3. Record deviations on Project Record Drawings that are accepted and not corrected.

4. Prepare certified survey showing dimensions, locations, angles, and elevations of construction and sitework on completion of foundation walls, major site improvements, and other work requiring surveying.

3.3 FINAL PROPERTY SURVEY

A. Prior to Substantial Completion, prepare a final property survey illustrating locations, dimensions, angles, and elevations of buildings and site work that have resulted from construction of Project indicating their relationship to permanent bench marks and property lines.

B. Show significant features (real property) for Project.

C. Include certification on survey, signed by surveyor, that principal metes, bounds, lines, levels, and elevations of Project are accurately shown.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Section includes incidental cutting, fitting, and patching within new construction required to complete work or to make its several parts fit together.

1.2 SUBMITTALS

A. Submit written request to perform cutting and patching 2 weeks in advance of cutting or alteration which affects:
   1. Structural value or integrity of any element of Project.
   2. Integrity or effectiveness of weather exposed or moisture resistant elements or systems.
   3. Efficiency, operation, maintenance, or safety of operational equipment.
   4. Visual qualities of elements exposed to view.

B. Include in request:
   1. Identification of Project.
   2. Location and description of affected Work.
   3. Description of proposed Work:
      a. Scope of cutting, fitting, patching, or alteration.
      b. Listing of applicable trades.
      c. Proposed products and materials.
      d. Extent of refinishing.
   4. Necessity for cutting or alteration.
   5. Alternatives to cutting and patching.
   6. Effect on structural integrity of Work.
   7. Effect on weatherproof integrity of Work.
   8. Effect on the building’s appearance and significant visual elements.
   9. Effect on utilities:
      a. List utilities affected by cutting and patching.
      b. List utilities that will be relocated.
      c. List utilities that will be temporarily out-of-service. Indicate time period of service outage.
   10. Date and time of execution.

C. Should conditions or schedule require change of products or methods different than original installation, submit written recommendation to Architect explaining conditions necessitating change and requirements of alternative materials or methods.

D. Approval by Architect to proceed with cutting and patching does not waive Architect’s right to later require complete removal and replacement of unsatisfactory work.
PART 2 - PRODUCTS

2.1 MATERIALS

A. Primary Products and Materials: Those required for original installation; comply with Specifications for each specific product involved.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Comply with provisions of Section 01700.

B. After uncovering existing Work, examine conditions affecting installation of products and performance of Work.

3.2 PREPARATION

A. Provide temporary supports to ensure structural integrity of affected portions of Work.

B. Provide devices and methods to protect other portions of Project from damage.

C. Provide protection from elements for areas which may be exposed by uncovering work; maintain excavations free of water.

D. Provide materials and control operations to prevent spread of dust in surrounding area. Provide drop cloths or other suitable barriers.

E. Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.

F. Avoid cutting in service pipes, ducts, or conduit until provisions have been made to bypass them.

3.3 PERFORMANCE

A. Cut into construction to provide for installation of other Work and subsequent fitting and patching required to restore surface to original condition.

B. Cut, fit, patch, excavate, and backfill to complete Work and to:
   1. Fit several parts together, to integrate with other work.
   2. Uncover portions of work to provide for installation of ill-timed work.
   3. Remove and replace defective work.
   4. Remove and replace work not conforming to requirements of Contract Documents.
   5. Remove samples of installed work as necessary for testing.
   6. Provide openings in elements of work for penetrations of plumbing, mechanical, and electrical work.
7. Uncover work to allow for Architect’s observation of covered work which has been covered up prior to required observation by Architect.

C. Execute in manner which does not void required or existing warranties.

D. Execute by methods which will prevent damage to other Work and which will produce appropriate surfaces to receive installation of new Work:
   1. Use hand or small power tools designed for sawing or grinding, not hammering or chopping.
   2. Cut holes and slots as small as possible, neatly to size required, with minimum disturbance of adjacent surfaces.
   3. Temporarily cover openings when not in use.
   4. To avoid marring existing finished surfaces, cut or drill from exposed or finished side into concealed surfaces.
   5. Cut through concrete and masonry using cutting machine, such as Carborundum saw or diamond-core drill.

E. Execute excavating and backfilling by methods in accordance with applicable Sections of Division 2 which will prevent settlement or damage to Project.

F. Execute fitting and adjustment to produce finished installation complying with specified products, functions, tolerances, and finishes.

G. Restore surfaces which have been cut, removed, or damaged, to match existing conditions.

H. Install products and materials to complete Work in accordance with requirements of Contract Documents.

I. Employ original installer to perform cutting and patching for weather exposed and moisture resistant elements, and sight exposed surfaces.

J. Do not cut and patch structural elements in manner that would result in reduction of load carrying capacity or of load deflection ratio.

K. Do not cut and patch operational elements or safety related components in manner that would result in reduction of their capacity to perform in manner intended, including energy performance, that would result in increased maintenance, decreased operational life, or decreased safety.

L. Fit work tight to pipes, sleeves, ducts, conduit, and other penetrations through surfaces.

M. At penetrations of fire-rated assemblies, completely seal with firestops in accordance with Section 07840.

N. Where utilities are to be removed, relocated, or abandoned, by-pass before cutting. Cut-off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal the remaining portion of pipe, duct, or conduit to prevent entrance of moisture or matter after by-passing and cutting.
O. Except where indicated otherwise, restore exposed finishes of patched areas to match adjacent surface and where necessary extend finish restoration into adjacent surfaces in manner which will eliminate evidence of patching and refinishing. Thoroughly clean surfaces prior to application of paint and other finishes.

P. Where patching occurs in previously painted surface, provide appropriate prime coat followed by first finish coat of paint. Provide final finish coat over entire area containing patch; for continuous surface extend to nearest vertical break or intersection, for an assembly refinish entire unit. Except where indicated otherwise, finish in sheen and color to match existing.

3.4 CLEANING

A. Thoroughly clean areas and spaces affected by Work. Completely remove paint, mortar, oils, putty, and items of similar nature.

B. Restore damaged surfaces to its original condition.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. While not a certified Cleanroom, given the nature of the work conducted in this space, this specification shall apply to this project in force.

1.2 DEFINITIONS

A. The existing formulation room and the addition are Clean Zone areas and include environmentally controlled areas with mechanical air circulation and filter bank arrangements, designed to reduce airborne particulate levels, including designated perimeter areas.

1.3 REQUIREMENTS

A. Unacceptable Activities Inside Clean Zone (violators may be permanently barred from Project Site by Owner.):
   1. Eating or drinking foodstuffs, smoking or chewing tobacco products.
   2. Standing, sitting, or walking on “process” or specialty gas piping, HVAC duct work, fire sprinkler piping, or other building utility piping.
   3. Standing, sitting, or walking on ceiling filter modules.
   4. Cutting or threading of pipe or fittings.
   5. Operating propane, diesel, gas, or oil-fueled tool, high-lift, or other piece of construction equipment.
   6. Entering Clean Zone in garments and footwear that are not in compliance with posted Clean Zone cleanliness stage protocol.

B. Mandatory Procedures For Entering and Working in Clean Zones:
   1. Clean footwear prior to entry to gowning area.
   2. Walk on sections of “tacky mat” provided at controlled entry to Clean Zones.
   3. Wipe down and HEPA vacuum construction materials, tools, and accessories as specified, prior to movement into Clean Zone.
   4. Clean-up spills (e.g., caulking, sealant, filter gel, paint, and similar materials) immediately and dispose of same in designated trash receptacles.
   5. Dispose of tie-straps, plastic seal wraps, and other building product/system component protection devices in designated trash receptacles.
   6. Require shoe covers and protective body garments be worn at times when working in Clean Zone.
   7. Protect each working area to insure that bits of construction debris such as screws, bolts, nuts, washers, wire cut-ends, insulation scraps, and metal trimmings are prevented from falling beyond area into interstitial or underfloor cavities.

C. Security:
   1. Obtain and require construction personnel to display Owner’s security badges at times inside Clean Zone.
a. Owner’s security badges will be color coded to permit entry into posted controlled security/clean areas or construction zones.
   1) No entry is permitted without proper badge clearances.
   2) Use badges to control construction workers by level of “build clean construction” protocol and safety training.

b. Remove construction workers immediately from Job Site when found by Owner or Architect inside a posted, controlled, security/Clean Zone area, without proper badge clearance.
   1) Require remedial training.
   2) Repeat violators may be permanently prohibited (by Owner) from entering Project Site.

c. Limit entrance to Clean Zones to authorized construction employees and Owner-approved, Owner/Architect staff with “Clean Zone” badges. Require other visitors or guests to be accompanied by an Owner’s Representative and to check in with Owner’s Surveillance Foreman prior to entry into Clean Zone.

d. Require Clean Zone clothing be worn by personnel within Clean Zone in conformance with posted cleanliness stage.

e. Install “temporary” door locks at each Clean Zone exit point to restrict entry but permit safe exit in case of emergency.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Comply with requirements of Section 01600.

B. Require materials to be sealed and delivered in their original unopened packages.

C. Use extreme care in handling building systems components to prevent damage after delivery.

D. Store Clean Zone products awaiting installation within “building” in space designated by Owner.

E. Store products and components to prevent damage or intrusion of foreign matter.
   1. Conspicuously mark “Rejected” on materials which have been damaged or rejected, and remove from Job Site immediately.

F. Do not store products in “clean staging area” in quantities in excess of that to be installed in one 24-hour working period.

G. Do not store contaminated materials in “clean staging areas” or Clean Zones.
   1. Remove from Job Site immediately.

H. Do not allow wood, cardboard, and paper products in Clean Zone staging and perimeter clean spaces at any time.

PART 2 - PRODUCTS
NOT USED

PART 3 - EXECUTION
NOT USED

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Construction and final cleaning prior to Certification of Substantial Completion.

1.2 SYSTEM DESCRIPTION

A. Execute cleaning during progress of work and at completion of work as required by this section and the Conditions of the Contract.

B. Hazards Control:
   1. Store volatile wastes in covered safety containers.
   2. Remove containers from premises daily.
   3. Prevent accumulation of waste which creates hazardous conditions.
   4. Provide adequate ventilation during use of volatile or noxious substances.

C. Conduct cleaning and disposal operations to comply with local ordinances and anti-pollution laws.
   1. Do not burn or bury rubbish and waste materials on Project site.
   2. Do not dispose of volatile wastes or hazardous materials such as mineral spirits, oil, or paint thinner in storm or sanitary drains.
   3. Do not dispose of wastes into streams or waterways.

PART 2 - PRODUCTS

2.1 CLEANING MATERIALS

A. Use only materials and methods recommended by manufacturer of material being cleaned.

B. Do not use materials which will create hazards to health or property, or which will damage surfaces.

C. Provide covered containers for deposit of waste materials, debris, and rubbish.

PART 3 - EXECUTION

3.1 CLEANING DURING CONSTRUCTION

A. Execute periodic cleaning to keep building, site, and adjacent properties free of accumulations of waste materials, debris, rubbish, and wind blown debris resulting from construction operations.
B. Prior to Substantial Completion remove construction tools, scaffolding, equipment, machinery, and surplus materials.

C. Broom clean and vacuum interior areas prior to start of surface finishing, and continue cleaning to eliminate dust.

D. Schedule cleaning operations so that dust and other contaminants will not fall on or adhere to wet or newly-coated surfaces.

E. Remove debris and rubbish from pipe chases, plenums, attics, crawl spaces, and other closed or remote spaces, prior to enclosing space.

F. Do not throw materials from heights.

G. Open free-fall chutes not permitted. Terminate closed chutes into appropriate containers with lids.

H. Collect and remove waste materials, debris, and rubbish from site periodically [weekly] until execution of final cleaning and dispose off site in lawful manner.

3.2 FINAL CLEANING

A. Comply with manufacturer’s instructions.

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

C. Employ experienced personnel or professional cleaning firm.

D. Cleaning:
   1. Clean exposed exterior and interior hard-surfaced finishes to dirt-free condition, free of stains, films, and similar foreign substances.
   2. Remove labels which are not required as permanent labels.
   3. Clean glossy materials to polished condition; remove foreign substances.
   4. Polish reflective surfaces to clear shine. Glass and glazing:
      a. Wash and clean mirrors and both sides of glass.
      b. Remove putty and other substances which obscure vision.
      c. Replace chipped, scratched, and broken glass.
   5. Clean concrete floors in unoccupied spaces.
   6. Clean resilient flooring, stone flooring, tile, pavers, and other similar hard-surface flooring, including associated bases. Refer to individual Specification sections for requirements of sealing, buffing, waxing, and polishing.
   7. Clean carpet and similar soft surfaces, removing debris, soil, and excess nap.
   8. Clean exposed surfaces of equipment; remove excess lubrication.
   9. Clean plumbing fixtures, drinking fountains, and similar equipment to sanitary condition.
  10. Clean light fixtures and lamps; replace burned-out lamps.
E. Avoid disturbing natural weathering of exterior surfaces.

F. Heating, Ventilating, and Air Conditioning Systems:
   1. Clean permanent filters and replace disposable filters for units operated during construction.
   2. Clean ducts, blowers, and coils for units operated without filters during construction.

G. Site:
   1. Clean areas disturbed by construction activities, including landscape areas, free of rubbish, litter and foreign substances.
   2. Sweep paved areas to broom clean condition.
   3. Remove stains, spills, and other foreign deposits.
   4. Rake grounds that are neither paved nor planted to even-textured surface.

H. Remove waste, foreign matter, and debris from roofs, gutters, areaways, and drainage systems.

I. Prior to final completion, conduct inspection of sight-exposed interior surfaces, exterior surfaces, and associated work areas to verify that entire Work is clean.

J. Maintain cleaning until Project, or portion thereof, is accepted by Owner.

END OF SECTION
SECTION 01750

STARTING AND ADJUSTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Perform operations in following order prior to request for Substantial Completion:
   1. Starting of Systems
   2. Testing, Adjusting, and Balancing
   3. Demonstration of Systems
   4. Instruction of Owner’s designated personnel.

1.2 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Submit following items as required by this Section:
   3. Record of Owner’s Instructions.

1.3 STARTING OF SYSTEMS

A. Coordinate schedule for startup of various equipment and systems.

B. Notify Architect and Owner at least 7 days prior to startup of each item.

C. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, or for other conditions which may cause damage.

D. Verify that tests, meter readings, and specified electrical characteristics agree with those required by contract documents and equipment or system manufacturer.

E. Verify wiring and support components for equipment are complete and tested.

F. Execute startup under supervision of applicable manufacturer’s representatives and Contractor’s personnel in accordance with manufacturer’s instructions.

G. When specified in individual Specification Sections, require manufacturer to provide authorized representative to be present at site to inspect, check, and approve equipment or system installation prior to startup, and to supervise placing equipment or system in operation.

H. Submit manufacturer’s field report in accordance with Section 01400 stating that equipment or system has been properly installed and is functioning correctly.

1.4 TESTING, ADJUSTING, AND BALANCING (TAB)

Contractor shall select specialist certified by National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) with at least 3 years of experience in those testing, adjusting, and balancing requirements similar to those required for this Project, who is not installer of system to be tested and is otherwise independent of Project.
A. TAB firm will perform services specified in Section 15190 prior to demonstration of system to Owner.
B. Submit reports by TAB firm, in accordance with Section 01450, to Architect indicating observations and results of tests and indicating compliance or non-compliance with Contract Document requirements.

1.5 DEMONSTRATION

A. Demonstration is for verification that systems will start and operate properly.
B. Demonstrate systems operation to Owner’s personnel prior to performing instruction of Owner’s personnel.
C. Demonstrate Project equipment by qualified manufacturers’ representative who is knowledgeable about Project requirements and operation and maintenance of equipment being demonstrated.
D. For equipment or systems requiring seasonal operation, perform demonstration for other season within 6 months.
E. Demonstrate startup, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item of equipment.
F. Prepare and insert additional data in operations and maintenance manuals required by Section 01780 when need for additional data becomes apparent during instruction.

1.6 INSTRUCTION OF OWNER’S PERSONNEL

A. Prior to Substantial Completion, fully instruct Owner’s designated operation and maintenance personnel in operation, adjustment, and maintenance of products, equipment and systems requiring regular maintenance. Perform instructions within continuous period of 30 days. For equipment that requires seasonal operation, provide similar instruction during other seasons.
B. Arrange and pay for services of qualified manufacturer’s representatives to fully instruct Owner on specialized portions of installation, such as refrigeration machines, automatic controls, water treatment, and electrical systems.
C. Use operations and maintenance manual as basis of instruction. Review contents of manual with personnel in full detail to explain all aspects of operations and maintenance. Include detailed review of following items:
   1. Maintenance manuals.
   2. Record documents.
   3. Spare parts and materials.
   4. Tools.
   5. Lubricants.
   6. Fuels.
D. Submit complete record of instructions as part of operations and maintenance manual given to Owner. For each instructional period, supply following data:
   1. Date.
   2. System or equipment involved.
   3. Names of persons giving instructions.
   4. Other persons present.

PART 2 - PRODUCTS
NOT USED
PART 3 - EXECUTION
NOT USED

END OF SECTION
PART 1 - GENERAL

1.1 PREREQUISITES TO SUBSTANTIAL COMPLETION

A. Complete items in following paragraphs before requesting Certification of Substantial Completion, either for entire Work or for portions of Work.

B. Conduct inspection to substantiate basis for request that Work is substantially complete. Create comprehensive list (initial punch list) indicating items to be completed or corrected, value of incomplete or non-conforming work, reason for being incomplete, and date of anticipated completion for each item. Include copy of list with request for Certificate of Substantial Completion.

C. Submit statement showing accounting of changes to Contract Sum.

D. Advise Owner of pending insurance change-over requirements at final payment.

E. Obtain and submit releases enabling Owner’s full, unrestricted use of Project and access to services and utilities. Include certificate of occupancy, operating certificates, and similar releases from authorities having jurisdiction and utility companies.

F. Submit project record documents in compliance with Section 01780, maintenance manuals, and other similar final record data.

G. Deliver tools, spare parts, extra stocks of material, and similar physical items to Owner.

H. Make final change-over of locks and transmit keys directly to Owner. Advise Owner’s personnel of change-over in security provisions.

I. Comply with requirements of Section 01500 for restoring permanent systems operated prior to Substantial Completion.

J. Complete facility startup, testing, adjusting, and balancing of systems and equipment, demonstrations, and instructions to Owner’s operating and maintenance personnel as specified in Section 01750.

K. Discontinue or change over and remove temporary facilities and services from Project site, along with construction tools, mock-ups, and similar elements.

L. Perform final cleaning in accordance with Section 01740.

M. Touch-up and otherwise repair and restore marred exposed finishes.
1.2 SUBSTANTIAL COMPLETION REVIEW

A. When Contractor considers Work to be substantially complete, submit to Architect:
   1. Written certificate that Work, or designated portion, is substantially complete.
   2. List of items to be completed or corrected (initial punch list).

B. Within 7 days after receipt of request for Substantial Completion, Architect and Owner will make site review to determine whether Work or designated portion is substantially complete following procedures indicated in Conditions of the Contract.

C. Should Architect or Owner determine that Work is not substantially complete:
   1. Architect or Owner will promptly notify Contractor in writing, stating reasons for its opinion.
   2. Contractor shall remedy deficiencies in Work and send second written request for Substantial Completion to Architect or Owner.
   3. Architect or Owner will re-perform review of Work.

D. When Architect or Owner finds that Work is substantially complete, Architect or Owner will:
   1. Prepare Certificate of Substantial Completion on AIA Form G704, accompanied by Contractor’s list of items to be completed or corrected as verified and amended by Architect and Owner (final punch list).
   2. Submit Certificate to Owner and Contractor for their written acceptance of responsibilities assigned to them in the Certificate.
   3. The project will not be deemed substantially complete until the Certificate is issued irrespective of Owner occupancy.

E. After Work is substantially complete, Contractor shall:
   1. Allow Owner occupancy of Project under provisions stated in Certificate of Substantial Completion.
   2. Complete work listed for completion or correction within time period stipulated.

1.3 PREREQUISITES FOR FINAL COMPLETION

A. Complete items in following paragraphs before requesting final acceptance and final payment. List known exceptions, if any, in request.

B. When Contractor considers Work to be complete, submit written certification that:
   1. Contract Documents have been reviewed.
   2. Work has been examined for compliance with Contract Documents.
   3. Work has been completed in accordance with Contract Documents.
   4. Work is completed and ready for final inspection.

C. Submit final punch list indicating all items have been completed or corrected.

D. Submit final payment request with final releases and supporting documentation not previously submitted and accepted. Include certificates of insurance for products and completed operations where required.
E. Submit specified warranties, workmanship/maintenance bonds, maintenance agreements, and other similar documents in accordance with Section 01780.

F. Submit updated accounting statement for final changes to Contract Sum.

G. Submit consent of surety to final payment.

H. Perform final cleaning for Contractor soiled areas in accordance with Section 01740.

1.4 FINAL COMPLETION REVIEW

A. Within 7 days after receipt of request for final review, Architect will make site review to determine whether Work or designated portion is complete following procedures indicated in Conditions of the Contract.

B. Should Architect consider Work to be incomplete or defective:
   1. Architect will promptly notify Contractor, in writing, listing incomplete or defective work.
   2. Contractor shall take immediate steps to remedy stated deficiencies and send second written request to Architect that Work is complete.
   3. Architect will reinspect Work.

1.5 REVISITS FOR SITE REVIEWS

A. Should Architect have to re-perform site reviews due to failure of Work to comply with claims of completion made by Contractor, Owner will reimburse Architect for such additional services and will deduct amount of compensation from final payment to Contractor.

1.6 EVIDENCE OF PAYMENTS AND RELEASE OF LIENS

A. Submit Contractor’s affidavit of Payment of Debts and Claims on AIA Document G706.

B. Submit Contractor’s affidavit of Release of Liens on AIA Document G706A with:
   2. Contractor’s Release or Waiver of Liens.
   3. Separate releases or waivers of liens from subcontractors, suppliers and others with lien rights against property of Owner, together with list of those parties.

C. Execute submittals before delivery to Owner.

1.7 FINAL ADJUSTMENT OF ACCOUNTS

A. Submit final statement of accounting to Architect.

B. Show adjustments to Contract Sum:
   1. Original Contract Sum.
   2. Additions and deductions resulting from:
a. Previous Change Orders.
b. Allowances.
c. Unit Prices.
d. Deductions for uncorrected Work.
e. Deductions for inspection payments.
f. Other adjustments.

3. Total Contract Sum as adjusted.
4. Previous payments.
5. Retainage.
6. Sum remaining due.

C. Architect will prepare final Change Order reflecting approved adjustments to Contract Sum which are not included in Change Orders previously processed.

1.8 FINAL APPLICATION FOR PAYMENT

A. Submit final Application for Payment in accordance with procedures and requirements stated in Conditions of the Contract.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

END OF SECTION
SECTION 01780
CLOSEOUT SUBMITTALS

PART 1 - GENERAL

1.1 RECORDING

A. Post changes and modifications to record documents as they occur. Do not wait until end of Project. Architect will periodically review record documents to assure compliance with this requirement.

1.2 SUBMITTAL

A. Deliver closeout submittals and samples to Architect for transmittal to Owner.

B. Include typed list identifying each item submitted as closeout document.

1.3 OPERATIONS AND MAINTENANCE MANUALS

A. Prepare data in form of instructional manual in heavy-duty three-ring binders with durable plastic covers.
   1. Where written instructions are required, use personnel skilled in technical writing to extent necessary for communication of essential data.
   2. Where drawings or diagrams are required, use personnel capable of preparing drawings clearly in understandable format.
   3. In addition to hard copy, provide operations and maintenance manuals in electronic pdf format.

B. Examine for completeness.

C. Submit one copy of completed volumes in final form after instructing Owner’s personnel under Section 01750, but prior to request for Substantial Completion. This copy will be returned with Architect’s comments. Revise as necessary prior to final submittal.

D. Prepare and insert additional data in manuals when need for such data becomes apparent during Owner’s instruction.

E. Submit 3 copies of final volumes at time of request for Substantial Completion.

F. Label covers and spine of each binder with typed or printed title OPERATIONS AND MAINTENANCE MANUAL, title of project, and subject matter of binder when multiple binders are required.

G. Separate contents with tab dividers, logically organized with tab title clearly printed under reinforced laminated plastic tabs.
H. Manuals shall contain:
   1. Table of contents.
   2. Directory listing names, addresses, and telephone numbers of Architect, Engineer, Construction Manager, and Contractor.
   3. List names, addresses and telephone numbers of subcontractors, suppliers, and service representatives, including local source of supplies and replacement parts.
   4. General system or equipment description.
   5. Copies of applicable shop drawings and product data.
   6. Mark product data to clearly identify specific products and component parts.
   7. Supplement product data with drawings necessary to illustrate relationship of component parts of equipment and systems, include control and flow diagrams.
   8. Arranged by product, system, or process flow, and subdivided by Specification section. Identify following:
      a. Significant design criteria.
      b. List of equipment.
      c. System or equipment identification, including:
         1) Name of manufacturer.
         2) Model number.
         3) Serial number of each component.
      d. Parts list for each component.
      e. Operating instructions.
      f. Maintenance instructions and schedules for equipment and systems.
      g. Emergency instructions.
      h. Wiring and piping diagrams.
      i. Inspection and test procedures.
      j. Precautions against improper use and maintenance.
10. Protective plastic jackets: Provide protective transparent plastic jackets designed to enclose diagnostic software for computerized electronic equipment.
11. Text material:
   a. Provide manufacturer’s standard printed material or typewritten specially prepared data.
   b. Provide text on 8-1/2 inches by 11 inches, 20 pound white bond paper.
12. Drawings and diagrams:
   a. Provide reinforced punched binder tabs on drawings and bind in with text.
   b. Oversize drawings:
      1) Fold drawings to same size as text pages and use as fold-out.
      2) Drawings too large to be used as fold-out, place folded drawing in front or rear pocket of binder. Insert typewritten page indicating drawing title, description of contents, and drawing location at appropriate location in manual.

1.4 MATERIAL AND FINISHES MAINTENANCE MANUAL

A. Manual:
   1. Submit 3 copies of each manual, in final form, on material and finishes to Architect for distribution.
2. Provide one section for interior products, including applied materials and finishes, and second for products designed for exterior products.

B. Interior Products:
   1. Provide manufacturer’s data and instructions on care and maintenance of architectural products, including applied materials and finishes.
   2. Product data: Provide complete information on architectural products, including following, as applicable:
      a. Manufacturer’s catalog number.
      b. Size.
      c. Material composition.
      d. Color.
      e. Texture.
      f. Reordering information for specially manufactured products.
   3. Care and maintenance instructions: Provide information on care and maintenance including manufacturer’s recommendations for types of cleaning agents to be used and methods of cleaning. Provide information regarding cleaning agents and methods that could prove detrimental to product. Include manufacturer’s recommended schedule for cleaning and maintenance.

C. Exterior Products:
   1. Provide complete manufacturer’s data with instructions on inspection, maintenance, and repair of products exposed to weather or designed for moisture-protection purposes.
   2. Manufacturer’s data: Provide manufacturer’s data giving detailed information, including following, as applicable:
      a. Applicable standards.
      b. Chemical composition.
      c. Installation details.
      d. Inspection procedures.
      e. Maintenance information.
      f. Repair procedures.

1.5 SPARE PARTS AND MAINTENANCE MATERIALS

A. Provide tools, spare parts, maintenance and extra stock materials in quantities specified in individual Specification sections.

B. Deliver to Project site and place in locations as directed; obtain receipt from subcontractors and suppliers.

C. Submit letter at time of inspection for Substantial Completion listing items and quantities; attach receipts.

1.6 WARRANTIES AND BONDS

A. Disclaimers and Limitations: Manufacturer’s disclaimers and limitations on product warranties do not relieve Contractor of warranty on Work that incorporates products, nor does
it relieve suppliers, manufacturers, and subcontractors required to countersign special
warranties with Contractor.

B. Owner’s Recourse:
   1. Written warranties made to Owner are in addition to implied warranties, and shall not
      limit duties, obligations, rights and remedies otherwise available under law.
   2. Warranty periods shall not be interpreted as limitations on time in which Owner can
      enforce such other duties, obligations, rights, or remedies.
   3. Rejection of warranties: Owner reserves right to reject warranties and to limit
      selections to products with warranties not in conflict with requirements of Contract
      Documents.

C. Submit 3 copies of warranties, maintenance bonds, and maintenance/service contracts as
   specified in various Specification sections. Include one copy of each warranty in Operations

D. Assemble data in heavy-duty three-ring binders with durable plastic covers, two required.

E. Label cover and spine of each binder with typed or printed title WARRANTIES AND BONDS
   and title of Project.

F. Prepare table of contents in sequence of table of contents of Project Manual, with each item
   identified with number and title of Specification section in which specified, and name of
   product or work item.

G. Separate each warranty, bond, or service contract with tab and index sheets keyed to listing in
   table of contents. Provide full information, using separate typed sheets as necessary. List
   subcontractor, supplier, and manufacturer, with name, address, and telephone number of
   responsible principal.

H. Obtain warranties, bonds, and maintenance/service contracts executed in triplicate by
   responsible subcontractors, suppliers, and manufacturers; warranties commence on Date of
   Substantial Completion.

I. Verify that documents are in proper form, contain full information, and are notarized.

J. Time of Submittals:
   1. Submit binders containing warranties, bonds, and maintenance/service contacts within
      10 days after date of Substantial Completion.
   2. For equipment or component parts of equipment put into service during construction
      with Owner’s permission, submit photo copies of documents within 10 [_____] days
      after acceptance listing date of acceptance as beginning of warranty period. Retain
      originals of executed documents for final submittal as indicated in subparagraph above.
   3. For items of Work when acceptance is delayed beyond date of Substantial Completion,
      submit within 10 days after acceptance listing date of acceptance as beginning of
      warranty period.

1.7 RECORD DOCUMENT REQUIREMENTS
A. Maintain at Project site record copy of:
   3. Addenda.
   4. Change Orders, Change Directives, Supplemental Instructions, and other modifications to Contract.
   5. Approved shop drawings, product data, samples, and similar required submittals.
   6. Approved substitutions.
   7. Reports of inspection and testing agencies.
   8. Inspection certificates.
   9. Manufacturer’s certificates, manufacturer’s instructions, and reports of manufacturer’s field observations.
  10. Samples.
  11. Other items indicated in various sections within Division 1.

B. Obtain from Architect and pay reproduction costs for one set of archival quality mylar Contract Drawings for recording changes and modifications.

C. Obtain from Architect and pay reproduction costs for one set of Project Manuals for record purposes.

D. Store record documents and samples in field office apart from documents used for construction. Provide files and racks for secure storage.

E. Label and file documents and samples in accordance with section number listings in Table of Contents of Project Manual. Label each item PROJECT RECORD DOCUMENT in stamped or printed letters in prominent location on each Drawing.

F. Maintain documents and samples in clean, dry, legible condition; do not use for construction purposes.

G. Record information concurrently with construction progress.

H. Make documents available for review by Architect and Owner during construction period.

1.8 CONTRACT DRAWINGS AND SHOP DRAWINGS

A. Legibly mark drawings to record actual construction which varies appreciably from Contract Documents. Give particular attention to information on concealed elements which would be difficult to identify or measure and record later. Items required to be marked include but are not limited to:
   1. Dimensional changes to Drawings.
   2. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
   3. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of construction.
   4. Revisions to routing of piping and conduits.
5. Revisions to electrical circuitry.
6. Actual equipment locations.
7. Duct size and routing.
8. Revisions to details shown on Drawings.
9. Details not on original Contract Drawings.
10. Changes made by addenda, change orders, change directives, supplemental instructions, and other issued modifications.
11. References to related shop drawings and other similar detailed modifications.

B. Mark-up Procedures:
1. Mark completely and accurately record prints of Contract Drawings or shop drawings, whichever is most capable of showing actual physical conditions. Where shop drawings are marked, show cross-reference on Contract Drawings location.
2. Mark record sets with red erasable colored pencil; use other colors to distinguish between changes for different categories of Work at same location.
3. Mark important additional information which was either shown schematically or omitted from original Drawings.
4. Record modifications caused by Supplemental Instructions, Construction Change Directives, Change Orders, Alternates, and similar modifications.
5. Accurately record information using understandable technique.
6. Record data as soon as possible after it has been obtained. In case of concealed installations, record and check mark-up prior to concealment.
7. At time of Substantial Completion, submit Record Drawings to Architect for Owner’s records. Organize into sets, bind and label sets for Owner’s continued use.

1.9 PROJECT MANUALS

A. Legibly mark-up manuals to record actual construction, including:
1. Manufacturer, trade name, and model number of each product actually installed, including product options and approved substitutions.
2. Changes made by addenda.
3. Changes made by change order, field order, supplemental instructions, and other issued modifications.
4. Other matters not originally specified.
SECTION 02225

SELECTIVE DEMOLITION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Removal of designated building equipment, materials and fixtures.
   2. Removal of existing construction to accommodate new construction.
   3. Disconnecting and capping or removal of identified utilities.
   4. Installation of temporary partitions to allow continued building occupancy by Owner.

1.2 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Schedules:
   1. Schedule demolition and removal work to ensure uninterrupted progress of Owner's on-site operations.

C. Submit following Informational Submittals:
   1. Certifications specified in Quality Assurance article.
   2. Qualification Data: Submit demolition contractor's qualifications.

D. Closeout Submittals:
   1. Project Record Documents:
      a. Submit under provisions of Section 01780.
      b. Record actual locations of capped utilities.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with applicable codes, ordinances, rules, regulations, and laws of local, municipal, state and federal authorities having jurisdiction.
   2. Obtain and pay for necessary permits and notices; post where required.
   3. Comply with safety requirements of local fire department.

B. Notify affected utility companies before starting work and comply with their requirements.

C. Do not close or obstruct egress width of fire exits or access.

D. Do not disable or disrupt building fire or life safety systems without 72 hours prior written notice to Owner.
1.4 PROJECT CONDITIONS

A. Occupancy:
   1. Owner will vacate demolition area prior to start of demolition work.
   2. Owner will continuously occupy areas of building immediately adjacent to selective
      demolition areas.
   3. Conduct selective demolition work in manner that will minimize need for disruption of
      Owner's normal operations.
   4. Provide minimum of 72 hours advanced notice to Owner of demolition activities which
      will severely impact Owner's normal operations.
   5. Maintain free and safe passage to and from Owner occupied areas.

B. Existing Conditions:
   1. Owner assumes no responsibility for actual condition of areas to be demolished.

C. Hazardous Materials:
   1. Inform Architect and Owner immediately upon discovery of asbestos products,
      radioactive materials, radon gas, toxic wastes, or other similar hazardous materials.
   2. Strictly follow procedures and regulations applicable to hazardous materials.
   3. Do not remove hazardous materials without Owner authorization.
   4. Give special consideration to handling of material that may contain asbestos. Neither
      asbestos detection or removal is part of this Contract, and direction relating to that type
      of work will be given by the Owner.
   5. Architect will have no responsibility for detection, evaluation, or removal of asbestos
      materials, or for construction contract administration of removal process.

D. Explosives: Not permitted.

E. Traffic and Passageways:
   1. Maintain accessibility for fire fighting apparatus.
   2. Conduct demolition operations and debris removal to avoid interference with use of
      adjacent occupied facilities.
   3. Provide alternate routes when closing or obstructing traffic ways when required by
      governing authorities.
   4. Ensure safe passage of persons around area of demolition. Provide and maintain
      temporary covered passageways; comply with requirements of governing authorities.

F. Protection:
   1. Perform Work in manner to eliminate hazards to persons or property and avoid
      interference with adjacent areas, utilities and structures.
   2. Provide and maintain temporary barricades, fences, warning signs, guardrails, warning
      lights, weatherproof and dust partitions, and other similar provisions as necessary or
      required by applicable regulatory authorities for protection of building occupants and
      workers.
   3. Provide and maintain fire extinguishers; comply with requirements of governing
      authorities.
   4. Maintain existing utilities which are to remain in service and protect from damage during
      demolition operations.
5. Do not interrupt existing utilities serving occupied facilities, except when authorized by Owner in writing. Provide temporary services during interruptions to existing utilities.
6. Coordinate in advance with Owner mechanical, electrical, and plumbing shutdowns.
7. Protect existing work indicated to remain from damage.
8. Protect existing floors with suitable coverings when necessary.
9. Construct temporary dustproof partitions and seal return air plenums where necessary to areas where noisy or dirt and dust operations are being performed.
10. Provide temporary weather protection for areas where existing exterior elements were removed to ensure no water leakage or damage occurs to structure or interior areas of existing building.

1.5 SEQUENCING
A. Sequence work under the provisions of Section 01100 and in coordination with owner.

1.6 SCHEDULING
A. Schedule work to conform to the approved construction progress schedule specified in Section 01330.
B. Schedule work to coincide with new construction.
C. Describe demolition removal procedures and schedule.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine conditions and proceed with Work in accordance with Section 01700.
B. Verify demolition areas are unoccupied.

3.2 PREPARATION
A. Provide, erect, and maintain temporary barriers and security devices as directed by Owner.
B. Prevent movement or settlement of adjacent structures. Provide bracing and shoring as necessary and be responsible for safety and support of structure. Assume liability for such movement, settlement, damage, or injury.
C. Utilities:
   1. Mark and identify location of utilities to be disconnected.
   2. Notify affected utility company in advance of date and time when service needs to be disconnected.
   3. Disconnect and cap utility services; comply with requirements of governing authorities.
4. Do not commence demolition operations until associated disconnections have been completed.

3.3 SALVAGEABLE MATERIAL AND EQUIPMENT

A. Materials Retained by Contractor:
   1. Items of salvageable value not indicated as Owner salvaged or scheduled for reinstallaton may be removed as work progresses.
   2. Salvaged items must be removed from site as they are removed. Storage or sale of salvaged items on site will not be permitted.

3.4 DEMOLITION

A. General:
   1. Conduct demolition to minimize interference with adjacent occupied building areas.
   2. Cease demolition operations immediately if adjacent structures appear to be in danger. Conduct safety operations as necessary. Do not resume demolition operations until directed.
   3. Conduct operations with minimum interference to public or private accesses. Maintain egress and access at all times.
   4. Sprinkle debris with water to minimize dust. Provide hoses and water connections as necessary.
   5. Do not cause flooding or contaminated runoff.

B. Demolish existing construction as indicated in orderly and careful manner to accommodate new work. Protect supporting structural members. Remove demolished materials from site daily and legally dispose of such materials.

C. Perform demolition in accordance with governing authorities.

D. Remove and immediately dispose of contaminated or vermin infested materials when encountered.

E. Report to Architect and Owner unanticipated mechanical, electrical, or structural elements which conflict with intended function or design when encountered. Submit report in writing. Rearrange demolition schedule as necessary to continue overall project progress without delay.

F. Do not burn or bury materials or debris on site. Leave structures and site in clean condition.

3.5 ADJUSTING

A. Repair demolition performed in excess of that required.

B. Return structures and surfaces to remain to conditions existing prior to commencement of selective demolition Work.

3.6 CLEANING
A. Broom clean demolition areas of dust, dirt, and debris caused by demolition operations. Return adjacent areas to condition existing prior to start of work.

B. Remove temporary work and protection when no longer needed.

END OF SECTION
SECTION 02300

EARTHWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Preparing subgrade for equipment pads.
   2. Drainage fill course for support of building slabs.
   3. Backfilling of trenches within building lines.
   4. Excavating and backfilling required in conjunction with underground mechanical and electrical utilities, and buried mechanical and electrical appurtenances.
   5. Excavating for structure and stockpiling existing clean subsoil fill on site.
   6. Shoring and bracing excavations with temporary shoring, sheeting or retention system as required by code, law, or ordinance to protect excavation area, workers, nearby streets, and structures.
   7. Placing and compacting fills to rough grade elevations.
   8. Dewatering excavations.

1.2 SYSTEM DESCRIPTION

A. Design Requirements:
   1. Contractor is responsible for executing, designing, detailing, and documenting excavation retention system including accessories.
   2. Employ registered professional engineer to engineer each component of excavation retention system.

1.3 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Submit following Informational Submittals:
   1. Test Reports:
      a. If recent test results are available for fill materials to be used, submit to testing laboratory in lieu of samples.
      b. Test results are to clearly indicate types of materials and composition, hardness, compactibility and suitability for proposed usage.
   2. Laboratory Test Reports for Following:
      a. Test reports on borrow material.
      b. Verification of each footing subgrade.
      c. Field density reports.
      d. One optimum moisture-maximum density curve for each type soil encountered.
      e. Materials certificate stating materials acceptance for fill and backfill.
   3. Certifications: Submit certifications specified in Quality Assurance article.
C. Closeout Submittals:
   1. Project Record Documents: Submit under provisions of Section 01780.

1.4 QUALITY ASSURANCE

A. Testing and Inspection Service: Employ, at Contractor's expense, testing laboratory to perform soil testing and inspection service for quality control testing during earthwork operations.

B. Regulatory Requirements: Perform excavation work in compliance with applicable requirements of governing authorities having jurisdiction.

1.5 PRE-CONSTRUCTION CONFERENCE

A. Conduct pre-construction conference in accordance with Section 01310.

B. Schedule meeting between Owner, Testing Laboratory, Architect, and Contractor to discuss potential problems that may be encountered during earthwork. Submit earthwork plan for review and resolve differences of opinion before beginning earthwork.

C. Schedule meeting at Project site immediately prior to start of earthwork to discuss Specifications, authority of geotechnical and testing agency, and agree upon testing procedures and frequency.

1.6 PROJECT CONDITIONS

A. Existing Utilities:
   1. Locate existing underground utilities in earthwork areas.
   2. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations.
   3. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult Owner immediately for directions.
   4. Cooperate with Owner and utility companies in keeping respective services and facilities in operation.
   5. Repair damaged utilities to satisfaction of utility owner.
   6. Do not interrupt existing utilities serving facilities occupied and used by Owner or others, during occupied hours, except when permitted in writing by Owner and then only after acceptable temporary utility services have been provided.
   7. Provide minimum of 72-hour notice to Owner and receive written notice to proceed before interrupting utility service.
   8. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shut-off of services if lines are active.

B. Use of Explosives: Use of explosives is not permitted.

C. Protection:
   1. Protect bench marks, utilities, existing structures, roads, sidewalks, paving, and curbs against damage from equipment and vehicular traffic or foot traffic.
2. Protect excavations by shoring, bracing, sheet piling, underpinning or other methods as necessary to prevent cave-ins or loose dirt from falling into excavations. Monitor shoring system and surrounding ground surface during construction to detect movement. If movement occurs, take contingency steps to brace excavation and adjacent utility lines.
3. Notify Architect of unexpected subsurface conditions and discontinue work in area until Architect provides notification to resume work.
4. Protect bottom of excavations and soil around and beneath foundations from frost.
5. Grade around excavation to prevent surface water runoff into excavated area.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide per Structural notes on Architecture and Structural drawings.

B. Select Fill: Satisfactory borrow material free from clay, roots, rocks, or gravel larger than 2 inch size, debris, waste, frozen material, vegetable and other deleterious matter with Plasticity Index between 4 and 12 and liquid limit of 30 or less.

C. Topsoil:
1. Approved excavated material from Section 02200.
2. Imported natural, fertile, friable soil possessing characteristics representative of productive growing soils in Project area.
3. Topsoil will be rejected if excessively acid or alkaline, or contains toxic substances harmful to plant growth.
4. Provide topsoil free from weeds, nutgrass, lumps, stones, roots or similar substances.

D. Excavated Subsoil Fill: Satisfactory excavated material, approved by testing laboratory for reuse, free from frozen material, waste, clay, rock, debris, organic matter, or gravel larger than 2 inches in any dimension.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions and proceed with work in accordance with Section 01700.

B. Establish extent of excavation by area and elevation; designate and identify datum elevation.

C. Set required lines and levels.

D. Maintain bench marks, monuments and other reference points.

E. Verify fill materials are acceptable.

F. Verify foundation perimeter drainage installation has been inspected and tested.
3.2 PREPARATION

A. Existing Utilities:
1. Before starting excavation, establish location and extent of underground utilities occurring in work area.
2. Notify utility companies to remove and relocate lines which are in way of excavation.
3. Maintain, reroute or extend as required, existing utility lines to remain which pass through work area.
4. Protect utility services uncovered by excavation.
5. Remove abandoned utility service lines from areas of excavation; cap, plug or seal such lines and identify at grade.
6. Accurately locate and record abandoned and active utility lines rerouted or extended on Project Record Documents.

B. Protect bench marks, existing structures, sidewalks, paving, and curbs from excavation equipment and vehicular traffic.

3.3 EXCAVATION

A. General:
1. Inform testing laboratory of excavation, proofrolling and filling operations before starting.
2. Testing laboratory may require deeper excavation than specified to remove unsuitable soil material either observed on site or encountered by proofrolling operations.
3. Excavate subsoil in accordance with lines and levels required for construction of Work, including space for form construction, bracing and shoring, waterproofing application, and inspection.
4. Machine slope banks to angle of repose or less. Hand trim excavations and leave free from loose or organic matter.
5. Excavations are not to interfere with normal 45 degree bearing splay of foundations.
6. Stockpile excavated clean fill for reuse where directed. Remove excess or unsuitable excavated fill from site.

B. Excavation Classifications: Following classifications of excavation will be made when rock excavation is encountered in Work:
1. Earth excavation includes excavation of pavements and other obstructions visible on ground surface; underground structures, utilities and other items indicated to be demolished and removed; together with earth and other materials encountered that are not classified as rock or unauthorized excavation.
2. Rock excavation in trenches and pits includes removal and disposal of materials and obstructions encountered which cannot be excavated with a 1.0 cubic yard (heaped) capacity, 42 inch wide bucket on track-mounted power excavator similar to Caterpillar Model 215, rated at not less than 90 HP flywheel power and 30,000 pound pull. Trenches in excess of 10'-0" in width and pits in excess of 30'-0" in either length or width are classified as open excavation.
3. Rock excavation in open excavations includes removal and disposal of materials and obstructions encountered which cannot be dislodged and excavated with modern track-mounted heavy-duty excavating equipment without drilling, blasting or ripping.
Rock excavation equipment is defined as Caterpillar Model No. 973 or No. 977K, or similar track-mounted loader, rated at not less than 170 HP flywheel power and developing 40,000 pound break-out force.

4. Typical materials classified as rock are boulders 1/2 cubic yard or more in volume, solid rock, rock in ledges, and rock-hard cementitious aggregate deposits.

5. Intermittent drilling, or ripping performed to increase production and not necessary to permit excavation of material encountered will be classified as earth excavation.

C. Unauthorized Excavation:
   1. Consists of material removal beyond indicated subgrade elevations or dimensions without specific direction of Architect or Owner.
   2. Correct unauthorized excavation, as well as remedial work directed by Architect, at no additional cost to Owner.
   3. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom without altering required top elevation.
   4. Lean concrete fill may be used to bring elevations to proper position, when acceptable to Architect.
   5. Backfill and compact other unauthorized excavations as specified for authorized excavations of same classification, unless otherwise directed by Architect.

D. Additional Excavation:
   1. When excavation has reached required subgrade elevations, notify soils testing laboratory for examination of conditions.
   2. If unsuitable bearing materials are encountered at required subgrade elevations, excavate deeper and replace excavated material as directed by soils testing laboratory.
   3. Removal of unsuitable material and its replacement as directed will be paid on basis of Contract conditions relative to changes in Work.
   4. Disturbed material below slabs on-grade will require over-excavation and replacement at no additional cost to Owner.
   5. Correct unauthorized excavation as directed.
   6. Do additional excavation only by written authorization of Architect.

E. Underpin adjacent structures which may be damaged by excavation work, including utilities and pipe chases.

F. Dewatering:
   1. Prevent surface water and subsurface or ground water from flowing into excavations and from flooding Project site and surrounding area.
   2. Do not allow water to accumulate in excavations.
   3. If presence of subsurface water is encountered during excavation, provide interior drainage.
   4. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations.
   5. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.
6. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or run-off areas.

7. Do not use trench excavations as temporary drainage ditches.

G. Material Storage:
1. Stockpile satisfactory excavated materials where indicated, until required for backfill or fill.
2. Place, grade and shape stockpiles for proper drainage.
3. Locate and retain soil materials away from edge of excavations.
4. Do not store within drip line of trees indicated to remain.
5. Legally dispose of excess soil material and waste materials.

H. Excavation for Pavements: Cut surface under pavements to comply with cross-sections, elevations and grades as indicated.

3.4 BACKFILL AND FILL

A. Proofrolling:
1. Proofroll exposed subgrade in building and paving areas with heavily loaded dump truck or similar acceptable construction equipment, to detect unsuitable soil conditions.
2. Commence proofrolling operations after a suitable period of dry weather to avoid degrading acceptable subgrade surfaces.
3. Make 4 passes over each section with proofrolling equipment, with last 2 perpendicular to first 2.

B. Stockpile fill materials in area designated by Owner.

C. Do not start backfilling operations until building drainage system and waterproofing have been reviewed.

D. Ensure areas to be backfilled are free from debris, snow, ice, and water and that ground surfaces are not in frozen condition.

E. Do not backfill over existing subgrade surfaces which are porous, frozen, wet, or spongy.

F. General:
1. Place acceptable fill material in layers to required subgrade elevations for each area classification listed below.
2. In excavations, use satisfactory excavated or borrow material.
3. Under grassed areas, use satisfactory excavated or borrow materials.
4. Under walks and pavements, use subbase material, or satisfactory excavated or borrow material, or combination of both.
5. Under steps, use subbase material.
6. Under building slabs, use subbase material.
7. Under piping and conduit, use subbase material where subbase is indicated under piping or conduit; shape to fit bottom 90 degrees of cylinder.
G. Ground Preparation:
1. Scarify and recompact top 6 inches of existing subgrade surfaces between 92 percent and 97 percent of Standard Proctor Density (ASTM D698) at optimum to maximum plus 4 percent optimum moisture content if densities are not equal to that required for backfill materials.
2. Cut out soft areas of existing subgrade.
3. Backfill with select fill and compact to required density.

H. Placement and Compaction:
1. Backfill areas to grades, contours, levels and elevations indicated.
2. Backfill systematically and as early as possible to allow maximum time for natural settlement and compaction.
3. Place unfrozen backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
4. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content.
5. Maintain optimum moisture content of backfill materials to attain required compaction density.
6. Compact each layer to required percentage of density for each area classification.
7. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
8. Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations.
9. Take care to prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.
10. Place and compact fill materials using method so as not to disturb or damage building drainage system and foundation waterproofing.
11. Backfill simultaneously on each side of unsupported foundation walls to equalize soil pressures.
12. Where temporary unbalanced pressures are liable to develop on walls before floor slabs are placed, erect necessary shoring to counteract imbalance. Leave in place until removal is acceptable to Architect.

I. Interior Floor Slab-on-Grade:
1. Fill material: Nonexpansive select fill solids compacted to at least 95 percent standard proctor density at optimum moisture content.
2. Subbase: Provide 4 inch minimum layer of subbase material beneath floor slabs to help distribute loads and to ease slab construction.
3. [If natural coarse, granular soils or fill occur at grades above water table, subbase may be omitted.]
4. Install vapor barrier in accordance with Section 03300.

J. Building Slab Drainage Course:
1. Drainage course consists of placement of drainage fill material, in layers of indicated thickness, over subgrade surface to support concrete building slabs.
2. Place drainage fill material on prepared subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness. 
3. Maintain optimum moisture content for compacting material during placement operations. 
4. When compacted drainage course is shown to be 6 inches thick or less, place material in a single layer. 
5. When shown to be more than 6 inches thick, place material in equal layers, except no single layer more than 6 inches or less than 3 inches in thickness when compacted. 

K. Walkways: 
1. Compact top 6 inches of subgrade and each layer of fill at 95 percent Proctor. 
2. Provide sand cushion under walks. 

3.5 GRADING 

A. Uniformly grade areas within limits of grading including adjacent transition areas. 
B. Smooth finished surface areas and compact with uniform levels or slopes. 
C. Grade areas adjacent to building to drain away from structure, walks, and paving and to prevent ponding. 
D. Slope grade away from building minimum 2 inches in 10'-0" unless noted otherwise. 
E. Make grade changes gradual. Blend slope into level areas. 
F. Finish Grading: 
1. Fine grade areas to achieve final contours indicated. Leave areas to receive topsoil 6 inches below final desired grade. 
2. Adjust contours to achieve positive drainage away from building. Provide uniform rounding at top and bottom of slopes and other breaks in grade. Correct irregularities and areas where water will stand. 

G. Remove surplus backfill materials from site. 
H. Leave fill material stockpile areas completely free of excess fill materials. 

3.6 ADJUSTING 

A. Protect newly graded areas from traffic and erosion. Keep free of trash and debris. 
B. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances. 
C. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, re-shape, and compact to required density prior to further construction.
D. Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn or other finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.7 CLEANING

A. Remove surplus backfill materials from site. Legally dispose of excavated materials off construction site.

B. Leave stockpile areas completely free of excess fill materials.

C. Clean debris caused by excavation and backfill work. Keep premises and adjacent streets clean and neat.

END OF SECTION
SECTION 03120

ARCHITECTURAL CAST-IN-PLACE CONCRETE FORMS

PART 1 – GENERAL

1.1 SUMMARY

A. Related Sections:
   1. Section 03200 - Concrete Reinforcement.
   2. Section 03330 - Cast-In-Place Concrete.

1.2 DEFINITIONS

A. Architectural Concrete: Concrete with a special finish which will be permanently exposed to view and which may require special concrete materials, forming, placing, or finishing to obtain desired architectural appearance.

1.3 SYSTEM REQUIREMENTS

A. Design Requirements:
   1. Design, engineering, construction and removal of formwork is solely Contractor's responsibility.
   2. Employ registered professional engineer, licensed to practice structural engineering in jurisdiction where Project is located, to engineer each component of formwork system.
   3. Establish necessary concrete strength criteria for removal of formwork and reshoring of structure.
   4. Design formwork for construction loads; minimum of 50 psf unless higher load required by placing equipment or local codes.
   5. Design shoring and reshoring procedures and methods so not to create loadings which exceed design service load capacity of or which produce loading patterns not consistent with structural members. Limit deflections of members to those which would occur under design loads at 28 day design strength.

B. Structural Requirements: Maximum allowable deflection of form facing material between supports: 1/400 x span for architectural concrete.

C. Interface With Other Systems: Coordinate sleeve, insert, and anchor installation with requirements of other trades.

1.4 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Product Data: Submit product data and installation instructions for manufactured form systems, form liners, release agents, ties, and accessories.
C. Submit following Informational Submittals:
   1. Qualification Data: Submit formwork designer’s and manufacturer’s qualification data.
   2. Manufacturer's instructions for proprietary products.

1.5 QUALITY ASSURANCE

A. Formwork Manufacturer Qualifications: Forms shall be manufactured by a manufacturer with a minimum of 5 years experience in manufacturing architectural concrete forms for projects of similar size and scope.

B. Regulatory Requirements: Conform to governing codes regarding safety provisions.

C. Allowable Tolerances: Construct formwork to provide completed cast-in-place concrete surfaces complying with the following tolerances.
   1. Vertical Alignment:
      a. For heights 100 feet or less: Lines, surfaces, and arrises - 1 inch.
      b. For heights greater than 100 feet:
         1) Lines, surfaces, and arrises - 1/1000 times height but not more than 6 inches.
         2) Outside corner of exposed corner columns and control joint grooves in concrete - 1/2000 times height but not more than 3 inches.
   c. Lateral Alignment:
      1) Members - 1 inch.
      2) In slabs, centerline location of openings 12 inches or smaller and edge location of larger openings - 1/2 inch
      3) Saw cuts, joints, and weakened plane embedments in slabs - 3/4 inch

1.6 DELIVERY, STORAGE, AND HANDLING

A. Comply with requirements of Section 01600.

B. Store form materials and accessories off ground in ventilated and protected area to prevent damage and deterioration from moisture.

PART 2 – PRODUCTS

2.1 FORM MATERIALS

A. General:
   1. Plywood, metal, fiberglass, wood, hardboard, or other material providing continuous surfaces, non-reactive with form release agent or water.
   2. Furnish in largest practicable sizes to minimize number of joints.
   3. Provide form material with sufficient thickness to support weight of concrete without deflection exceeding specified tolerances and without affecting appearance of finished surfaces.
B. Smooth Surface Panel-Type Forms:
   1. Plywood: Comply with PS-1, high density overlay.
   2. Fiberglass Reinforced Plastic: Smooth surfaces free from dents, sags, cracks, exposed fibers, or other irregularities.
   3. Metal: Smooth surfaces free from dents, sags, rust, or other irregularities, 16 gage minimum thickness.

C. Pan Form Units:
   1. Fabricate of metal or molded fiberglass of required cross sections, free from dents, sags, rust or other irregularities.
   2. 16 gage minimum thickness for metal; 0.11 inch thickness for fiberglass.

2.2 FORMWORK ACCESSORIES

A. Snap-off Form Ties:
   1. Galvanized steel ties of fixed length; tight fitting to prevent leakage and designed to prevent form deflection and to prevent spalling concrete surfaces upon removal. Provide ties with waterstop washers centered on tie length at below grade concrete.
   2. Provide ties designed to break off inside concrete as follows:
      b. Exposed to Salt Water or Corrosive Environment: 2 inches.
      c. Other Exposures: 1 inch.
   3. Provide tie cones which will not leave holes larger than 1 inch diameter in concrete surfaces.

B. Removable Tapered Form Ties: Tapered, threaded end metal ties of adjustable length, designed for complete removal from concrete after setting.

C. Threaded, Disconnecting-Type Form Ties: Sectional metal ties of adjustable length, consisting of permanent inner rods with threaded ends and removable, tapered outer rods.

D. Form Release Agent:
   1. Colorless, non-staining, liquid chemical free of kerosene, oil, wax, and resin, of type which will not bond with or adversely affect concrete surfaces and which will be compatible with subsequent treatments of concrete surfaces.
   2. Acceptable Products:
      a. Nox-Crete Form Coating, Nox-Crete Chemicals, Omaha, NE.
      b. Debond, L and M Construction Chemicals, Inc., Omaha, NE.
      c. Duogard Form Release Agent, W. R. Meadows, Inc., Elgin, IL.
      d. Cast-Off, Sonneborn Building Products, Shakopee, MN.
   3. Provide certification that release agent complies with local regulations controlling use of volatile organic compounds (VOC).

E. Inserts: Provide metal inserts for anchorage of materials or equipment to concrete construction not supplied by other trades.
2.3 FORMWORK DESIGN

A. General: Design, brace, and maintain formwork to safely support vertical and lateral loads until loads can be supported by concrete structure.

B. Design forms and falsework to include values of live load, dead load, weight of moving equipment operated on formwork lateral loads, and other factors pertinent to safety of structure during construction.

C. Design formwork for easy removal without impact, shock, or damage to concrete and adjacent materials.

D. Fabricate formwork to prevent cement paste from leaking while placing concrete. Solidly butt joints and provide backup material at joint to prevent leakage and fins.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine conditions and proceed with Work in accordance with Section 01700.

3.2 PREPARATION

A. Form Coatings:
   1. Coat form contact surfaces with form-release agent in accordance with manufacturer’s instructions before placing reinforcement.
   2. Do not allow excess material to accumulate in forms or to come into contact with reinforcement or surfaces that will be bonded to fresh concrete.
   3. Thin form-coating compounds only with thinning agent of type, and in amount, and under conditions of form coating manufacturer's directions.
   4. Apply coating according to manufacturer's instructions.
   5. Coat steel forms with nonstaining, rust-preventative release agent, or otherwise protect from rusting. Rust-stained steel formwork is not acceptable.

B. Before placing concrete check lines and levels of erected formwork. Make corrections and adjustments to ensure proper size and location of concrete members and stability of the forming systems.

C. During concrete placement check formwork and related supports to ensure forms are not displaced and that completed work will be within specified tolerances.

3.3 FORM CONSTRUCTION

A. General:
   1. Construct forms to sizes, shapes, lines, and dimensions shown, and as required to obtain accurate alignment, location, level, and plumb work in finished structures.
2. Provide for openings, offsets, keyways, recesses, chamfers, blocking, screeds, bulkheads, and other as required.
3. Fabricate forms for easy removal without hammering or prying against exposed concrete surfaces.
4. Provide crush plates where stripping might damage cast concrete surfaces.
5. Provide top forms for inclined surfaces where slope is too steep to place concrete.
6. Provide temporary openings where inaccessible formwork interior can be cleaned and inspected before placing concrete.
7. Place temporary form openings as inconspicuously as possible, consistent with project requirements.

B. Falsework: Erect falsework. Support, brace, and maintain to safely sustain vertical, lateral, and asymmetrical loads applied until such loads can be supported by in-place concrete structures.

C. Forms for Exposed Concrete:
   1. Drill forms from contact face to outside to suit ties used and to prevent leakage of concrete mortar around tie holes.
   2. Do not splinter forms by driving ties through improperly prepared holes.
   3. Use removable tapered ties.

D. Provide sharp, clean corners at intersecting planes with no visible edges or offsets.

E. Assemble forms so that they may be easily removed without damaging exposed concrete surfaces.

F. Corner Treatment: Form exposed corners of beams and columns to produce square, smooth, solid, unbroken lines, except as otherwise indicated.

G. Form chamfered corners with 3/4 by 3/4 inch strips, accurately formed and surfaced to produce uniformly straight lines and tight edge joints.

H. Unexposed corners may be formed either square or chamfered.

I. Control Joints: See Cast-In-Place Concrete Section for treatment of control and construction joints, including wood screens, metal keyways, and sawcuts.

J. Provisions for Other Trades: Provide openings in concrete formwork. Size and location of openings, recesses, and chases are the responsibility of the trade requiring such openings. Accurately place and securely support items to be built into forms.

3.4 INSTALLING EMBEDDED ITEMS

A. General: Set and build into formwork those anchorage devices and other embedded items required for other work that is attached to, or supported by, cast-in-place concrete.
B. Use setting templates or drawings, diagrams, instructions, and directions provided by suppliers of items to be attached.

C. Confirm that locations do not interfere with casting space.

3.5 REMOVING FORMS

A. General:
   1. Remove formwork only after length of time which represents cumulative number of hours or days during which temperature of air surrounding concrete is above 50 degrees F.
   2. Do not remove forms until concrete has sufficiently hardened to avoid being damaged.

B. Formwork Removal:
   1. Walls, sides of beams, and columns: 24 hours
   2. Beam soffits, joists, slabs, and other structural elements, may not be removed until the concrete has attained the design minimum 28-day compressive strength.

C. Form-facing material may be removed 4 days after placement if shores and other vertical supports have been arranged to permit removal without disturbing shores and supports.

3.6 REUSING FORMS

A. Forms may be cleaned, repaired, re-coated and re-used if they will provide acceptable exposed surfaces.

B. Store reusable forms in manner to prevent damage to contact surfaces.

END OF SECTION
SECTION 03300
CAST-IN-PLACE CONCRETE

PART 1 – GENERAL

1.1 DEFINITIONS

A. Severe Exposure: Concrete which is in contact with moisture or deicing salts, such as pavements, sidewalks.

1.2 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Shop Drawings: Submit drawings locating slab-on-grade construction joints, control joints, and isolation joints.

C. Product Data: Submit product data for proprietary products.

D. Design Mixes: Submit proposed concrete mix designs for each class or use.

E. Submit following Informational Submittals:
   1. Test Reports: Submit aggregate and concrete mix test reports from independent testing laboratory as required by Source Quality Control Article in PART 2.
   2. Certifications specified in Quality Assurance article.
   3. Manufacturer's instructions.

1.3 QUALITY ASSURANCE

A. Certifications:
   1. Submit material certification for admixtures and aggregates, certifying their compliance with specifications.
   2. Submit certified mill test reports for each lot of cement.

1.4 PRE-INSTALLATION CONFERENCE

A. Conduct pre-installation conference in accordance with Section 01310 or as directed by owner.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General: Comply with requirements of Section 01600.

B. Deliver packaged products to site in manufacturer's sealed and labeled containers; inspect to verify compliance with specified requirements.
C. Label containers to indicate manufacturer's name, product name, date of manufacture, and instructions for use.

D. Store liquid materials in tightly covered containers in well ventilated area at ambient temperatures recommended by manufacturer. Store dry materials on raised platforms and cover to prevent moisture damage. Maintain containers in clean condition, free of foreign materials and residue with labels in legible condition.

E. Take precautionary measures to prevent fire hazards and spontaneous combustion.

1.6 SCHEDULING

A. Refer to Section 03100 for requirements pertaining to schedule of pouring and stripping.

PART 2 – PRODUCTS

2.1 CONCRETE MATERIALS

A. Portland Cement:
   1. ASTM C150, Type I.
   2. Air-entraining portland cement, as defined by ASTM C150, is prohibited.

B. Aggregate:
   1. Coarse Aggregate:
      a. ASTM C33 for normal weight aggregate.

C. Water: Clean, fresh and potable.

D. Admixtures:
   1. Calcium chloride, thiocyanates, or admixtures containing more than 0.05 percent chloride ions are not permitted unless approved by Architect.
   3. Water-reducing: ASTM C494, Type A.
   4. High Range Water-reducing (Superplasticizer): ASTM C494, Type F or Type G.
   5. Water-reducing, Non-corrosive, Non-chloride Accelerator:
      a. ASTM C494, Type E.
      b. Submit long term non-corrosive test data from independent testing laboratory using accelerated test method such as electrical potential measure.
   6. Water-reducing, Retarding: ASTM C494, Type D.

E. Bonding Admixture:
   1. Acrylic or styrene butadiene, non re-emulsifiable.
   2. Acceptable Products:
      a. Flex-Con or SBR Latex, Euclid Chemical Company, Cleveland, OH.
      b. Everbond, L&M Construction Chemicals, Inc., Omaha, NE.
      c. Acryl Set, Master Builders, Cleveland, OH.
      d. Intralok, W. R. Meadows, Inc., Elgin IL.
e. Sika Latex, Sika Corporation., Lyndhurst, NJ.

F. Bonding Grout:
1. Mix consisting of portland cement, part fine sand passing No. 30 mesh sieve, bonding admixture, and water in proportions as recommended by bonding admixture manufacturer.
2. Minimum 1:1 cement to sand ratio.
3. Mix to achieve consistency of thick cream.

2.2 CURING MATERIALS

A. Sheet Curing Materials: ASTM C171; white opaque polyethylene film, white polyethylene coated burlap sheeting, or regular waterproof paper.

B. Dissipating Resin Curing Compounds:
1. ASTM C309, Type 1 clear or translucent, Class B, free of natural or petroleum waxes. Class A not acceptable.
2. Liquid, membrane forming, 100 percent resin based allowing maximum moisture loss in 72 hours of 0.11 lb/sq. ft.
3. Compatible with subsequent coatings and toppings.

C. Acrylic Curing/Sealing Compounds:
1. ASTM C1315, Type I clear or translucent, Class A, free of natural or petroleum waxes.
2. Liquid, membrane forming, minimum 30 percent acrylic resin solids, allowing maximum moisture loss in 72 hours of 0.08 lb/sq. ft.
3. Compatible with subsequent coatings and toppings.
4. Acceptable Products:
   a. Super Rez-Seal (31 percent)
   b. Euclid Chemical Company, Cleveland, OH.
   c. Dress & Seal 30, L&M Construction Chemicals, Inc., Omaha, NE.
   d. Tiah (30 percent), W. R. Meadows, Inc., Elgin, IL.
   e. ABCO Cure & Seal 830 (30 percent), Nox-Crete Chemicals, Omaha, NE.
   f. Cure & Seal 31 percent, Symons Corporation, Des Plaines, IL.

D. Water Based Acrylic Curing/Sealing Compounds:
1. ASTM C1315, Type I, Class A, VOC compliant, free of natural or petroleum waxes. Dries clear with high gloss sheen.
2. Liquid, membrane forming, minimum 30 percent acrylic resin solids, allowing maximum moisture loss in 72 hours of 0.08 lb/sq. ft.
3. Compatible with subsequent coatings and toppings.
4. Acceptable Products:
   a. Super Diamond Clear VOX, Euclid Chemical Company, Cleveland, OH.
   b. Dress & Seal WB 30, L&M Construction Chemicals, Inc., Omaha, NE.
   c. VOCOMP 30, W. R. Meadows, Inc., Elgin, IL.

E. Vapor Barriers:
1. Vapor barrier shall have all of the following qualities
a. Maintain permeance of less than 0.01 Perms \([\text{grains}/(\text{ft}^2 \cdot \text{hr} \cdot \text{inHg})]\) as tested in accordance with mandatory conditioning tests per ASTM E1745 Section 7.1 (7.1.1-7.1.5)

1. Other performance criteria:
   a. Strength: ASTM E1745 Class A.
   b. Thickness: 15 mils minimum
2.2 PATCHING AND REPAIR MATERIALS

A. Epoxy Adhesive:
   1. 100 percent solids, two component material suitable for use on dry or damp surfaces, conforming to ASTM C881.
   2. Acceptable Products and Manufacturers:
      a. Concresive Liquid LPL, Master Builders, Inc., Cleveland, OH.
      b. Sikadur Hi-Mod 32, Sika Corporation, Lyndhurst, NJ.
      c. Euco 452 or 620 System, Euclid Chemical Company, Cleveland, OH.]

B. Patching Compound:
   1. Polymer modified cementitious mortar.
   2. Acceptable Products and Manufacturers:
      a. Thin Coat, Concrete Coat, or Verticoat, Euclid Chemical Company, Cleveland, OH.
      b. Duratop, L&M Construction Chemicals, Inc., Omaha, NE.
      c. Sikatop 111, 121, 122, 123, or 126 Sika Corporation, Lyndhurst, NJ.

C. Patching Mortar:
   1. Comprised of same materials and approximately same proportions as used for surrounding concrete, except with coarse aggregate omitted.
   2. Consisting of not more than 1 part cement to 2-1/2 parts sand.
   3. Substitute white portland cement for portion of gray portland cement to match color of surrounding exposed concrete.
   4. Limit mixing water to no more than necessary for handling and placing. Maximum water/cement ratio of 0.50.

D. Bonding Agent:
   1. Acrylic, ASTM C1059, Type II, Non redispersable.
   2. Acceptable Products and Manufacturers:
      a. Everbond, L&M Construction Chemicals, Inc., Omaha, NE.
      b. Daraweld-C, Grace Construction Products, Cambridge, MA.
      c. Intralok, W. R. Meadows, Inc., Elgin IL.
      d. Sikadur Hi-Mod 32, Sika Corporation, Lyndhurst, NJ.

E. Evaporation Retardants:
   1. Eucofilm, Euclid Chemical Co., Cleveland, OH.
   2. E-Con, L&M Construction Chemicals, Inc., Omaha, NE.
   3. Confilm, Master Builders, Inc., Cleveland, OH.
   4. Sika Film, Sika Corporation, Lyndhurst, NJ.

2.3 CONCRETE MIXES

A. Mix Design:
   1. Submit design mixes for each type and class of concrete based on laboratory trial batch method or field experience methods described in ACI-318, Chapter 5.
2. If trial batch method is used, employ an independent testing agency acceptable to Architect for preparing and reporting proposed mix designs. Contractor employed testing agency shall not be same firm as Owner employed testing agency.
3. Use concrete of approved mix designs only.
4. Do not place concrete until design mix for that class and type of concrete is approved by Architect.
5. Indicate locations in structure where each mix design is to be used.
6. Identify each mix design with code number which will be used on batch tickets.

B. Design Compressive Strengths: As indicated on Structural Drawings.

C. Maximum Size of Coarse Aggregate:
   1. 1/5 narrowest dimension between form sides.
   2. 1/3 depth of slabs.
   3. 3/4 of minimum clear distance between reinforcing bars, wires, bundles of bars.
   4. 1 inch maximum for normal weight concrete.

D. Concrete Slump at Point of Discharge:
   1. Per structural drawings

E. Cement Factor: Not less than 470 pounds of cement per cubic yard of concrete.

F. Admixtures:
   1. Only use admixtures which have been tested and approved in mix designs.
   2. Water-reducing Admixture: Use in all concrete.

2.4 MIXING

A. Ready-Mix Concrete:
   1. Comply with ASTM C94.
   2. Before using trucks for batching, mixing, and transporting concrete, thoroughly clean trucks and equipment of materials capable of contaminating concrete.
   3. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C94 is required.
   4. When air temperature is between 85 degrees F and 90 degrees F, reduce mixing and delivery time from 90 minutes to 75 minutes, and when air temperature is above 90 degrees F, reduce mixing and delivery time to 60 minutes.
   5. Do not add water to ready-mix concrete at Project site except when slump is below specified limits and total water does not exceed the design water-cement ratio; inject added water into mixer and mix thoroughly before discharging.

B. Provide certificate signed by authorized official of supplier with each load of concrete stating following:
   1. Time truck left plant.
   2. Mix of concrete, identify with code number of mix design.
   3. Amount of water and cement in mix.
   4. Amount and type of admixtures.
   5. Amount of water added at Project site.
   6. Time truck is unloaded at Project site.
C. Truck mixers without batch tickets will be rejected.

D. Retain certificates at Project site. Submit to Architect for review upon request.

2.5 SOURCE QUALITY CONTROL

A. Testing will be performed under the provisions of Section 01450, except as otherwise specified.

B. Independent Testing Laboratory, approved by Architect and employed by Contractor, is responsible for:
   1. Testing aggregate as follows at start of work and whenever change in aggregate source occurs:
      d. Effect of organic impurities on strength: ASTM C87 for effect of organic impurities on strength.
   2. Testing concrete mixes as follows at start of work and whenever change in materials source occurs:
      a. Prepare mix designs, test concrete strength, and report results if trial batch method is used to establish design mix proportions.

C. Independent Testing Laboratory, employed by Owner, is responsible for observing and evaluating the following at batch plant at start of Work and at other times as requested by the Architect:
   1. Condition of batching equipment.
   2. Conformance with design mix proportions.
   4. Mixing equipment.
   5. Mixing and transporting equipment.
   6. Other testing to verify compliance if requested by Architect.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine conditions and proceed with Work in accordance with Section 01700.

B. Verify forms, reinforcement, anchors, plates, joint materials, vapor retarder and other items to be cast into concrete are accurately placed and held securely.

C. Verify forms are free of debris and water.
D. Verify excavations are free of loose material and water.

3.2 PLACEMENT

A. Place concrete according to ACI 301 and 304R, except as modified and supplemented on Drawings or in this Section.

B. Notify Architect and Owner's testing laboratory minimum of 48 [24] hours prior to commencement of placing operations.

C. Vapor Barrier:
   1. Install vapor barrier in accordance ASTM E1643
   2. Unroll vapor barrier with the longest dimension parallel with the direction of the concrete placement and face laps away from the expected direction of the placement whenever possible.
   3. Extend vapor barrier over footings and grade beams to a distance acceptable to the structural engineer or stop at impediments such as dowels and waterstops.
   4. Seal vapor barrier to foundation wall, grade beam, or slab at an elevation consistent with the top of the slab or terminate at impediments such as waterstops or dowels.
   5. Overlap joints 6 inches and seal with manufacturer’s tape
   6. Apply tape to a clean and dry vapor barrier
   7. Seal all penetrations (including pipes) per manufacturer’s instructions
   8. No penetration of the vapor barrier is allowed except for reinforcing steel and permanent utilities
   9. Repair damaged areas by cutting patches of vapor barrier, overlapping damaged area 6 inches and taping all sides with tape

D. Cold Weather Concreting:
   1. Comply with requirements of ACI 306.1.
   2. Do not place concrete when ambient air temperature is expected to fall below 40 degrees F within 24 hours, except with prior written approval of Architect.
   3. Remove frost, ice, and snow from formwork, reinforcing, and accessories prior to placing concrete.
   4. Do not place concrete foundations, footings or slabs on frozen ground.
   5. Limit concrete temperature at time of discharge to 55 degrees F for sections less than 12 inches in any dimension and to 50 degrees F for other sections.

E. Hot Weather Concreting:
   1. Comply with requirements of ACI 305R when ambient air temperature exceeds 75 degrees F.
   2. Use water-reducing, retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions to extend setting time to limits specified as approved by Architect.
   3. Cool aggregates, cool mixing water, substitute ice for part of mixing water, or take other measures to limit concrete temperature at time of discharge to 90 degrees F.
   4. Cover reinforcing steel and steel forms with water soaked burlap or use fog spray to limit temperature of steel to 120 degrees F immediately prior to concrete placement.
   5. Use evaporation retardant between finishing passes.
F. At time of placement, provide concrete temperature between 50 degrees F and 90 degrees F.

G. Maintain surfaces receiving concrete at approximately same temperature as concrete being placed.

H. Maintain surface of hardened concrete below 100 degrees F.

I. Convey concrete from mixer to place of deposit by method that will prevent segregation or loss of material, and that will not require addition of water to produce desired slump at point of placement. Do not use supported reinforcing as runway base for concrete conveying equipment.

J. Depositing:
   1. Deposit concrete as nearly as practicable to its final location.
   2. Place concrete continuously between construction joints.
   3. Deposit concrete in layers not exceeding 24 inches in depth.
   4. Avoid inclined layers.
   5. Place each layer while preceding layer is still plastic.
   6. Do not allow free fall of concrete to exceed 4 feet. Do not allow free fall of concrete containing high-range water reducing admixture to exceed 10 feet.
   7. Drop concrete in vertical direction, not at incline.
   8. Place beams, girders, haunches, brackets, column capitals, and drop panels monolithic with slab system unless otherwise indicated.
   9. Do not cast beams, girders, and slabs supported on columns and walls until concrete in supporting element is no longer plastic, minimum of 2 hours.
  10. If forms and reinforcing above level of concrete already in place become coated with accumulations of hardened or partially hardened concrete, remove accumulations before proceeding.
  11. Place concrete without displacing reinforcing and accessories.

K. Consolidation:
   1. Vibrate concrete to eliminate formation of surface air voids, honeycombs and sand streaks.
   2. Use mechanical, internal vibrators with proper frequency, rpm, and spud size. Select spud for size and spacing of reinforcement and clearance to formwork. Supplement vibration by hand-spading, rodding, or tamping.
   3. Insert and withdraw vibrator vertically at spacing not to exceed 1-1/2 times radius of action of vibrator, maximum of 24 inch centers.
   4. Insert vibrators into placed layer and at least 6 inches into preceding layer.
   5. Do not allow vibrator to touch form face or embedded items.
   6. Do not use mechanical vibration for slabs less than 4 inches thick. Use hand spading and tamping in these locations.

L. Placing Concrete Slabs:
   1. Deposit and consolidate concrete slabs in continuous operation, in single layer, within limits of construction joints, until placing of panel or section is completed.
   2. Bring slab surfaces to correct level with straightedge and strike-off.
3. Use bull floats, highway straight edges, or darbies to produce smooth surface, free of humps or hollows before bleed water appears on surface.
4. Do not disturb slab surfaces prior to beginning finishing operations.

M. Curbs and Equipment Pads:
1. Form curbs and equipment pads in areas indicated.
2. Placement on same day:
   a. Place and consolidate base slab.
   b. Screed to elevation to allow for curb/pad thickness.
   c. After bleed water has disappeared and surface will support worker's weight without indentation, place curb/pad concrete mixture, compact, and float.
3. Placement after one day:
   a. Place and consolidate base slab.
   b. Brush partially set surface with wire broom to remove laitance and scratch surface.
   c. Wet cure base slab at least three days.
   d. Immediately, prior to placing curb/pad concrete, clean base slab and dampen surface.
   e. Scrub bonding grout into base slab surface, or apply bonding agent in accordance with manufacturer’s recommendations.
   f. Place curb/pad concrete before grout has set or dried, compact and float.
4. Finish interior curbs and pads by stripping forms while concrete is still green and steel trowel surfaces to hard, dense finish with corners, intersections and terminations slightly rounded.

N. Filling Holes:
1. Fill holes and openings left in concrete for passage of work by other trades after work of other trades is in place, unless otherwise indicated.
2. Apply bonding agent in accordance with manufacturer’s recommendations.
3. Rewettable bonding agent may be used only in areas not subject to wet conditions.
4. Mix, place, and cure concrete to blend with in-place construction.
5. Screed off flush and finish to match adjacent surfaces.
6. Coordinate with Section 07840 when filling holes in fire rated assemblies.

3.3 FINISHING

A. General: Provide finishes at specified locations, unless indicated otherwise.

B. Finishing Formed Surfaces:
1. Rough Form Finish:
   a. Leave surfaces with texture imparted by forms, except patch tie holes and defects.
   b. Remove fins and other projections exceeding 1/4 inch in height.
   c. Locations: Concrete surfaces not exposed to view.
2. Smooth Form Finish:
   a. Provide smooth, hard, uniform surface with minimum number of seams.
   b. Repair and patch defective areas, fill tie holes, remove fins and other projections completely.
c. Locations: Exposed concrete surfaces or concrete surfaces designated to receive coatings applied directly to concrete, such as waterproofing, dampproofing, plaster, painting, and other similar applied finishes.

C. Finishes for Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces, strike-off smooth and finish with texture matching adjacent formed surfaces.

D. Slab Finishes:

1. Trowel Finish:
   a. After float finish, follow by power troweling and then hand troweling.
   b. Begin final troweling when surface produces ringing sound as trowel is moved over surface.
   c. Finish surface free of trowel marks, uniform in texture and appearance, and to $F_{r25}/F_{l20}$ tolerance.
   d. Grind surface smooth to remove defects which may telegraph through applied finish.
   e. Locations: Slabs and interior face of stem walls left exposed to view.

2. Heavy Broom Finish:
   a. After float finish, while surface is still plastic, draw fiber bristle broom uniformly over surface to provide texture perpendicular to main traffic or at right angles to floor slope.
   b. Locations: sidewalks, ramps, exterior steps, landings, and platforms.

E. Construction and Control Joints in Slab-on-grade:

1. Construction joints to coincide with planned control joint pattern.
2. Provide joints as indicated on Drawings.
3. Joint Spacing:
   a. Provide control joints not exceeding 20 feet on center in each direction; conform to column centerlines, half bays, third bays.
   b. Rectangular panels formed by control joints; long side shall be no longer than 1-1/2 times as long as short side.
4. Tooling Control Joints and Construction Joints:
   a. Slabs Exposed to View: Tool joints after finishing slab.
   b. Concealed Slabs:
      1) Provide joints immediately after final finishing.
      2) Use dry-cut sawing system (Soft-Cut) to depth of 1 inch unless noted otherwise; without dislodging aggregates by sawing. Complete sawing no later than two hours after finishing at each control joint location.
      3) At Contractors option, conventional saw may be used as soon as concrete has hardened sufficiently to prevent aggregates from being dislodged, and finish cutting before shrinkage cracking appears, no later than 12 hours after placement. Conventional sawcutting will not be permitted for parking garages and exterior slabs.

3.4 CURING
A. General:
1. Comply with ACI-301, except as modified or supplemented.
2. Start immediately after placing and finishing concrete.
3. Protect from premature drying, temperature extremes, temperature variations, rain, flowing water, and mechanical injury.
4. Cure continuously, without allowing to dry, for minimum period required for hydration of cement and hardening of concrete.
5. Maintain temperature of concrete above 50 degrees F for curing period.
6. Minimum Length of Curing Period:
   a. High Early Strength Concrete: 3 days.
   b. Other Concrete: 7 days.
7. Shortened Curing Periods permitted under either of following Conditions:
   a. Field cured cylinders indicate concrete compressive strength of at least 70 percent of specified strength.
   b. Laboratory cured cylinders indicate concrete compressive strength of at least 85 percent of specified strength and in-place concrete has been maintained at minimum 50 degrees F for same length of time as cylinders.
8. Control rate of temperature drop after removal of protection in accordance with ACI-306.1.

B. Acceptable Curing Methods:
1. Concrete to receive Hardeners or Sealers: Moist curing, moisture-retaining sheet covering, dissipation of resin compounds, or chemical curing compounds; acceptable to manufacturer of hardener or sealer.
2. Concrete to receive Cement Setting Beds, Bonded Toppings: Moist curing, moisture-retaining sheet covering, or chemical curing compounds.
3. Concrete to receive Adhered Finishes: Moist curing, moisture-retaining sheet covering, acrylic curing/sealing compounds, dissipation of resin compounds, or chemical curing compounds; which are acceptable to manufacturer of applied finishes and permit slab moisture to be reduced to acceptable levels for adhesives used.
4. Concrete exposed to Direct Sun when Ambient Temperature Exceeds 75 degrees F: Where permitted, use white pigmented liquid compounds.
5. Other Concrete: Moist curing, moisture-retaining sheet covering, liquid membrane-forming compounds, or chemical curing compounds.

C. Acceptable Curing Procedures:
1. Moist Curing Unformed Surfaces:
   a. Ponding: Maintain 100 percent coverage of water continuously.
   b. Fog Spraying or Sprinkling: Maintain continuously moist with nozzles or sprayers.
   c. Fabric Mats: Cover surfaces with wet burlap or other absorptive material which will not discolor concrete; keep continuously wet.
   d. Sand: Minimum 2 inch thick layer, kept continuously saturated with water, free from deleterious materials which would stain concrete.
2. Sheet Curing Unformed Surfaces:
   a. Wet surface of concrete with fine spray of water prior to applying sheet.
b. Immediately cover surface with polyethylene sheeting, waterproof paper, or burlap-polyethylene sheet.
c. Lap edges of sheeting minimum of 12 inches.
d. Repair damaged sheet.
e. Ballast sheet to prevent movement and blow-off.

3. Liquid Membrane-forming Compound Curing of Unformed Surfaces:
   a. Apply in accordance with manufacturer's recommendations.
   b. Protect surfaces from foot and vehicular traffic.
   c. Curing compounds used must be compatible with adhesives used in setting resilient tile or sheeting flooring, epoxy and other similar finishes.

4. Curing Formed Surfaces:
   a. Keep forms continuously moist.
   b. Loosen forms for vertical surfaces to allow curing water to run between concrete and forms.
   c. If forms are removed prior to end of curing period, continue curing with any of methods described for unformed surfaces.

5. Curing of surfaces which are moist cured for first 24 hours may be cured by other acceptable methods for remaining curing period provided they are not allowed to become dry.

3.5 FIELD QUALITY CONTROL

A. Field testing will be performed under the provisions of Section 01450.

B. Independent testing laboratory, employed by Owner, is responsible for:
   1. Sampling Fresh Concrete: ASTM C172, sample at point of discharge from mixer; if water is added at Project site, obtain another sample for testing.
   2. Concrete Temperature: Test each time slump and air content are tested and each time set of compressive strength test specimens is made.
   3. Slump: ASTM C143; one test from first truck at point of discharge each day, one test each time set of compressive strength test specimens is made, and when change in consistency occurs.
   4. Air Content of Plastic Mix:
      a. For Normal Weight, Air Entrained Concrete: ASTM C231, pressure method or ASTM C173, volumetric method.
      b. For Lightweight, Air Entrained Concrete: ASTM C173, volumetric method.
      c. Make one test each time a set of compressive strength test specimens is made.

5. Compressive Strength Tests:
   a. Per structural drawings

6. Environmental Conditions:
   a. When ambient air temperature falls below 40 degrees F, record maximum and minimum air temperature in each 24 hour period; record air temperature inside protective enclosure; record minimum temperature of surface of hardened concrete.
   b. When ambient air temperature rises above 85 degrees F, record maximum and minimum air temperature in each 24 hour period; record minimum relative
humidity; record maximum wind velocity, and record maximum temperature of surface of hardened concrete.

7. Observe conveying, placement and consolidation of concrete for conformance to Specifications.

8. Observe condition of formed surfaces upon removal of formwork prior to repair of surface defects and observe repair of surface defects.


10. Observe Preparations for Placement of Concrete:
   a. Inspect handling, conveying, and placing equipment, inspect vibrating and compacting equipment.
   b. Inspect preparation of construction, expansion, and isolation joints.

11. Observe preparations for protection from hot weather, cold weather, sun, and rain and preparations for curing.

12. Observations of Concrete Mixing:
   a. Monitor and record amount of water added at Project site.
   b. Observe minimum and maximum mixing times.

13. Other Inspections:
   a. Grouting under base plates.
   b. Grouting anchor bolts and reinforcing steel in hardened concrete.

14. Test for Water Soluble Chloride Ion Content in Hardened Concrete:
   a. Test in accordance with procedure described in FHWA Report No. FHWA RD-77-85.
   b. Make one test for each set of compressive strength test specimens.
   c. Test may be waived by Architect upon written request from Contractor after review of concrete design mix has been made.

C. Evaluation and Acceptance of Concrete:

1. Strength Test: Defined as average strength of two 28 day cylinder tests from each set of cylinders.

2. Acceptance Criteria Based on Strength Tests: Strength level of individual class of concrete is considered satisfactory if both:
   a. Average of three consecutive strength test results equal or exceed required design compressive strength, and
   b. No individual strength test results falls below required design compressive strength by more than 500 psi.

3. Acceptance Criteria Based on Field Tests:
   a. Core Tests: Where strength tests indicate concrete of deficient strength, obtain and test cores in accordance with ASTM C42 and ACI-301, at locations directed by Architect.
   b. Strength level of concrete in area represented by core test is considered adequate if both:
      1) Average strength of three cores is at least 85 percent of required design compressive strength and,
      2) No individual core is less than 75 percent of required design compressive strength.
c. Fill core holes with low slump concrete or patching mortar used to repair surface defects.

4. Revise concrete mix proportions, curing procedures and protection as necessary to provide concrete conforming to Specifications.

D. Acceptance of Structure:
1. Acceptance of structure for dimensional tolerances, appearance, and strength will be based on ACI-301, Chapter 18.
2. Remove and replace concrete which does not meet acceptance criteria.

3.6 PATCHING AND REPAIRING

A. General:
1. Rewettable bonding agent may be used only in areas not subject to wet conditions.
2. Patching compound may only be used for concrete not exposed to view.

B. Repairing Formed Surfaces:
1. Surface Defects Requiring Repair:
   a. Color and texture irregularities.
   b. Honeycomb, air bubbles, rock pockets, and spalls.
   c. Fins, burrs and other surface projections.
   d. Cracks.
   e. Stains and other discolorations that cannot be removed by cleaning.
2. Patch defective areas and tie holes immediately after removal of forms.
3. Cut out honeycomb, rock pockets, and voids over 1/4 inch down to solid concrete but not less than 1 inch depth.
4. Make edges of cuts perpendicular to concrete surface.
5. Clean and dampen area including 6 inches of surrounding surface with water.
6. Apply bonding grout by brushing into surface, after surface water has evaporated.
7. Place patching mortar or patching compound before grout has set or dried.
8. Compact patching material in place and strike off slightly higher than surrounding surface.
9. Finish after minimum of one hour to match surrounding surface.
10. Flush out form tie holes, fill with patching mortar, patching compound, or precast cement cone plugs secured in place with bonding compound.
11. Cure repair areas by same methods as surrounding concrete or keep continuously damp for 7 days.

C. Repairing Unformed Surfaces:
1. Surface Defects Requiring Repair:
   a. Fine crazing cracks.
   b. Cracks larger than 0.012 inch wide or cracks which penetrate to reinforcing.
   c. Cracks penetrating completely through non-reinforced sections.
   d. Spalling, popouts, honeycomb, and rock pockets.
   e. High and low areas in slabs.
2. Correct high areas in hardened concrete by grinding after concrete has cured at least 14 days.
3. Correct high and low areas during, or immediately after, completion of initial floating operations by cutting high areas and by placing fresh concrete in low areas.

4. Repair defective areas, except isolated random cracks and single holes not exceeding 1 inch diameter, by cutting out and replacing with patching mortar or patching compound.
   a. Remove defective areas to sound concrete with clean, square cuts.
   b. Dampen concrete surfaces in contact with patching material and apply bonding grout by brushing into surface, after surface water has disappeared.
   c. Place patching mortar or patching compound before grout has set or dried.
   d. Compact and finish to blend with adjacent finished concrete.
   e. Cure in same manner as adjacent concrete.

5. Repair isolated random cracks and single holes not over 1 inch diameter with patching mortar.
   a. Groove top of cracks and cut out holes to sound concrete and clean area.
   b. Dampen cleaned surfaces and apply bonding grout by brushing into surface, after surface water has disappeared.
   c. Place patching material before bonding grout is set or dry.
   d. Compact in place and finish to match adjacent concrete.
   e. Keep patched area continuously moist for not less than 72 hours.

D. Structural Repairs: Materials, methods, and procedures as approved by Architect.

E. Other repair methods not specified may be used, but are subject to acceptance of Architect.

3.7 PROTECTION

A. Protect finished work in accordance with Section 01700.

B. Protect concrete from construction traffic, weather, or mechanical damage for 14 days after placing.

C. Provide raised runways for traffic areas.

D. Protect concrete from staining.

END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Related Sections:
   1. Section 03300 - Cast-in-Place Concrete.

1.2 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Product Data: Submit product data, including chemical properties and percentage of solids, for each product.

C. Samples:
   1. Submit one 12 inch by 18 inch concrete sample for each sealer specified.
   2. Coat one-half of each sample with sealer and leave one-half untreated.
   3. Samples shall illustrate range of color and texture expected in final Work.
   4. Resubmit samples until approved.

D. Submit following Informational Submittals:
   1. Certifications specified in Quality Assurance article.
   2. Qualification Data: Applicator's qualification data.
   3. Manufacturer's Instructions: Application instructions, including surface preparation and application rates for each type of substrate, methods, and techniques.

1.3 QUALITY ASSURANCE

A. Applicator's Qualifications: Company specializing in performing work of this Section with 3 years minimum experience.

B. Certifications:
   1. Submit manufacturer's certificate stating proper amount of materials was ordered and shipped to Project.
   2. Submit sealer manufacturer's certificate indicating review of Project conditions and intent to issue extended warranty. Submittal of certificate is required prior to application of materials.

1.4 PRE-INSTALLATION CONFERENCE
A. Conduct pre-installation conference in accordance with Section 01310.

B. Arrange for manufacturer's technical representative to be on Project site to advise applicator of proper procedures and precautions and to observe application methods of products.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Comply with requirements of Section 01600.

B. Store products above 50 degrees F, but no greater than 85 degrees F, unless otherwise recommended by manufacturer.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Comply with local air pollution and safety regulations of governing authorities while performing sandblasting operations.

B. Do not apply materials when ambient or substrate surface temperatures are below 40 degrees F or higher than 100 degrees F.

C. Do not apply during inclement weather or when forecasted conditions will not permit compliance with manufacturer's printed instructions.

D. Provide mechanical ventilation during and after application to dissipate fumes if natural ventilation is insufficient.

1.7 SCHEDULING

A. Schedule application of products at proper time intervals after concrete finishing and curing operations.

B. Maintain proper moisture content of concrete before, during, and after application of specified products.

1.8 WARRANTY

A. Comply with provisions of Section 01780.

B. Warrant applied sealer system to be free of defects related to material deficiency and workmanship for 5 years.

C. Warranty period begins at date of Substantial Completion.

PART 2 – PRODUCTS

2.1 MATERIALS
A. Provide materials, equipment, and personnel required to achieve specified finish.

B. Muriatic Acid Solution: One part commercial quality 36 percent hydrochloric acid mixed with four parts clean water.

C. Liquid Membrane-Forming Sealer:
   1. ASTM C1315, Type I clear or translucent, Class A, free of natural or petroleum waxes.
   2. Liquid, membrane-forming compound, minimum 30 percent acrylic resin solids, allowing maximum moisture loss in 72 hours of 0.08lb/sq.ft.
   3. Acceptable Products:
      a. Super Rez-Seal, Euclid Chemical Company, Cleveland, OH.
      b. Dress & Seal 30, L&M Construction Chemicals, Inc., Omaha, NE.
      d. ABCO Cure & Seal 830, Nox-Crete Chemicals, Omaha, NE.
      e. Cure & Seal 31%, Symons Corporation, Des Plaines, IL.

D. Penetrating Water Repellent Sealer: Refer to Section 07190.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine conditions and proceed with work in accordance with Section 01700.

B. Ensure concrete has cured for sufficient amount of time before commencing sandblasting operations in order to match texture of approved sample.

C. Verify that damage and defects in concrete surface have been repaired as specified in Section 03300 and accepted by Architect.

D. Verify that form ties have been broken off below concrete surface and plastic cones, fins and burrs have been removed.

E. Verify that form tie holes have been patched, unless specifically indicated to be left unfilled.

F. Verify that surfaces are clean, dry, dust free, and free of efflorescence, oil or other matter detrimental to sealer application.

G. Verify that joint sealant work in adjoining surfaces is complete prior to applications of sealers. Delay application until sealants have cured.

H. Ensure concrete has cured for time period required by manufacturer of product to be applied 28 days minimum before application of products.
3.2 PREPARATION

A. Provide protection as necessary to protect adjacent materials and surfaces from dirt, dust, and other surface or physical damage.

B. Prevent migration of airborne materials by use of tarpaulins, wind breaks, and similar containment devices.

C. Maintain control of concrete chips, dust and debris. Collect water and acid runoff to prevent damage to adjacent surfaces.

D. Remove loose particles, foreign matter, and oil by method which will not affect sealer application.

E. Prepare surfaces in accordance with manufacturer's directions.

F. Provide protection as necessary to protect adjacent materials and surfaces from dirt, dust, spillage, overspray and other surface or physical damage.

3.3 APPLICATION

A. General:
   1. Provide finishes to match approved samples at locations indicated.
   2. Apply materials in accordance with manufacturer's printed instructions.

B. Penetrating Water Repellent Sealer:
   1. Apply sealer using low pressure airless sprayer in number of coats and at rate indicated by manufacturer to obtain penetration and full coverage.
   2. Do not allow flooding of surface or multi-coat overlapping.
   3. Do not dilute or alter material as packaged.
   4. Locations: Interior containment slabs and stem walls and where indicated or scheduled on Drawings.

3.4 FIELD QUALITY CONTROL

A. After penetrating water repellent sealer has dried, spray surfaces with clear water to reveal areas that have not received application. Allow surfaces to dry before applying penetrating water repellent sealer materials in areas exhibiting moisture absorption.

3.5 ADJUSTING

A. Repair or replace adjacent Work which has been damaged by finishing operations.

3.6 CLEANING

A. Clean-up and remove debris daily.
3.7 PROTECTION

A. Protect finished work in accordance with Section 01700.

B. Protect finished concrete surfaces from damage by construction equipment, operations and from adverse weather conditions.

END OF SECTION
SECTION 05120
STRUCTURAL STEEL

PART 1 – GENERAL

1.1 SUMMARY

A. Related Sections:
   1. Section 03300 - Cast-In-Place Concrete: Installation of anchor bolts and anchor plates.
   2. Section 05500 - Metal Fabrications: Miscellaneous steel fabrications, and loose lintels.

1.2 SYSTEM REQUIREMENTS

A. Interface With Adjacent Systems:
   1. Coordinate primer with finish paint and fireproofing.
   2. Provide templates and instructions for installing anchors in other Work.
   3. Verify that anchors are properly set.

1.3 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Product Data: Submit product data for:
   1. High-strength bolts.
   2. Shop paint.

C. Shop Drawings:
   1. Check shop drawings thoroughly before submitting. Verify dimensions requiring field verification before submitting and mark as having been verified.
   2. Indicate section profiles, sizes, spacing and locations of members, including:
      a. Fabrication and erection details.
      b. Size, weight and material grades of members.
      c. Details of shop and field connections.
      d. Locations and details of anchors, base plates and bearing plates.
      e. Holes, camber, schedules and anchor bolt setting plans.
      f. Surface preparation and shop painting.
      g. Erection plans at 1/8 inch minimum scale.
   3. Identify slip critical bolted connections on erection drawings.
   4. Indicate welded connections with AWS A2.4 welding symbols. Indicate net weld lengths.
   5. Description of welding process, welding procedures, electrodes, and sequence of welding.
   6. Describe structural steel erection sequence.
   7. Architect’s approval of shop drawings will be for size and arrangement of primary and auxiliary members and for strength of connections. Any errors in dimensions shown on shop drawings are Contractor’s responsibility.
   8. Provide setting drawings and installation instructions for items in other work.
D. Calculations:
   1. Submit calculations of proposed alternate connections not detailed on Drawings, sealed by a Professional Engineer.
   2. Submit calculations of anticipated loads, if any, to structural steel due to temporary shoring or construction equipment.

E. Submit following Informational Submittals:
   1. Mill Test Reports: Submit certified mill test reports of chemical analysis and physical test for each heat number of structural steel.
   2. Certifications specified in Quality Assurance article.
   3. Qualification Data: Fabricator's, erector's and welder's qualification data.

1.4 QUALITY ASSURANCE

A. Fabricator Qualifications:
   1. Minimum 5 years documented experience in fabrication of structural steel.
   2. Certified in accordance with AISC Quality Certification Program for Category I.

B. Erector Qualifications: Minimum 5 years documented experience in erection of structural steel for similar structures.

C. Welder Qualifications: AWS certified within past 12 months for each type of weld required.

D. Certifications:
   1. Submit certificates verifying AWS qualifications for each welder employed on Project.
   2. Submit fabricator's certification that structural steel, bolts, nuts and washers, anchor bolts, threaded rods, filler metal and flux for welding, shop paint, and non-shrink grout meet or exceed specified requirements.
   3. Submit Contractor’s certification that steel is installed in accordance with Contract Documents, based on inspection and testing specified as part of field quality control.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Comply with requirements of Section 01600.

B. Store to facilitate inspection.

1.6 PROJECT CONDITIONS

A. Existing Conditions: Field verify conditions. Architect will not review or take responsibility for dimensions.
PART 2 – PRODUCTS

2.1 MATERIALS

A. Structural Steel Shapes: ASTM A36 Grade 50; locations indicated on Drawings.

B. Structural Steel Plates and Bars: ASTM A36 Grade 50; locations indicated on Drawings.

C. Square and Rectangular Structural Tubing:
   1. Cold-Formed: ASTM A500, Grade B.

D. Pipe and Round Structural Tubing:
   1. Pipe: ASTM A53, Grade B.

E. Headed Stud Shear Connectors: ASTM A108, Grades 1010 through 1020, forged steel, headed, uncoated; and AWS D1.1.

F. Bolts, Nuts and Washers:
   1. Anchor bolts:
      b. Threaded Rods: ASTM A36, Grade 50.
      c. Nuts: ASTM A563, Grade D, heavy hex.
      d. Washers: ASTM A36 plates.
   2. Standard Threaded Fasteners:
      a. Bolts: ASTM A307, Grade A.
      b. Nuts: A563, Grade A.
      c. Washers: Plain; beveled where required.
   3. High Strength Fasteners:
      a. ASTM A325, Type 1:
         1) Diameter: Up to 1-1/2 inches.
         2) Nuts: ASTM A563, Class C plain, Class DH galvanized, heavy hex; or
            ASTM A194, Grade 2H plain, Grade 2H galvanized, heavy hex.
         3) Washers: Hardened.
   4. Washers:
      a. Plain Washers: ANSI B18.22.1, Type A.
      d. Tension Indicating Washers: ASTM F959.

G. Welding Materials: AWS D1.1; type required for materials being welded.

H. Shop Paint:
   1. Alkyd Primer for interior concealed steel members, other than soil contact items:
      a. Acceptable Products:

05500-3 STRUCTURAL STEEL
NOAO Spectrograph
KITT Peak WIYN
Revision 0 – July 11, 2017
Advantech Facility Design Inc
11607.00
1) Amercoat 5105, Ameron International, Brea, CA.
2) Devguard 4100, ICI Devoe Coatings, Louisville, KY.
3) Series 10, Tnemec Company, Inc., Kansas City, MO.

2. Epoxy Primer for exterior exposed items, concealed items outside weather protection envelope, soil contact items, (including columns below slabs, base plates, and grade beams):
   a. Acceptable Products:
      1) Amercoat 370, Ameron International, Brea, CA.
      2) Bar-Rust 235, ICI Devoe Coatings, Louisville, KY.
      3) Series 161, Tnene-Fascure, Tnemec Company, Inc., Kansas City, MO.

3. Intermediate and top coats for soil contact items: Polyamide epoxy, 4.0 mils minimum per coat.
   a. Acceptable Products:
      1) Amercoat 370, Ameron International, Brea, CA.
      2) Bar-Rust 235, ICI Devoe Coatings, Louisville, KY.
      3) Series 161, Tnene-Fascure, Tnemec Company, Inc., Kansas City, MO.

4. Class B shop primer:
   a. Acceptable Products:
      1) Carbo Zinc 11, Carboline Company, St. Louis, MO.
      2) Catha-Coat 304V, ICI Devoe Coatings, Louisville, KY.
      3) Tneme-Zinc, 90-97, Tnemec Company, Inc., Kansas City, MO.

I. Field Touch-Up Paint:
   1. Primed Surfaces: Same paint as applied in shop.
   2. Galvanized Surfaces: SSPC Paint 20, Type II, organic zinc rich.

J. Non-Shrink Grout:
   1. ASTM C1107, pre-mixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing additives.
   2. Minimum Strength at 28 Days: 34.5 5000 psi.
   3. Acceptable Products:
      a. Masterflow 713, Master Builders, Cleveland, OH.
      b. Euco N.S., Euclid Chemical Company, Cleveland, OH.
      c. Crystex, L&M Construction Chemicals, Inc., Omaha, NE.
      d. SikaGrout 212, Sika Corporation, Lyndhurst, NJ.
      e. Sonogrout 10K, Sonneborn Building Products, Shakopee, MN.

2.2 FABRICATION

A. Shop Fabrication and Assembly:
   1. Fabricate structural steel members in accordance with AISC S326.
   2. Perform corrective work on material not meeting ASTM A6/A6M tolerances for camber, profile, flatness, or sweep subject to limitations given in appropriate ASTM material specification.
   3. Fabricate architecturally exposed structural steel (AESS) members in accordance with AISC S302:
      a. Use materials which are smooth and free of surface blemishes including pitting, seam marks, roller marks, and roughness.
b. Remove blemishes by grinding, or welding and grinding, prior to cleaning, treating and application of shop paint.

B. Connections:
1. Bolt or weld shop connections.
2. Bolt or weld field connections, except where welded connections are indicated.
3. Use high-strength threaded fasteners for bolted connections, except that standard threaded fasteners may be used in temporary erection connections when final connection is welded after adjustment and for temporary bracing.
4. Install high-strength bolted construction in accordance with AISC S329 [S334L] utilizing fully pre-tensioned bolts, unless noted otherwise.
5. Punch, ream or drill bolt holes.
6. Weld in accordance with AWS D1.1.

C. Holes for Other Work:
1. Provide holes required for securing other work to structural steel framing, and for passage of other work through steel framing members, as approved by Architect.
2. Cut, drill, or punch holes perpendicular to metal surfaces. Do not flame cut holes or enlarge holes by burning.

D. Base Plates and Column Plates: Milled or pressed, loose or attached.

E. Bearing Plates: Provide under beams resting on piers and walls; loose or attached.

F. Anchor Bolts: Provide templates for anchor bolt groups.

2.3 FINISH

A. Clean steel of oil and grease by SSPC SP1 Solvent Cleaning; remove dirt and foreign material by brushing.

B. Steel members which are in contact with concrete or metal deck: Unpainted.

C. Steel members which receive spray-on fireproofing: Unpainted.

D. Interior Steel Members Exposed to View and Exposed to Cleanroom Airstream:
1. Preparation: Clean by SSPC SP6 - Commercial Blast Cleaning.
2. Primer: Apply specified shop paint to thickness indicated or, if not indicated, as recommended by finish coat manufacturer 2 mil dry thickness.
3. Do not paint within 2 inches of field welds and on contact surfaces of slip-critical connections.
4. Clean and paint surfaces inaccessible after shop assembly prior to assembly.

E. Exterior steel members exposed to atmosphere and concealed members located outside exterior weatherproofing envelope:
1. Preparation: Clean by SSPC SP6 - Commercial Blast Cleaning.
2. Primer: Apply shop paint for exposed members to thickness indicated or, if not indicated, as recommended by finish coat manufacturer 2 mil dry thickness.
3. Do not paint within 2 inches of field welds and on contact surfaces of slip-critical connections.
4. Clean and paint surfaces inaccessible after shop assembly prior to assembly.

F. Steel members in contact with soil including columns below slabs, base plates, and grade beams:
   1. Preparation: Clean by SSPC SP6 – Commercial Blast Cleaning.
   2. Primer, intermediate, and top coat: Apply shop paint to thickness specified.

G. Interior Concealed Steel Members:
   1. Preparation: Clean by SSPC SP2 - Hand Tool Cleaning and SSPC SP3 - Power Tool Cleaning.
   2. Primer: Apply standard shop paint to thickness recommended by paint manufacturer to minimum 2 mil dry thickness.
   3. Do not paint within 2 inches of field welds [and on contact surfaces of slip-critical connections].
   4. Clean and paint surfaces inaccessible after shop assembly prior to assembly.

H. Galvanized Finish:
   1. Hot-dipped galvanized coating according to ASTM A123.
   2. Provide for exterior suspended steel lintels and at other locations noted on Drawings.

I. Protect machine finished surfaces with rust-inhibiting coating, which is removable prior to erection, or which has characteristics which make removal unnecessary.

2.4 SHOP QUALITY CONTROL

A. Shop testing will be performed by an Independent Testing Laboratory employed by Contractor under provisions of Section 01450, except as otherwise specified.


C. Weld Inspection:
   1. Perform visual inspection of welds in accordance with AWS D1.1.
   2. Verify qualifications of welders.
   3. Verify welding procedure qualification and equipment.
   4. Verify weld materials and storage facilities.
   5. Inspect joint fit-up prior to welding.

D. Non-Destructive Testing of Welds:
   1. Ultrasonic Testing (UT):
      a. Conform to ASTM E164.
      b. Divide moment connections into groups containing not less than 40 connections. Test 25 percent of connections in each group. If any weld is rejected, test all connections in group.

E. Inspect bolted connections in accordance with AISC S329.
F. Inspect shop fabricated assemblies, verify dimensional tolerances.

G. Mark inspected connections.

H. Retest rejected connections after repair.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine conditions and proceed with Work in accordance with Section 01700.

3.2 PREPARATION

A. Temporary Shoring and Bracing:
   1. Provide temporary shoring and bracing members and connections during construction to carry loads to structure including wind, dead loads, equipment loads and erection loads.
   2. Provide temporary shoring for members indicated as shored construction.
   3. Provide temporary guy lines to achieve proper alignment of structure as erection proceeds.
   4. Remove temporary members and connections when permanent members are in place and final connections are made.

3.3 ERECTION

A. Erect structural steel members in accordance with AISC S326.

B. Setting Base Plates and Bearing Plates:
   2. Clean bottom surface of base and bearing plates.
   3. Set loose and attached base plates and bearing plates for structural members on wedges or other adjusting devices.
   4. Tighten anchor bolts after supported members are positioned and plumbed. Do not use impact torque wrenches.
   5. Do not remove wedges or shims, but if protruding, cut off flush with edge of base or bearing plate prior to grouting.
   6. Place non-shrink grout solidly between bearing surfaces and plates or steel member so that no voids remain. Comply with grout manufacturer’s instructions.

C. Field Assembly:
   1. Set structural frames accurately to lines and elevations indicated.
   2. Align and adjust various members forming part of complete frame or structure before permanently fastening.
   3. Clean bearing surfaces and other surfaces which will be in permanent contact before assembly.
   4. Adjust as necessary to compensate for discrepancies in elevations and alignment.
5. Establish required leveling and plumbing measurements on mean operating temperature of structure. Make allowances for difference between temperature at time of erection and mean temperature at which structure will be when completed and in service.

6. Splice members only where indicated on approved shop drawings.

7. Complete field connections before load is applied.

8. On exposed welded construction, remove erection bolts, run-off plates, tack welds and backing bars. Fill holes with plug welds and grind smooth at surfaces which remain exposed to view.

9. Field weld components indicated on approved shop drawings.

10. Do not field cut or alter structural members or connections without approval of Architect.

11. Install high strength bolted construction in accordance with AISC S329 [S334L] utilizing fully pre-tensioned bolts unless noted otherwise.

12. Tightening of bolts in slip-critical connections shall be done by turn-of-nut tightening, installation of alternate design bolts or direct tension indicator tightening. Calibrated wrench tightening may also be used for connections noted to be fully pre-tensioned but not slip-critical.

13. Coordinate installation of slip-critical connections with the Independent Testing Laboratory to facilitate inspection.

D. Erection Tolerances:
   1. Comply with AISC S326.
   2. All specified tolerances are to be achieved at an ambient temperature of 70 degrees F.

E. Touch-Up Painting:
   1. After erection, touch-up abrasions on shop-primed or galvanized surfaces except surfaces that are indicated as unpainted.
   2. After inspection and approval, paint welds, bolts and nuts, and surfaces adjacent to welds, on painted steel members.

3.4 FIELD QUALITY CONTROL

A. Field testing will be performed by an Independent Testing Laboratory employed by Contractor under provisions of Section 01450, except as otherwise specified.


C. Weld Inspection:
   1. Perform visual inspection of welds in accordance with AWS D1.1.
   2. Verify qualifications of welders.
   3. Verify welding procedure qualification and equipment.
   4. Verify weld materials and storage facilities.
   5. Inspect joint fit-up prior to welding.

D. Non-Destructive Testing of Welds:
   1. Ultrasonic Testing (UT):
      a. Conform to ASTM E164.
b. Divide connections into groups containing not less than 40 connections. Test 25 percent of connections in each group. If any weld is rejected, test all connections in group.

E. Bolt Inspection:
1. Slip-Critical Connections: Inspect 10 percent of the bolts, but not less than 2 bolts, selected at random in each connection in accordance with AISC S329. Inspect all bolts in the connection when one or more are rejected.
2. Fully Pre-Tensioned Connections: Inspect 10 percent of the bolts, but not less than 2 bolts, selected at random in 25 percent of the connections in accordance with AISC S329. Inspect all bolts in the connection when one or more are rejected.
3. Bolts installed by turn-of-nut tightening may be inspected with calibrated wrench when visual inspection was not performed during tightening.
4. Snug Tight Connections: Inspect 100 percent of connections verifying that plies of connected elements have been brought into snug contact.

F. Mark inspected connections.

G. Inspect beams for camber requirements.

H. Inspect field-erected assemblies, verify locations of structural steel for plumbness, level and alignment.

I. Repair and retest rejected connections.

J. Contractor’s Field Quality Control Responsibilities:
1. Survey steel frame as erection proceeds to determine plumbness, level and alignment.
2. Adjust steel frame as necessary during erection to maintain erection tolerances.
3. Survey elevations of each level of steel frame as work progresses.

END OF SECTION
SECTION 07210
BUILDING INSULATION

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Batt insulation.
   2. Rigid foam board insulation.
   3. Closed Cell Foam Insulation

1.2 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Product Data: Submit product data for each product.

C. Submit following Informational Submittals: Manufacturer's instructions.

1.3 QUALITY ASSURANCE

A. Single Source Responsibility: Furnish each insulation type from one manufacturer for entire Project, unless otherwise acceptable to Architect.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Comply with requirements of Section 01600.

B. Identify products with appropriate markings of applicable testing and inspecting organization.

C. Storage and Protection:
   1. Store materials raised off floor or ground and under cover to keep dry.
   2. Protected from weather, direct sun light, contamination, sources of ignition, and damage from construction operations.

PART 2 – PRODUCTS

A. MANUFACTURERS

A. Acceptable Glass Fiber Insulation Manufacturers:
   1. CertainTeed Vinyl Building Products, Valley Forge, PA.
   2. Owens Corning, Toledo, OH.
   3. Johns Manville Corporation, Denver, CO.

B. Acceptable Rigid Foam Board Insulation Manufacturer:
   1. The Dow Chemical Company, Midland, MI.
C. Acceptable Manufacturer: ThermoSeal, LLC,

***Requests for substitutions will be considered in accordance with provisions of Section 01 60
00 - Product Requirements.

B. MATERIALS

A. Fiberglass Batt Insulation - Unfaced
   1. General:
      a. Glass fiber composition, friction fit type, unfaced.
      b. Thermal resistance R-values as indicated.
   2. Classification: ASTM C665, Type I.
   3. Density: 1 pcf minimum.
   4. Thermal Resistance: ASTM C518, 0.56 m² K/W per R-value of 3.2 per inch of
      thickness at 75 degrees F mean temperature.
   5. Fire Rating: ASTM E84, Flame spread 25 or less and smoke development 50 or less.
   6. Acceptable Products:
      a. Unfaced Building Insulation, CertainTeed Vinyl Building Products, Valley Forge,
         PA.
      b. Thermal Batt Insulation, Owens Corning, Toledo, OH.
      c. Unfaced Thermal-SHIELD, Johns Manville Corporation, Denver, CO.

B. Rigid Foam Board Insulation: closed cell polyisocyanurate foam board with glass fiber
   reinforced core, to ASTM C1289, Type I, Class 2; meeting the following criteria:
   1. Thermal Resistance ASTM C518 @ 75 deg. F: R-6.5
      per 1 inch of thickness.
   5. Board Thickness: 1 inch.
   7. Faces: 1.0 mil (0.025 mm) thick aluminum foil facer, both sides.
      developed < 450.
   9. Water Vapor Transmission (ASTM E96): less than 0.03 perms.
   10. Water Absorption by Volume (ASTM C209): maximum 0.3 percent.
   11. Product and Manufacturer Name: THERMAX™ Insulation Sheathing by The Dow
       Chemical Company.

C. SPRAY FOAM INSULATION

A. Spray Applied Semi Rigid Polyurethane Open Cell Foam Insulation System: Two
   component, water blown insulation. (Bases of design Thermaseal 500 manufactured by
   ThermoSeal, LLC.
   1. Contains zero ozone depleting agents, catalysts, polyols, and fire retarding materials.
   2. Fills cracks, crevices, and voids to form air seal and thermal insulation.
   4. Physical Properties:
a. Density (ASTM D 1622): 0.5 lb/cf (0.008 gm/cu. cm).
b. Thermal Resistance (ASTM C 518): R-3.7 (sf.h degree F/BTU) at 1 inch at 90
days at 76 degree F (24.4 degree C). Refer to ICC-ESR 3225 for R-Value table.
c. Open Cell Content (ASTM D 6226): Greater than 97 percent.
d. Water Vapor Transmission - Permeance (ASTM E 96): 21 Perms at 1 inch.
e. Air Leakage (ASTM E 283): Less than 0.02 L/sm².
f. Tensile Strength (ASTM D 1623): 5.19 lbf/sq. inch (35.8 kPa).
g. Dimensional Stability (ASTM D 2126): Less than 5 percent.
i. Noise Reduction Coefficient (NRC) (ASTM C 423): .75.
j. Surface Burning Characteristics (ASTM E 84): Class 1 Pass, Flame Spread
   Index less than 25, Smoke Developed Index less than 450.

5. Equipment used to apply the foam insulation shall have fixed ratio positive
displacement pumps and approved by ThermoSeal, LLC.

6. Equipment used to apply the water based intumescent coating shall be an airless
sprayer approved by ThermoSeal, LLC.

7. Ignition / Thermal Barrier: DC315 manufactured by International Fireproof
   Technology, Inc.
   b. Thermal Barrier (NFPA 286): Pass at 88.88 sq.ft./gal at 18 mils wet, 12 mils
dry, coverage rate of 1.136 gallons (4.3 L) per 100 square feet (9.2 m²).

C. ACCESSORIES

A. Insulation Fasteners: Screw Type: ITW Buildex Multi-Diameter Insulation Teks with Dow
   Quik-Caps or similar fastener with a 1-1/4 inch plastic washer.

B. Joint Closure Strips - Clip Strip Type: rigid PVC construction, J-channel shape, 1 inch
   nominal size.

C. Tape: Self-adhering pressure sensitive, compatible with insulation, foil type recommended by
   manufacturer of insulation.
   1. Fire Rating: ASTM E84, flame spread 25 or less and smoke developed of 50 or less.

D. Sealant: As recommended by insulation manufacturer.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine conditions and proceed with work in accordance with Section 01700.

B. Verify that work of other trades which will be covered by insulation is complete, approved,
   and tested.
3.2 INSTALLATION

A. General: Comply with Section 01700.

B. Batt Installation:
1. Install insulation after plumbing, mechanical, and electrical services have been installed.
2. Provide mechanical fasteners, wire mesh, or other accessories to ensure insulation remains in specified position.
3. Fit insulation tight within spaces and tight to exterior side of plumbing, mechanical, and electric services within plane of insulation leaving no gaps or voids.
4. Butt insulation tightly.
5. Cut and fit tightly around items penetrating insulation.
7. Use batts free of damage.
8. Install insulation within metal framing systems full height and width. Do not allow voids or openings to occur. Insulation is required for full width between studs, including cavity of each stud.
9. Cut and trim insulation neatly, to fit spaces.
10. Cut insulation oversize to ensure tight butt joints when installed. Cut insulation to fit around protrusions and irregularly shaped projections.

C. Rigid foam board installation:
1. Install rigid foam board insulation system in accordance with manufacturer’s installation guidelines.
2. Install boards with long axis perpendicular to supports. Ensure end joints are fully supported.
3. Install insulation boards to ensure board width spans not less than 3 framing supports.
4. Cut and fit boards to suit project requirements.

3.3 PROTECTION

A. Protect finished work in accordance with Section 01700.

B. Protect insulation from moisture until building is made watertight.

END OF SECTION
SECTION 08100
METAL DOORS AND FRAMES

PART 1 – GENERAL

1.1 SUMMARY

A. Related Sections:
   1. Section 08710 - Door Hardware.

1.2 SYSTEM DESCRIPTION

A. General:
   1. Meet or exceed ANSI A250.8 and more stringent requirements specified in this Section.
   2. Fire Rated Assemblies:
      a. Fabricate assemblies as tested and approved by Underwriters Laboratories or other nationally recognized testing agency acceptable to authorities having jurisdiction.
      b. Comply with requirements of NFPA 80.
      c. Tested in accordance with NFPA 252 or UL 10B.
      d. Identify each assembly with factory applied label indicating applicable fire rating.
      e. Assemblies at stair enclosures require maximum temperature rise not to exceed 450 degrees F above ambient temperature at end of 30 minute fire exposure test.
   3. Hardware Preparation:
      a. Comply with ANSI/DHI A115 Series and ANSI 250.6, except for hardware locations.
      b. Comply with Section 08710 for hardware locations.
      c. Mortise, reinforce, drill, and tap frames and doors at factory to receive mortised and concealed hardware in accordance with templates and approved hardware schedules.
      d. Reinforce frames and doors for surface mounted hardware; drilling and tapping will be in field at time of hardware application.
      e. Comply with ANSI A250.8 and ANSI 250.6 for thickness of hardware reinforcing.

1.3 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Shop Drawings:
   1. Submit schedule indicating opening identification number, door and frame types, sheet metal thickness, dimensions, swing, label, hardware requirements, and undercuts when applicable. Use same identification numbers for openings as shown by Contract Drawings.
   2. Include elevations and details indicating door and frame types, profiles, conditions at openings, methods of anchoring, hardware locations, reinforcements for hardware, core construction, and provisions for vision panels and louvers when applicable.
3. Clearly identify work that cannot be permanently factory assembled before shipment. Indicate locations of field splice joints and include associated details to ensure proper assembly at project site.

1.4 DELIVERY, STORAGE, AND HANDLING

   A. Comply with requirements of Section 01600.
   B. Store in protected dry area under cover.
   C. Place units on wood skids and store in manner that will prevent corrosion and damage.
   D. Avoid use of non-vented plastic or canvas coverings that could trap moisture.
   E. Store assemblies upright, do not stack flat. Provide space between stacked assemblies to promote air circulation.

PART 2 – PRODUCTS

2.1 MATERIALS

   A. Cold-Rolled Steel: ASTM A366, commercial quality, Class 1, stretcher-leveled, matte finish.
   B. Hot-Rolled Steel: ASTM A569, commercial quality, pickled, and oiled.
   C. Galvanized Steel:
      1. ASTM A653, G60 coating designation, zinc coated by hot-dip process, commercial quality, stretcher-leveled, mill phosphatized; or
      2. ASTM A591, Class C coating, zinc coated by electro-deposition, commercial quality, mill phosphatized.
   D. Anchor Bolts, Fasteners, and Screws: Manufacturer's standard type, except cadmium or zinc plated finish. Stainless steel also acceptable.
   E. Primer: Manufacturer’s standard rust inhibitive primer, air-dried or baked, compatible with finish painting specified in Section 09900.

2.2 FABRICATION

   A. General:
      1. Except where specified or noted otherwise, fabricate frames, door faces and edges using cold-rolled steel. Concealed stiffeners, reinforcing, and other components may be cold-rolled or hot-rolled steel at fabricator's option.
      2. Fabricate sheet metal work neat in appearance and free from defects, warps, or buckles.
      3. Accurately form metal to required sizes and profiles.
      4. Grind and dress exposed welds smooth and flush with adjacent surfaces.
      5. Remove tool marks and surface imperfections by dressing, filling, and sanding smooth. Do not use metallic filler to conceal manufacturing defects.
B. Edge Clearances:
   1. Between Bottom Edge of Door and Finish Floor at Non-Label Assemblies: In accordance with ANSI A250.8 except where larger undercuts are scheduled. Finish floor is defined as top surface of substrate. Where carpet or other applied surface materials are placed over floor substrate and greater than 1/2 inch thickness, provide ¼ inch clearance.
   2. Between Bottom Edge of Door and Threshold: 1/4 inch.
   3. Fire Rated Doors: In accordance with NFPA 80.

2.3 FABRICATION - FRAMES

A. General Requirements:
   1. Fabricate exterior assemblies of 14 gage steel, thickness as scheduled.
   2. Fabricate interior assemblies of 16 gage steel [for door openings 4’-0" or less in width, 14 gage steel for door openings over 4’-0" in width, thickness as scheduled.
   3. Welded construction required; knocked-down not acceptable.
   4. Closed or tubular members may be fabricated of two pieces if interlocked at base of stops; visible seams or joints are not acceptable.

B. Guard Box:
   1. Closed box design, 26 gage minimum, welded to frame.
   2. Required at mortise hardware cutouts for assemblies installed within masonry walls or where assemblies will have frames grouted with mortar or similar materials at time of installation.

C. Spreader: Manufacturer's standard temporary channel or angles tack welded at bottom of jamb members.

D. Floor Anchor Clips:
   1. Provide at each jamb and mullions that extend to floor.
   2. In areas where concrete topping or other similar construction occurs, provide adjustable design to permit securing to depressed subfloor construction. In lieu of adjustable design, frames may extend to subfloor.

E. Jamb Anchors:
   1. Masonry Walls: 3/16 inch diameter crimped galvanized wire or corrugated steel T-strap design. Locate near bottom of frame, near top of frame, and 32 inch centers maximum intermittently, minimum 3 per jamb.
   2. Metal Stud Wall Systems: Steel clips welded to frame, type or design compatible with stud system. Locate at top of frame, 12 inch from top, and 24 inch centers maximum intermittently, minimum 4 per jamb.
   3. Previously Placed Concrete, Masonry, or Structural Steel: Tension plate and spacer design, welded to frame at approximately 24 inch centers, minimum 3 per jamb. Frames drilled and countersunk for 1/4 inch flathead anchor bolts, set below frame surface.
   4. Label Frames: Comply with fire testing agency label and listing requirements.

F. Silencers:
1. Drill or Punch Frames for Silencers. Coordinate hole size with silencers specified in Section 08710.
2. Single Interior Doors: 3 at strike jamb.
3. Pair of Interior Doors: 2 at header.
4. Dutch Doors: 4 at strike jamb.
5. Weatherstripped doors: None required.
6. Sound, Light, or Smoke Sealed Doors: None required.
7. Transom Panels: 2 at each jamb.

2.4 FABRICATION - DOORS

A. Flush Doors:
   1. ANSI Level 2, Model 1.
   2. Core:
      a. Interior: Resin impregnated kraft paper honeycomb.
      b. Fire rated Assemblies: Mineral fiber board.
   3. Face sheets broken to form and meet in joint on stile edges, weld and grind smooth joints on stile edges.
   4. Vertical edges continuously reinforced from top to bottom with steel channels or flat bars placed immediately inside of face sheets.
   5. Reinforce top and bottom edge full width of door with steel channel not less than 16 gage.
   6. Fabricate exterior doors with top edge closed flush and fabricate bottom edge with flush closure where required for attachment of weather stripping. Provide openings in bottom closure of exterior doors to permit escape of entrapped moisture.
   7. Provide insulating material in void spaces for sound deadening in assemblies utilizing internal core of steel stiffeners.
   8. Fill face welds and surface depressions with metallic paste filler or body putty, grind smooth and flush to unblemished finish appearance.
   9. Bevel lock or latch edge 1/8 inch in 2 inches at single doors and at meeting stiles at pairs of doors.

B. Doors Scheduled to Receive Electric Hardware: Provide with electric wire conduit raceway mounted inside door running from center hinge to electric hardware location; comply with fire rating label requirements for fire-rated doors.

C. Astragals:
   1. Full height overlapping design, applied on in-active leaf at pairs of interior label doors as necessary to meet label requirements, minimum 20 gage steel.

2.5 FINISHES

A. Ferrous and Galvanized Steel Assemblies:
   1. Clean surfaces free of mil scale, rust, oil, grease, dirt, and other foreign materials.
   2. Phosphatize or chemically treat surfaces before application of prime coat finish.
   3. Touch-up areas where abrasions and welding have destroyed zinc coating with zinc-rich paint before application of prime coat finish.
4. Prime Coat: Manufacturer’s standard rust inhibitive primer to produce smooth and uniform coat.

2.6 ACCESSORIES

A. Cement Grout: Portland cement, sand and water; with minimum compressive strength of 3000 psi at seven days.

B. Bituminous Paint: Coal Tar Epoxy.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine conditions and proceed with Work in accordance with Section 01700.

3.2 INSTALLATION

A. Install hollow metal assemblies in accordance with SDI 105 and HMMA 840.

B. Comply with NFPA 80 for fire rated assemblies.

C. Set frames plumb, level, in true alignment, securely fastened to floor with expansion shields and bolts, and fastened to adjoining walls with specified jamb anchors. Remove temporary spreaders and braces.

D. Fill face of countersunk flathead frame anchors with metallic paste filler; grind smooth and flush with frame surface.

E. Install doors accurately in frames maintaining specified clearances. Install hardware in accordance with manufacturer's written instructions and associated templates. Refer to Section 08710 for hardware installation requirements.

3.3 ADJUSTMENTS

A. After installation of hardware, test and adjust doors for smooth operation.

END OF SECTION
SECTION 08710

DOOR HARDWARE

PART 1 – GENERAL

1.1 SUMMARY

A. Related Sections:
   1. Section 08100 - Metal Doors and Frames.
   2. Division 16 - Electrical: Electrical service and control power for electronic hardware.

1.2 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Product Data: Submit product data for each item.

C. Hardware Schedules:
   1. Submit schedule indicating hardware required for each opening.
   2. Use same reference numbers for openings as Drawings.
   3. Include glossary of abbreviations, symbols and codes contained in schedule.
   4. Include name and manufacturer of each item.
   5. Include type, style, model number, function, size, fastenings, finish and other pertinent data for each item.
   6. Indicate degree of opening for closers, overhead stops, overhead holders, and similar hardware items.

D. Keying Schedule:
   1. Submit separate detailed schedule for Owner’s review after Hardware Schedule has been approved.
   2. Base keying schedule on agreements made at keying conference.

E. Templates:
   1. Furnish templates and approved Hardware Schedule to door and frame fabricators. Where a fabricator cannot work to paper templates, furnish physical hardware.
   2. Ship templates and physical hardware to factories of respective manufacturers; prepay costs for shipping and delivery.
   3. Furnish layout dimensions and template data to appropriate trades for block-outs as necessary for floor closer assemblies.

F. Closeout Submittals:
   1. Submit under provisions of Section 01780.
   2. Warranty: Submit specified warranty.

1.3 QUALITY ASSURANCE

A. General Requirements:
1. Hardware has been specified by manufacturer’s name, brand and catalog numbers for purpose of establishing basis for quality, design and operational function.
2. Except where specifically indicated otherwise, equivalent products from other listed manufacturers are also acceptable.
3. Provide designated product, or where more than one product or manufacturer is listed, provide equivalent product of one of other listed manufacturers.
4. Obtain each type of hardware from single manufacturer.
5. Hardware Sets within this Section are not complete with respect to thicknesses of doors, hand, backset, method of fastening, and other detail requirements.
6. Review Drawings and Door Schedules thoroughly and provide required hardware for all openings, including openings which may have been inadvertently omitted from Door Schedules.
7. Should an opening be omitted or an opening not indicated with hardware set, provide hardware of same quality, design and function as specified for similar openings.
8. Furnish hardware complete with brackets, plates, fittings, fastenings and other accessories required for installation.
9. Provide screws, nuts, bolts, through-bolts, washers, grommets and other fastening devices necessary for proper installation of hardware; match finish of hardware being attached. Non-ferrous or corrosion resistant type required where exposed to exterior atmosphere.
11. Do not attach hardware to metal frames and metal doors with self-tapping or sheet metal screws.
12. Wood screws shall have full thread.
13. Machine screws shall have undercut head and full thread.
14. Hardware items affixed to concrete, masonry, or stone shall have machine screws and threaded expansion shields.

B. Regulatory Requirements:
1. Comply with provisions of Americans with Disabilities Act (ADA) including ADA Accessibility Guidelines and ANSI A117.1 to accommodate barrier free design.
2. Comply with provisions of NFPA 80 for hardware at fire-rated assemblies.
3. Provide hardware which has been tested and listed by UL or FM for fire-rated assemblies of types which comply with requirements of door and frame labels.

C. Hardware Supplier Qualifications: Builders hardware supplier who has been furnishing hardware in Project’s vicinity for period of not less than 5 years, and who is, or who employs an Architectural Hardware Consultant (AHC) who will be available at reasonable times during course of Work for consultation about Project’s hardware requirements.

1.4 KEYING CONFERENCE

A. Schedule Meetings with Owner to determine keying requirements; obtain final instructions in writing.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Comply with requirements of Section 01600.
B. Pack each hardware item separately. Include manufacturer’s printed installation instructions, trim, fasteners, accessories, and special tools necessary for installation.

C. Legibly mark and adequately label each package indicating opening for which intended. Provide markings corresponding with approved Hardware Schedule.

1.6 WARRANTY

A. Submit manufacturer’s warranty stating closers will be free from defects in materials and workmanship for period of 5 years from date of Substantial Completion, except for electrical or pneumatic components which are warranted for period of 2 years.

PART 2 – PRODUCTS

2.1 HINGES

A. Acceptable Manufacturers:
   1. Hager Companies, Saint Louis, MO.
   2. McKinney Hinge, Scranton, PA.
   3. Stanley Hardware, New Britain, CT.

B. Butt Hinges:
   1. Comply with ANSI A156.1 and A156.7.
   2. Five knuckle design with radius corners.
   3. Full mortise type, except where indicated as half mortise, half surface, or full surface in Hardware Sets.
   4. Non-removable pins for out-swinging exterior doors and for interior reverse bevel doors equipped with locking device; safety stud also acceptable. Non-rising pin for other doors.
   5. Non-ferrous construction at locations exposed to exterior atmosphere.
   6. Heavy weight for doors 3’-4” width and over and for fire rated doors over 8’-0” height. Standard weight at other doors.
   7. Anti-friction or ball bearing type for doors equipped with closers, and for doors 3’-0” width and over.

C. Minimum Number Hinges:
   1. Doors 5’-0” or less in height: One pair.
   2. Doors over 5’-0” and not over 7’-6”: 1-1/2 pair.
   3. Doors over 7’-6”: One for each additional 2’-6” height or fraction thereof.

D. Minimum Size and Gage:
   1. Doors 3’-0” width or less: 4-1/2 by 4-1/2 inches, 0.134 gage.
   2. Doors over 3’-0” up to 3’-4”: 5 by 4-1/2 inches, 0.146 gage.
   3. Doors over 3’-4”: 5 by 4-1/2 inches, 0.190 gage.
   4. Fire Rated Doors over 8’-0” Height: Sized as indicated above, except not less than 0.180 gage.
2.2 KEYING

A. Prepare detailed keying schedule based on results of keying conference.

B. Locksets:
   1. Key locksets and cylinders to factory established and recorded system.

C. Key to existing Sargent in sets or subsets, masterkey, and grand masterkey as directed.

D. Furnish Keys of Nickel Silver Material in following Quantities:
   1. Grandmasterkeys (MGK): 6
   2. Masterkeys (MK - each set): 10
   3. Changekeys (per lock): 2
   4. Keyed alike sets (each set): 6
   5. Emergency control keys (each type): 6
   6. Construction masterkeys: 20

E. Identify grandmaster and masterkeys with a registry number; do not stamp with "MASTER," letter M, or other similar identification.

F. Stamp grandmaster and masterkeys with "DO NOT DUPLICATE."

2.3 CYLINDERS

A. Provide cylinders for locksets, deadlocks, exit devices, and other control and locking devices indicated in Hardware Sets.

B. Provide cylinders for locking devices specified in other sections.

C. Equip cylinders with appropriate rings.

D. Finish cylinders and rings to match trim.

2.4 LOCKING AND LATCHING DEVICES

A. Manufacturers:
   1. Products specified are manufactured by Sargent Manufacturing Company, New Haven, CT. Match existing to establish standard of quality, function, and design.
   2. Products of Equivalent Quality, Function and Design by following are also acceptable:
      a. Best Lock Corporation, Indianapolis, IN.
      b. Corbin Russwin Architectural Hardware, Berlin, CT.
      c. Sargent Manufacturing Company, New Haven, CT.
      d. Schlage Lock Company, San Francisco, CA.
      e. Yale Locks and Hardware, Charlotte, NC.

B. Heavy-Duty Cylindrical Locksets and Latchsets:
   1. Acceptable Products: Sargent 10-Line key-in-lever Series, heavy duty, of functions indicated in Hardware Sets which corresponds with following designations:
      a. Passage: 10U15 (F75)
2. Standard: Comply with ANSI A156.2, Grade 1.
3. Front: 2-1/4 by 1-1/8 inches, beveled 1/8 inch in 2 inches, finish to match trim.
5. Latch Bolt:
   a. 1/2 inch minimum throw at single doors.
   b. 3/4 inch minimum throw at pair of doors.
   c. Deadlocking feature required at locksets.
6. Strike:
   a. ANSI standard, 4-7/8 inch height, 1-1/4 inch curved lip.
   b. Equip with wrought or plastic box.
   c. Finish to match trim.

2.5 EXIT DEVICES

A. Acceptable Manufacturers:
   1. Corbin Russwin Architectural Hardware, Berlin, CT.
   2. Sargent Manufacturing Company, New Haven, CT.
   3. Von Duprin, Inc., Indianapolis, IN.
   4. Yale Locks and Hardware, Charlotte, NC.

B. Acceptable Products: Sargent 80 Series touch bar design as indicated in Hardware Sets with functions and trim as noted.

C. Standards:
   1. Comply with ANSI A156.3, Grade 1.
   2. Underwriters’ Laboratories Inc. listed for "Accident Equipment List - Panic Hardware" at exit assemblies.
   3. Underwriters’ Laboratories Inc. listed for "Fire Exit Hardware" at labeled assemblies.

2.6 SURFACE MOUNTED CLOSERS

A. Acceptable Manufacturers:
   1. Sargent Manufacturing Company, New Haven, CT.

B. Standard: Comply with ANSI A156.4, Grade 1.

C. Required Features:
   1. Manufacturer’s standard cast iron or cast aluminum construction.
   2. Regular or parallel arm mounting.
   3. Rack and pinion construction with compression spring, fully hydraulic.
   5. Adjustable spring power allowing adjustment up to 50% in field to suit individual door conditions.
   6. Adjustable backcheck for interior and exterior units.
   7. Maximum operating force of 8.5 pounds for exterior doors, 5 pounds for interior doors, and 15 pounds for label doors.
   8. Size as recommended by manufacturer for door size and weight.
   9. Hold open and deadstop features where indicated in Hardware Sets.
   10. Adjustable hydraulic delayed action feature where indicated in Hardware Sets.
11. Stainless steel corrosion resistant construction where indicated in Hardware Sets.

D. Accessories:
   1. Manufacturer’s standard full size metal or non-metallic cover.
   2. Furnish with necessary arms, tracks, brackets, plates, shoes, and other accessories to suit
doors and frame conditions.
   3. Finish accessories to match cover.

E. Mounting: Refer to hardware locations.

2.7 DOOR STOPS

A. Acceptable Manufacturers:
   1. Rockwood Manufacturing Company, Rockwood, PA.

B. Provide door stops at each door leaf, except not required at doors equipped with overhead
   stops/holders, or doors equipped with closers having deadstop feature.

C. Door stops consist of floor stops or wall stops to prevent doors from striking building
   components or equipment.

D. Wall Stops:
   1. Use at all locations, except where floor stops are indicated or permitted.
   2. Ives 407 or 407-1/2 as applicable equipped with expandable anchor for use at gypsum
      board/stud walls.
   3. Ives 408 or 408-1/2 as applicable equipped with machine screw and expansion shield
      for use at concrete or masonry walls.

2.8 MISCELLANEOUS HARDWARE

A. Acceptable Manufacturers:
   1. Schlage Locks and Hardware, Charlotte, NC.
   2. Rockwood Manufacturing Company, Rockwood, PA.

B. Coordinators: Ives 900 Series with full width fillers.

C. Silencers:
   1. Type: Preformed neoprene or rubber.
   2. Location and Quantities:
      a. Pairs of doors: Two at header.
      b. Single doors: Three at strike jamb.
      c. Dutch doors: Four at strike jamb.
      d. Weatherstripped doors: Not required.
      e. Smoke sealed doors: Not required.
      f. Sound sealed doors: Not required.

2.9 WEATHERSTRIPPING, SEALS AND THRESHOLDS
A. Acceptable Manufacturers:
   1. Pemko, Ventura, CA.

B. Thresholds:
   1. Type: Extruded aluminum.
   2. Size: 5 inch width, 1/2 inch height.

C. Thresholds: Extruded aluminum of types detailed and at locations where indicated on Door Schedule.

2.10 FINISHES

A. Except where indicated otherwise in Hardware Sets, comply with following:
   Match Existing Hardware Finish:

B. Prime coated items will be field painted under Section 09900.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine conditions and proceed with Work in accordance with Section 01700.

3.2 INSTALLATION

A. Install hardware plumb, level, and true to line in accordance with manufacturer’s templates, Section 01700, and Project conditions.

B. Install fire rated hardware in accordance with NFPA 80.

C. Where cutting and fitting is required on substrates to be field painted or similarly finished, install, fit, remove and store hardware prior to finishing. Reinstall hardware after finishing operations are completed.

D. Do not install surface mounted items until finishes have been completed on the substrate.

E. Reinforce attachment substrates as necessary for installation and operation.

F. For Substrates which are not Factory Prepared for Hardware:
   1. Mortise work to correct size and location without gouging, splintering or causing irregularities in exposed finish work.
   2. Fit faces of mortised components snug and flush without excessive clearance.

G. Set thresholds at exterior doors in bed of sealant. Remove excess sealant.

H. Coordinate installation of electronic hardware with electrical fire alarm systems as applicable.

3.3 ADJUSTING
A. Check and adjust each operating hardware item to ensure correct operation and function.

B. Ensure weatherstripping and seals do not inhibit closing and positive latching of door.

C. Lubricate moving or operating components as recommended by hardware manufacturer. Use graphite type lubrication if none other is recommended.

D. Replace defective materials or units which cannot be adjusted to operate as intended. Reinstall items found improperly installed.

E. Prior to date of Substantial Completion, readjust and relubricate hardware items as necessary.

3.4 DEMONSTRATION

A. Instruct Owner’s designated personnel in proper adjustment and maintenance of hardware at time of Substantial Completion.

3.5 HARDWARE LOCATIONS

A. Butt Hinges:
   1. Top: 5 inches from inside head of frame down to top of hinge.
   2. Bottom: 10 inches from finish floor to bottom of hinge.
   3. Intermediate: Equally spaced between top and bottom hinges.
   4. Intermediate at Dutch Doors: 5 inches from split line to respective top and bottom hinges.

B. Butt Hinge Backset:
   1. 5/16 inch on frame from stop to edge of hinge mortise.
   2. 1/4 inch on door from backface to edge of hinge mortise.

C. Pivots:
   1. Top and Bottom: According to manufacturer’s templates.
   2. Intermediate: Equally spaced between top and bottom pivots.

D. Locksets and Latchsets: 38 inches from finish floor to centerline of knob or lever.

E. Push/Pull Latches: 45 inches from finish floor to centerline of latchbolt.

F. Exit Devices: 38 inches from finish floor to centerline of cross bar or touch bar.

G. Emergency Access Door Stops: 48 inches from finish floor to centerline of stop.

H. Door Closers:
   1. Degree of door swing as indicated in Hardware Schedule approved by Architect, or if not indicated, locate to permit maximum door swing.
   2. Locate on interior side of exterior doors.
   3. Locate on stair side of doors at stairways.
   4. Locate on room side for doors in public areas, corridors and other similar areas.
I. Wall Stops: Place on adjacent wall at height to contact knob, lever or pull.

3.6 HARDWARE SETS (SEE CONSTRUCTION DOCUMENTS)

END OF SECTION
SECTION 09250

GYPSUM BOARD

PART 1 - GENERAL

1.1 SUMMARY

A. Related Sections:
   1. Section 07210 - Building Insulation: Z-Shaped metal furring.

1.2 DEFINITIONS

A. Wall: A vertical building element used to enclose or separate spaces. Walls include fixed partitions.

1.3 SYSTEM DESCRIPTION

A. Fire Resistance Ratings:
   1. Where assemblies with fire ratings are indicated, provide materials and installations which are identical to assemblies tested in accordance with ASTM E119 by testing laboratories acceptable to authorities having jurisdiction.
   2. Construct assemblies identical to those indicated by reference to GA 600 or to design designations listed by Factory Mutual, Underwriters Laboratories, Warnock Hersey, or listing of other agencies acceptable to authorities having jurisdiction.

1.4 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Product Data:
   1. Submit product data for:
      a. Framing members.
   2. Include data to indicate framing member materials, product criteria, section properties, load charts, and limitations.
   3. Include information for factory finishes, and fire resistance ratings.

1.5 QUALITY ASSURANCE

A. Single Source Responsibility: Except where specified otherwise, obtain gypsum board products, trim, joint treatment, and accessories from single manufacturer or from manufacturers recommended by prime manufacturer of gypsum board products.

B. Certifications:
   1. Submit manufacturer's certification that products furnished for Project meet or exceed specified requirements.
2. Submit certification for each proposed fire rated assembly attesting compliance with indicated requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Comply with requirements of Section 01600.

B. Storage and Protection:
1. Store in dry ventilated space off ground.
2. Protect materials from surface contamination, soiling, corrosion, construction traffic, and damage.
3. Support on level platform and fully protect from weather and direct sunlight exposure.
4. Store and support gypsum board in flat stacks to prevent sagging.
5. Protect materials to keep them dry. Remove wet gypsum board from Project site.
6. Protect gypsum board panels to prevent damage to edges, ends, and surfaces.
7. Do not bend or damage metal trim.

1.7 PROJECT CONDITIONS

A. Environmental Requirements: Comply with more restrictive of ASTM C840, or manufacturer's written requirements under which products can be installed.
1. Maintain minimum uniform 50 degrees F temperature in building for 48 hours before and continuously until applied joint treatment and bonding adhesives are thoroughly dry.
2. Do not allow ambient temperature to exceed 95 degrees F.
3. Provide ventilation to remove moisture in excess of that required for drying of joint treatment materials after its application. Avoid drafts during dry, hot weather to prevent too rapid drying.

PART 2 - PRODUCTS

2.1 FRAMING MATERIALS

A. General:
1. Studs, runners, and furring channels complying with ASTM C645.
2. Provide with galvanized coating complying with ASTM A653, G40 thickness; rolled channels used in ceilings may be finished with manufacturer's standard rust inhibitive paint.

B. Steel Stud and Shaftwall Framing Systems:
1. Non-load-bearing roll formed galvanized steel.
2. Wall studs: Channel-shaped design with punched web, manufacturer's standard return flange lip.
3. Wall Stud Runners: Channel type members, with 1-1/4 inch flanges, and same sheet metal thickness as wall studs.
4. Extended Leg Ceiling Runners: Channel type members, with 2 inch flanges, and same sheet metal thickness as wall studs.
5. Bracing Members: Same size as studs.
7. Shaftwall Runners: "J" shaped runner track, same sheet metal thickness as shaftwall studs.

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9. Wall Studs:
   a. Type 25:
      1) Return flange lip minimum dimension: 3/16 inches.
      2) Flange width minimum dimension: 1-1/4 inches.
      3) Uncoated sheet steel thickness: 0.0179 inches.
   b. Type 22:
      1) Return flange lip minimum dimension: 3/16 inches.
      2) Flange width minimum dimension: 1-1/4 inches.
      3) Uncoated sheet steel thickness: 0.0270 inches.
   c. Type 20:
      1) Return flange lip minimum dimension: 3/16 inches.
      2) Flange width minimum dimension: 1-1/4 inches.
      3) Uncoated sheet steel thickness: 0.0329 inches.
   d. Type 18:
      1) Return flange lip minimum dimension: 1/2 inches.
      2) Flange width minimum dimension: 1-5/8 inches.
      3) Uncoated sheet steel thickness: 0.0478 inches.
   e. Type 16:
      1) Return flange lip minimum dimension: 1/2 inches.
      2) Flange width minimum dimension: 1-5/8 inches.
      3) Uncoated sheet steel thickness: 0.0598 inches.

10. Shaftwall Stud Uncoated Sheet Steel Thicknesses:
    a. Type 25: 0.0179 inches.
    b. Type 22: 0.0270 inches.
    c. Type 20: 0.0329 inches.

C. Resilient Furring Channels: 1/2 inch high, 26 gage uncoated metal thickness single perforated metal leg design or expanded metal double leg design furring, capable of reducing sound vibration transmission.
B. Soffit Framing - Channel and Cross Furring System:
1. Comply with ASTM C754.
2. Main Runner Channels:
   a. Cold-rolled or hot-rolled steel.
   b. Size: 1-1/2 inch minimum.
   c. Weight: 0.45 pounds per foot, minimum.
3. Furring Anchorages: 16 gage thick galvanized wire ties, or wire-type clips.

C. Soffit Attachment Devices:
1. General:
   a. Size devices for 5 times load imposed by completed system as determined in accordance with ASTM E488.
   b. Powder-actuated fasteners in concrete: Size devices for 10 times load imposed by completed system as determined in accordance with ASTM E1190.
2. Hanger Anchorage Devices: Screws, clips, bolts, inserts or other devices applicable to indicated method of structural anchorage for ceiling hangers and whose suitability for use intended has been proven by certified test data.
3. Hangers: Comply with requirements of ASTM C754 for maximum ceiling area and loads to be supported.

2.2 GYPSUM BOARD PRODUCTS

A. Acceptable Manufacturers:
1. Domtar Gypsum, Ann Arbor, MI.
2. Georgia Pacific Corporation, Atlanta, GA.
3. National Gypsum Company, Charlotte, NC.
4. United States Gypsum Company, Chicago, IL.

B. Gypsum Board:
2. Type X or manufacturer's proprietary fire rated core for fire rated and shaftwall assemblies and locations where indicated; regular type at other assemblies.
3. Maximum available lengths to minimize end-to-end butt joints, square cut ends, tapered edge.
4. Thickness: 5/8 inch, except where indicated otherwise.

2.3 METAL TRIM

A. General:
2. Material: Zinc alloy or galvanized steel.
4. Flanges designed for concealment in joint compound, flange width to suit installation requirements.

B. Corner Beads at Straight Surfaces:
1. Drywall Corner Bead, Alabama Metal Industries Corporation (AMICO), Birmingham, AL.
2. Cornerbead, Clinch-On Products, Mounds View, MN.
3. Wallboard Corner Bead, National Gypsum Company, Charlotte, NC.
4. 100 Series Dur-A-Bead, United States Gypsum Company, Chicago, IL.

C. Edge Trim Beads:
1. Drywall L-Metal, Alabama Metal Industries Corporation (AMICO), Birmingham, AL.
2. L-Bead and U-Bead, Clinch-On Products, Mounds View, MN.
3. Number 100 and 200 Wallboard Casing, National Gypsum Company, Charlotte, NC.
4. 200 Series, United States Gypsum Company, Chicago, IL.

D. Control Joints:
1. V-Shaped slot.
2. Acceptable Products and Manufacturers:
   a. N-093, Alabama Metal Industries Corporation (AMICO), Birmingham, AL.
   b. E-Z Strip Expansion Joint, National Gypsum Company, Charlotte, NC.
   c. 093, United States Gypsum Company, Chicago, IL.

2.4 JOINT TREATMENT AND ADHESIVE MATERIALS

A. Joint Compound:
2. Board manufacturer's standard ready-mixed joint compounds.
3. Compounds specifically manufactured for topping coats are not permitted for first coat on metal trim and taping.
4. Mixing:
   a. Mix compounds in strict accordance with manufacturer's directions.
   b. Mix only enough at one time to be used during recommended pot life of compound.


2.5 ACCESSORIES

A. General: Provide auxiliary materials for gypsum board construction that comply with referenced standards and recommendations of gypsum board manufacturer.

B. Backer Plates:
1. Type: 16 gage uncoated metal thickness steel sheet, galvanized in accordance with ASTM A653, G60.
2. Length: Sufficient to extend to nearest studs beyond maximum dimension of attached item and engage fasteners from attached item; span minimum 3 studs.
3. Height: 6 inch minimum or higher where required to accommodate item being fastened.
4. When manufacturer of attached item has more rigorous mounting plate requirements, comply with manufacturer's requirements.

C. Fasteners:
1. Fasteners for Metal Framing:

09250-5 GYPSUM BOARD
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Revision 0 – July 11, 2017
a. Provide fasteners of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel framing and furring members securely to substrates involved.
b. Comply with the gypsum board manufacturer requirements for indicated applications.

2. Gypsum Board Fasteners:
a. Self-drilling, self-tapping, bugle head screws conforming to ASTM C1002, length to suit application.
b. Type S screws for 0.0329 to 0.0179 inches; 21 to 26 gage thick metal framing and furring.
c. Type S-12 screws for 0.1046 to 0.0359 inches; 12 to 20 gage thick metal framing and furring.
d. Type G screws for gypsum board to gypsum board.

D. Acoustical Insulation:
1. Comply with ASTM C665, Type I.
2. Mineral or glass fiber, friction fit, without integral vapor barrier membrane.
3. Flame spread 25 or less when tested in accordance with ASTM E84.
4. Thickness indicated in wall details.
5. Fire-rated assemblies: Use mineral fiber products; do not use glass fiber products.
6. Non-fire-rated assemblies: Use glass or mineral fiber products.
7. Acceptable Mineral Fiber Products:
   a. FBX 450, Fibrex, Westmont, IL.
   b. Thermafiber Sound Attenuation Fire Blankets, United States Gypsum Company, Chicago, IL.


2.6 TEXTURE MATERIALS

A. Primer or Sealer: Type required by texture coating manufacturer.

B. Wall Texture Coating:
1. Description:
   a. Non-aggregated texture compound.
   b. Spray or trowel applied.
   c. Flame spread and smoke developed rating not greater than 25 when tested in accordance with ASTM E84.
   d. Texture: Smooth.

2. Acceptable Products:
   a. Gyptex Ready-Mix Stucco, Domtar Gypsum, Ann Arbor, MI.
   b. G-P Wall Texture, Georgia Pacific Corporation, Atlanta, GA.
   c. Perfect Spray HF, National Gypsum Company, Charlotte, NC.
   d. Spray Texture Finish, United States Gypsum Company, Chicago, IL.]
2.7 SHEATHING JOINT TREATMENT

A. Sheathing Tape:
   1. Description:
      a. Self-adhering rubberized asphalt tape.
      b. Capable of being applied at temperature of 25 degrees F.
      c. Thickness: 30 mils.
      d. Permeance: 0.1 perms.
      e. Puncture Resistance: ASTM E514, 40 pounds-force, minimum.
      f. Tensile Strength of Membrane: ASTM D412, 600 psi, minimum.
      g. Pliability: 180 degree bend over 1 inch at 25 degrees F.
      h. Primer: Manufacturer's required surface primer.
   2. Acceptable Products and Manufacturers:
      a. JT-30 Exterior Sheathing Joint Tape, Polyguard Products, Inc., Ennis, TX.


PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions and proceed with work in accordance with Section 01700.

B. Verify rough-in utilities and blocking are in proper position.

3.2 PREPARATION

A. Items Which Require Backer Plates or Blocking:
   1. Coordinate sizes and locations.
   2. Install additional studs for attachment of backer plates and blocking in required locations to receive surface mounted accessories as indicated or as required by accessory manufacturer.
   3. Elimination of backer plates and blocking is not permitted.
   4. Direct attachment of items to studs is not permitted.

3.3 FRAMING INSTALLATION

A. General:
   1. Install in accordance with manufacturer's printed instructions, Town of Oro Valley standards, except for more stringent requirements of these specifications.
   2. Install units plumb, level, square, and free from warp and twist while maintaining dimensional tolerances and alignment with surrounding construction.
   3. Control and Expansion Joints:
      a. Do not bridge building control and expansion joints with metal framing systems.
      b. Install independent framing on each side of joints.
      c. Comply with manufacturer requirements for constructing control and expansion joints in fire-rated and shaftwall assemblies.
B. Framing:
   1. Install in accordance with ASTM C754 and with requirements of ASTM C840 that apply to framing installation, except for more stringent requirements of manufacturer or these Specifications.
   2. Soffits:
      a. Install channel and cross-furring in accordance with ASTM C754.
      b. Install proprietary systems in accordance with ASTM C636.
      c. Coordinate location of hangers and framing with other construction above ceiling line.
      d. Install ceiling framing independent of walls, columns, and above ceiling non-structural construction, unless otherwise required by fire-rated assembly requirements.
      e. Install free from contact with insulation and other objects within ceiling plenum that are not part of supporting structural or ceiling suspension system.
      f. Offset hangers only where required to miss obstructions; resist resulting horizontal forces by bracing, or other means.
      g. Where width of ducts and other construction within ceiling plenum produces interference with location of hangers required to support standard suspension system members:
         1) Install supplemental suspension members and hangers in form of trapezes or equivalent devices.
         2) Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards.
      h. Do not connect or suspend steel framing from pipes, ducts, and conduit.
      i. For proprietary grids, provide attachments and hangers from structural support above, spaced on a grid of 24 by 48 inches.
      j. Do not attach hangers to steel deck tabs or directly to metal roof deck. Provide supplementary framing to span between structural framing members when structural framing members are spaced more than 48 inches apart.
      k. Reinforce openings in framing which interrupt main runners, furring channels, and bracing. Extend reinforcing minimum of 24 inches past each end of each opening.
      l. Proprietary Direct Hung Framing: Tie direct to suspension; interconnect components in accordance with framing system manufacturer's instructions.
      m. Space main runners at maximum 48 inches on center, unless otherwise indicated.
      n. Space furring channels at maximum 16 inches on center, unless otherwise indicated.
      o. Provide additional framing to fulfill structural requirements and for support at recessed fixtures and similar items.
      p. Laterally brace entire suspension system.
   3. Studs and Runners:
      a. Runner Tracks: Provide continuous tracks sized to match studs.
      b. Where walls are indicated to extend to overhead surfaces (ceilings, deck construction, and structural elements), to prevent deflection transfer of structural loads or movements to walls provide either:
         1) Insert studs into runner tracks with minimum 1/2 inch gap between end of stud and inside surface of top and bottom runner. Maintain minimum of

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Revision 0 – July 11, 2017
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1/2 inch engagement between end of stud and end of legs of top and bottom runners.

2) Slip joint between walls and structure using top runner nested within 3 inch long segment of extended leg ceiling runner positioned at stud spacing and fastened to overhead surface. Do not fasten top runner to extended leg ceiling runner.

c. Terminate top of walls above ceiling construction, unless otherwise indicated.

d. Brace stud framing rigid which is not clad on both sides with gypsum board. Fasten horizontal stud or 1-1/2 inch wide 20 gage galvanized steel straps vertically spaced no more than 36 inches apart with top strap no more than 6 inches from top of wall.

e. Horizontally align openings in stud webs.

f. Use full length studs vertically positioned between runner tracks.

g. Minimum Jamb Stud Framing at Door Openings:

1) Walls laterally braced by ceiling framing or structure at 9'-0" above finish floor:
   (a) Single Doors not Larger than 3'-6" by 9'-0" and not Weighing more than 275 Pounds: 2 Type 25 studs or 1 Type 20 stud.
   (b) Paired Doors not Larger than 3'-6" by 9'-0" per leaf and not Weighing more than 275 Pounds per Leaf: 2 Type 20 studs or 1 Type 18 stud.

2) Walls Laterally Braced by Ceiling Framing or Structure at 12'-0" above Finish Floor:
   (a) Single Doors not Larger than 3'-6" by 9'-0" and not Weighing More than 275 Pounds: 2 Type 20 studs or 1 Type 18 stud.
   (b) Paired doors not larger than 3'-6" by 9'-0" per leaf and not weighing more than 275 Pounds per leaf: 2 Type 18 studs.

3) At welded frames with fixed anchor clips, secure studs to jamb anchors clips with not less than two self tapping screws per clip.

4) Provide wall framing above door openings to match wall framing adjoining the opening.

5) Provide one additional stud not more than 6 inches from jamb studs.

6) At fire-rated doors use minimum thickness of Type 20 studs, unless otherwise indicated.

7) Comply with GA-219 for fire-rated doors.

h. Minimum Window and Wall Opening Framing:

1) Provide 2 Type 25 studs at each jamb or provide 1 Type 20 stud at each jamb.

2) Provide wall framing above and below window and wall openings with wall framing to match wall framing adjoining the opening.

3) Provide 1 additional stud not more than 6 inches from jamb studs.

i. Fabricate corners with a minimum of three studs.

j. Provide additional studs and framing to support wall intersections, termination of walls, at openings and cut-outs and to support built-in anchorage and attachment devices for other work.

k. Locate studs no more than 2 inches from abutting walls, wall corners and other construction. Start typical wall studs 6 inches either side of stud reinforcing or frames.
l. Install electrical outlets and similar at indicated locations. Provide additional blocking and straps for proper locations; do not mount on "nearest" stud.

m. Install steel studs so that flanges point in the same direction and so that leading edges or ends of each gypsum board can be attached to open (unsupported) edges of stud flanges first.

4. Shaftwalls:
   a. Position top and bottom "J" runners with short leg toward the finish side of the wall and securely fasten to the construction at both ends and at intermediate points, maximum 24 inches apart.
   b. Isolate shaftwall framing from transfer of structural loading to system, both horizontally and vertically. Provide slip or perimeter movement relief type joints in accordance with manufacturer's instructions to attain lateral support and avoid axial loading.
   c. Support elevator hoistway door operating equipment independently of shaftwall framing system.
   d. Frame opening for elevator hoistway door frame in accordance with requirements of elevator and shaftwall manufacturers.
   e. Install supplementary framing, and bracing to support fixtures, equipment, services, heavy trim, furnishing and similar work which cannot be adequately supported directly on shaftwall framing.

5. Wall furring:
   a. Install furring channels either vertically or horizontally.
   b. Space furring at a maximum of 16 inches on center.
   c. Fasten furring to substrate with fasteners at 24 inches on center staggered through alternate wing flanges.
   d. Install corner furring channels in manner equivalent to furring on remainder of wall.

6. Backer Plates:
   a. Provide backer plate for securing surface mounted fittings, fixtures, accessories, and furnishings, including, but not limited to handrails, grab bars, toilet walls, towel bars, wall mounted door stops, and similar screw- and bolt-fastened items.
   b. Secure with sufficient quantity of self-tapping sheet metal screws to sustain loads imposed by items attached to backer plates.

7. Blocking: Coordinate with Section 06100 for installation of concealed wood blocking and furring required for securing wood trim, carpentry, woodwork, cabinets, millwork, casework, surface mounted equipment, and similar nail-fastened items.

3.4 GYPSUM BOARD INSTALLATION

A. General:
   1. Comply with more stringent requirements of GA 216, ASTM C840, manufacturer, and these Specifications.
   2. Install gypsum board in accordance with GA 600 for fire-rated assemblies.
   3. Install gypsum board panels with face side out.
   4. Use boards of maximum length to minimize end joints.
5. Abut boards without forcing; neatly fit ends and edges of board and do not place butt ends against tapered edges with gap between adjacent panels no greater than 1/16 inch. Hold bottom of board 1/4 inch above floor.

6. Support ends or edges of board directly on framing or furring members.

7. Joint Staggering:
   a. Ceilings: Stagger end joints not less than one framing member.
   b. Walls: Stagger vertical joints on opposite side of walls to occur on alternate framing members.
   c. Fire-Rated Assemblies: Comply with fire-rated assembly design requirements for joint staggering.

8. Do not locate gypsum board joints within 12 inches of external corners of windows, doors, or other such openings, except when control joints are installed at corners.

9. Cut openings in board with no greater than 1/4 inch gap around electrical outlets, plumbing, light fixtures, piping and other similar penetration items and small enough to be covered by plates and escutcheons; coordinate size of gap around penetrations in fire-rated assemblies with firestopping requirements of Section 07840.

10. Do not install imperfect, damp, and damaged boards.

11. In concealed spaces above ceilings where designated walls extend full height to structure above, install boards in full coverage on both faces of framing system for fire, sound, air, and smoke-rated walls.

12. Fit gypsum panels around ducts, pipes, and conduits.

13. Where walls intersect open concrete coffers, concrete joists, and other structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by coffers, joists, and other structural members; allow 1/4 to 1/2-inch wide joints to install sealant.

14. In concealed spaces above ceiling where designated chase walls extend full height to structure above, install boards in full coverage on one face of framing system. Fasten horizontal stud or 1-1/2 inch wide 20 gage galvanized steel straps vertically spaced no more than 36 inches apart with top strap no more than 6 inches from top of wall.

15. Attach gypsum panels to steel studs so that leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.

16. Attach gypsum panels to framing provided at openings and cutouts.

17. Isolate perimeter of non-load-bearing gypsum board walls at structural abutments, except floors, as detailed. Provide 1/4 to 1/2-inch wide spaces and trim edges with LC-bead edge trim where edges of gypsum panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant for exposed locations.

18. Do not attach gypsum panels across the flat grain of wide-dimension lumber including floor joists and headers. Float gypsum panels over these members using resilient channels or provide control joints to counteract wood shrinkage.

19. Floating Construction: Where feasible, including where recommended by manufacturer, install gypsum panels over wood framing, with floating internal corner construction.

20. Control and Expansion Joints:
   a. Do not bridge building control and expansion joints with gypsum board.
   b. Terminate gypsum board on each side of joints.
   c. Comply with manufacturer requirements for constructing control and expansion joints in fire-rated and shaftwall assemblies.
B. Fasteners:
   1. Attachment Methods:
      a. Attach board to framing and furring with screws.
      b. Attach board to board with screws.
   2. Except where indicated otherwise or where required for fire rated assemblies, space
      fasteners in compliance with more restrictive requirements of referenced installation
      standards or manufacturer's requirements.
   3. Attach board to supplementary framing and blocking which provide additional support
      at openings and cutouts.

C. Ceilings:
   1. Place with long edge perpendicular to orientation of furring or framing members.

D. Single Layer Wall Installation: Install vertically in manner which will minimize end-butt
   joints, unless specific orientation is required by fire-rating design.

E. Double Layer Wall Installation:
   1. Install gypsum board for base layer, place long edge parallel to framing or furring
      members, unless specific directional requirement is established by fire-rating design.
   2. Install gypsum board for face layer, place parallel to base layer with offset joints, unless
      specific direction is required by fire-rating design.
   3. Secure base layer with fasteners.
   4. Secure face layer with fasteners or adhesive supplemented with fasteners, except where
      fire rated assemblies require only fasteners.

F. Shaftwalls:
   1. Install gypsum liner panels between framing members in accordance with manufacturer
      requirements.
   2. For double layer gypsum board finish, fasten base layer vertically over studs. Install
      face layer vertically over base layer with joints staggered, screw attached through base
      layer into studs.
   3. Finish face layer joints as specified for "Gypsum Board Treatments."

3.5 TRIM INSTALLATION

A. Install trim flush using longest practical length; miter corners and intersections.

B. Fasten flanges by screws, stapling, or clinching in accordance with manufacturer's instructions.

C. Install corner beads at visually-exposed external corners, unless otherwise indicated.

D. Install edge trim where edge of board would be exposed or semi-exposed and where board
   abuts dissimilar materials.

E. Control Joints: Coordinate placement and locations with Architect prior to commencement of
   work. Install control joints in accordance with following:
   1. Locate at joints of maximum stress, at points of natural weak planes, such as at openings
      and at corners of offsets in walls exceeding 30'-0" in length.
2. Extend control joints from both corners of door frames to top of wall where doors occur in long runs of wall.
3. Where gypsum board is vertically continuous, as at stairwells and other long vertical wall areas, provide horizontal control joints at each floor level at top runner of shaftwall, at slip joints in shaftwall framing, and breaks in shaftwall framing.
4. Locate in ceilings with area exceeding 900 square feet, where framing or furring changes direction, and spaced apart not more than 30'-0".
5. Locate in ceilings where wings of "L", "U", and "T" shaped areas are joined.
6. Provide mineral fiber acoustical insulation or gypsum panel backing at control joints in fire-rated assemblies to maintain fire rating.

3.6 GYPSUM BOARD TREATMENTS

A. General:
1. Apply joint treatment to gypsum board joints (both directions); flanges of corner beads, edge trim, and control joints; penetrations; fasteners; surface defects; and elsewhere to prepare surfaces for decoration and specified levels of gypsum board finish.
2. Comply with manufacturer requirements for hardening and drying of joint treatment prior to application of succeeding coats.

B. Prefill: Fill open joints, rounded and beveled edges, and damaged areas, flush with adjoining surfaces using prefill compound.

C. Apply joint tape over gypsum board joints.

D. Levels of Finish:
1. Locations to Receive Level 4 Finish: Areas to be painted.
2. Locations to Receive Level 2 finish:
   a. Fire-rated assemblies in ceiling plenums concealed areas gypsum board used as a tile substrate.

3.7 ADJUSTING

A. Adjust and align metal framing to properly receive final finishes in accordance with required tolerances.

B. Correct damages, defects, and leave work ready for decoration. Clean compounds from trim. Visible cracks, nail heads, tool marks, waves, distortions, or other similar defects shall not appear in finished work.

3.8 CLEANING

A. Clean as recommended by manufacturer. Do not use materials or methods which may damage finish or surrounding construction.

B. Promptly remove joint compound from surfaces not intended to receive compound.
3.9 PROTECTION

A. Protect finished work in accordance with Section 01700.

B. Protect metal framing from damage detrimental to finished work.

END OF SECTION
SECTION 09510
ACOUSTICAL CEILINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Suspended exposed grid ceiling system.

B. Products Furnished But Not Installed Under This Section: Anchors or inserts for suspension system.

1.2 SYSTEM REQUIREMENTS

A. Interface With Other Systems: Coordinate layout and installation of acoustical ceiling units and suspension system components with other work supported by, or penetrating through, ceilings, including light fixtures, HVAC equipment, fire-suppression system components and partition system.

1.3 SUBMITTALS

A. General: Submit following items in accordance with Section 01330.

B. Product Data: Submit product data for each acoustical material and suspension system component.

C. Submit following Informational Submittals:
   1. Qualification Data: Installer's qualification data.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Company specializing in acoustical ceiling work having minimum of 3 years successful documented experience with work comparable to that indicated and specified.

B. Regulatory Requirements: Conform to local code for combustibility requirements for materials.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, handle, and protect products in accordance with Section 01600.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Permit acoustical materials to reach room temperature and a stabilized moisture content before installation.
B. Maintain uniform temperature of minimum 60 degrees F and humidity of 20 percent to 40 percent prior to, during, and after installation.

1.7 SEQUENCING

A. Do not install interior acoustical ceilings until space is enclosed and weatherproof, wetwork in space is completed and nominally dry, and work above ceilings is complete.

1.8 EXTRA STOCK AND MATERIALS

A. Furnish under provisions of Section 01780.

B. Deliver one percent of installed quantity of each type and color of tile and suspension system component installed.

C. Store at Job Site where directed. Ensure materials are boxed and identified by manufacturer, style and color.

D. Furnish full size units, matching material installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
   1. Acoustic Tile:
      a. USG Interiors, Inc., Chicago, IL.
      c. Celotex Roofing Products, Tampa, FL.
   2. Suspension System:
      a. USG Interiors, Inc., Chicago, IL.
      c. Chicago Metallic, Chicago, IL.
      d. Worthington Steel, Malvern, PA.

2.2 MATERIALS

A. Acoustic Panel:
   2. Thickness: 5/8 inch.
   3. Light Reflectance: 0.79.
   4. NRC Range: 0.55-0.65.
   6. Fire classification: Class A.
   8. Edge: Square.
11. Acceptable Products:
   a. Cleanroom Clima Plus, USG Interiors, Inc., Chicago, IL.

B. Exposed Suspension System:
   1. Grid: ASTM C635, intermediate duty, exposed gasketed T flanges; wide-face; steel capped; double-web; interlocking components; butt-edge cross tees.
   2. Grid Materials: Cold-rolled steel with galvanized coating.
   4. Acceptable Products:
      a. Donn CE, USG Interiors, Inc., Chicago, IL.

C. Suspension System Accessories:
   1. Manufacturer's standard trim and edge moldings to suit suspension system requirements; same finish as suspension system.
   2. Provide edge moldings to fit penetrations exactly, including circular penetrations.
   3. Provide hold-down clips, required for suspended grid system.

D. Attachment Devices:
   1. General: Size devices for 5 times loads imposed by complete system.
   2. Hanger Wire Form Inserts: No. 6 galvanized wire loop and 26 gage galvanized shell, or 14 gage galvanized steel strap with 5/16 inch hole.
   3. Hangers:
      a. As recommended by manufacturer and as required to comply with structural classification.
      b. Wire Hangers: ASTM A641, not less than 12 gage, galvanized carbon steel wire, soft temper, pre-stretched.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine conditions and proceed with work in accordance with Section 01700.

3.2 INSTALLATION
   A. General: Install acoustical panel ceilings to comply with publications referenced below per manufacturer's instructions and CISCA "Ceiling Systems Handbook."
      1. Install system in accordance with ASTM C636, except for more stringent requirements of manufacturer or these specifications.

   B. Install system capable of supporting imposed loads with maximum deflection of 1/360.

   C. Hanger Installation:
      1. Coordinate location of hangers with other work.
      2. Secure hangers or rods as required to structural support by connecting directly to structure where possible, otherwise connect to inserts, clips or other anchorage devices or fasteners.
3. Do not attach hangers directly to metal roof deck. Provide supplementary framing if necessary.
4. Space hangers not more than 6 inches from each ceiling edge.
5. Provide sufficient additional hangers for support of fixtures and other items supported by ceiling suspension system to prevent eccentric deflection or rotating of supporting runners. Provide hangers on crossrunners within 6 inches of grid intersections to support light fixtures.
6. Hang system independent of columns, ducts, pipes, and conduit.
7. Where carrying members are spliced, avoid visible displacement of face plane of adjacent members.
8. If ducts of other equipment prevent the regular spacing of hangers, reinforce nearest affected hangers to span extra distance.

D. Center system on room axis leaving equal border units.

E. Edge Molding Installation:
1. Install edge moldings where ceilings abut walls, partitions or other penetration elements.
2. Miter cut inside and outside corners to provide flush, tight, hairline joints.

F. Panel Installation:
1. Install in level and uniform plane; free from twist, warp and dents.
2. Rest edges on flanges of tees.
3. Support perimeters on wall moldings.
4. Neatly scribe and cut boards for accurate fit at borders, interruptions, and penetrations by other work.
5. Lay directional patterned units one way with pattern parallel to longest room axis.

G. Tile Installation
1. Install tiles in level and uniform plane; free from twist, warp and dents.
2. Support perimeters on wall moldings.
3. Neatly scribe and cut boards for accurate fit at borders, interruptions, and penetrations by other work.
4. Lay directional patterned units one way with pattern parallel to longest room axis.
5. Verify that access to plenum is achieved.

H. Site Tolerances:
1. Level completed assembly to tolerance of 1/8 inch in 10 feet.
2. Variation from Plumb of Grid Members Caused by Eccentric Loads: Two degrees maximum.

3.3 CLEANING

A. Clean exposed surfaces of exposed metal ceiling grid, trim, and edge moldings. Comply with manufacturers' instructions for cleaning and touchup of minor finish damage.

B. Remove and replace work that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage, including dented and bent units.
PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Preparation and priming of surfaces scheduled at end of this Section to receive finish coatings.
   2. Painting and finish coating of exterior and interior items and surfaces, including:
      a. Exposed interior surfaces.
   3. Exterior and interior items and surfaces not requiring painting, unless noted otherwise:
      a. Surfaces coated by other specification sections.
      b. Items with factory applied finishes.
      c. Aluminum, stainless steel, brass, bronze, chromium plate, copper, and nickel.
      d. Brick, stone, ceramic tile, plastic laminate, and precast concrete.
      e. Moving parts of operating units.
      f. Code required labels or equipment identification plates.
      g. Acoustical ceilings.
   4. Field finish coating of shop or factory primed items. Refer to individual Sections for priming requirements.
   5. Finish coatings schedule.
   6. Preparation work and coatings specified in this Section are in addition to shop and factory applied finishes and surface treatment specified in other Sections.
   7. Refer to Divisions 15 and 16 for painting requirements for items in dedicated mechanical and electrical spaces.
   8. Paint all other items unless specifically indicated not to be painted.

1.2 DEFINITIONS

A. Conform to PDCA Glossary for interpretation of terms used in this Section except as modified below.

B. Exposed Surfaces: Surfaces of products, assemblies, and components visible from any angle after final installation. Includes internal surfaces visible when operable doors, panels or drawers are open, and surfaces visible behind registers, grilles, or louvers.

C. Concealed Surfaces: Surfaces permanently hidden from view in finished construction and which are only visible after removal or disassembly of part or all of product or assembly.

D. Inaccessible Spaces: Spaces not intended for human use.

E. Spaces listed below are defined as "Concealed" or "Inaccessible":
   1. Space between suspended ceilings and floor or roof construction above.
2. Inside furred spaces.
3. Inside of partitions.
4. Mechanical and electrical items enclosed within casework or equipment.
5. Foundation spaces.
7. Trenches and manholes.
8. Mechanical shafts or chases.
9. Enclosed elevator shafts [unless visible through glass panels].
10. Utility tunnels.

F. Sheen: Degree of luster as measured with specular gloss meter in accordance with ASTM D523:
   - Flat: 85 degree meter Below 15
   - Eggshell: 60 degree meter 5 to 20
   - Satin: 60 degree meter 15 to 35
   - Semi-gloss: 60 degree meter 30 to 65
   - Gloss: 60 degree meter 65 to 80
   - High Gloss: 60 degree meter Over 80

G. Architectural Coatings: Coatings, field applied to stationary structures and their appurtenances, mobile homes, pavements, or curbs.

H. Industrial Maintenance Primers and Topcoats: High performance coatings formulated for and applied to substrates in industrial, commercial, or institutional situations for purpose resisting heavy abrasion, immersion, prolonged exposure to temperatures in excess of 250 degrees F, prolonged moisture condensation, chemical corrosion, solvent cleaning, or exterior exposure of metal structures.

I. Metallic Pigmented Coatings: Coatings containing at least 0.4 pounds of metallic pigment per gallon of coating as applied.

J. System DFT: Dry film thickness of entire coating system unless otherwise noted.

1.3 SYSTEM REQUIREMENTS

A. Perform testing according to following methods:

B. Application Requirements: Apply scheduled coatings to exposed surfaces of items and spaces unless specifically indicated otherwise.

C. Surfaces Not To Be Painted:
   1. Exposed concrete.
   2. Aluminum and aluminum based alloys, copper and copper based alloys, lead and lead based alloys, nickel and nickel based alloys, stainless steel, plated architectural metals, and "weathering" metals.
3. Decorative plastic and metal laminates, and synthetic countertops.
4. Elastomeric membranes and flashings, roofing materials, and exterior sealants and caulking.
5. Acoustic materials.
6. Rubber, vinyl, or plastic seals and bumpers.
7. Surfaces concealed or inaccessible in finished construction unless specifically required.
8. Other surfaces specifically scheduled or indicated to remain unfinished or unpainted.
9. Exposed roof structural members.

D. Materials and Products Not To Be Painted:
1. Items with integral or factory-applied final finish unless indicated otherwise.
2. Wire fencing and areaway grating.
3. Trench drain grates, manhole covers, and curb inlets.
4. Wire mesh partitions and gates, metal and wire storage shelving.
5. Moving parts of operating equipment such as valve and damper operators, linkages, sensing devices, motor and fan shafts.
6. UL, FM or other code-required labels, name plates, identification or performance rating labels.
7. Sprinkler heads.
8. Mechanical and electrical items within unfinished spaces unless noted otherwise.

E. Interface with Adjacent Systems:
1. Review other Sections specifying prime coats to ensure compatibility of total coating system for various substrates.
2. Upon request from other trades, furnish information on characteristics of finish materials proposed for use to ensure compatibility of various coatings.
3. Test compatibility of existing coatings, including shop applied primers and previously applied coatings, by applying specified special coating to small, inconspicuous area.
4. If specified coating lifts or blisters existing coating, apply barrier or tie coat as recommended by coating manufacturer.
5. If no compatible barrier or tie coat exists, remove existing coating completely and apply coating system as specified for new work.

1.4 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Product Data:
1. Submit product data, including label analysis for each product proposed for use.
2. Specifically include percent solids-by-volume and lead content percent of weight of dried film.
3. Schedule:
   a. List each material proposed for use, and cross-reference to specific coating system and substrate application.
   b. Identify each material by manufacturer's catalog number, product name, and generic classification.
c. Include typewritten list identifying coating systems and colors applied to each room, space, or item.

C. Color and Sheen Samples:
1. Prepare 2 samples of each opaque finish coating specified in each color and sheen scheduled for appearance verification.
2. Apply to 12 by 12 by 1/4 inch hardboard. Apply sufficient coating thickness to provide proper hiding and appearance.
3. Label each sample to indicate material, color, and sheen.

D. Coating System Samples:
1. Prepare 2 samples of each opaque coating system scheduled on actual substrate materials proposed for use. Apply in most common top coat color scheduled.
2. Step back each coat and process at least one inch to show bare substrate and each coat and process in system build-up.
3. Minimum sample size of 4 by 8 inches.
4. Label each sample to indicate materials, color, sheen, DFT of each coat applied, and total system DFT.

E. Submit following Informational Submittals:
1. Certifications specified in Quality Assurance article.
2. Qualification Data: Applicator's qualification data.
3. Manufacturer's instructions.

F. Closeout Submittals:
1. Submit under provisions of Section 01780.
2. Warranty: Submit specified warranty.

1.5 QUALITY ASSURANCE

A. Single Source Responsibility: Provide products of single manufacturer for use in each coating system. Do not mix products of different manufacturers without approval of Architect and manufacturers involved.

B. Applicator Qualifications: Company specializing in commercial painting and finishing with 3 years documented experience.

C. Regulatory Requirements:
1. Comply with CPSC 16 CFR 1303 and other applicable federal, state, and local regulations limiting lead content of coatings to be applied.

D. Certifications: Submit certification from manufacturer that materials furnished for use on this Project meet or exceed specified requirements and comply with applicable federal, state, and local requirements regarding lead content.

1.6 DELIVERY, STORAGE, AND HANDLING
A. Comply with requirements of Section 01600.

B. Deliver products to site in manufacturer's sealed and labeled containers; inspect to verify compliance with specified requirements.

C. Label containers to indicate manufacturer's name, product name and type of coating, brand code or stock number, date of manufacture, coverage, surface preparation, drying time, cleanup, color designation and instructions for mixing and reducing.

D. Store coating materials in tightly covered containers in well ventilated area at ambient temperatures of 45 degrees F minimum and 90 degrees F maximum, unless required otherwise by manufacturer. Maintain containers in clean condition, free of foreign materials and residue with labels in legible condition.

E. Take precautionary measures to prevent fire hazards and spontaneous combustion.

1.7 PROJECT CONDITIONS

A. Environmental Conditions: Comply with more restrictive of following or manufacturer's requirements under which systems can be applied.
   1. Provide continuous ventilation during application of coatings to exhaust hazardous fumes.
   2. Provide heating necessary to maintain surface and ambient temperatures within specified limits.
   3. Maintain temperature and humidity conditions for minimum 24 hours before, during, and 48 hours after application of finishes, unless longer times are required by manufacturer.
   4. Do not permit wide variations in ambient temperatures which might result in condensation on freshly coated surfaces.
   5. Provide illumination of not less than 80 footcandles measured mid-height at substrate surface during application of coatings.
   6. Apply water reducible coatings only when ambient and surface temperatures are between 50 degrees F and 90 degrees F.
   7. Apply solvent reducible coatings only when ambient and surface temperatures are between 45 degrees F and 90 degrees F.
   8. Do not apply coatings under any of following conditions:
      a. When surfaces are damp or wet.
      b. During snow, rain, fog, or mist.
      c. When relative humidity is less than 20 percent or exceeds 85 percent.
      d. When temperature is less than 5 degrees F above dew point.
      e. When dust may be generated before coatings have dried.
      f. In direct sunlight.
      g. When wind velocity is above 20 mph.
   9. Application of coatings may continue during inclement weather provided work areas and surfaces to be coated are enclosed and specified environmental conditions are maintained.

1.8 WARRANTY
A. Comply with provisions of Section 01780.

B. Warrant installation to be free from defects in material and workmanship for 2 years.

C. Repair or replace defects occurring during warranty period.

D. Defects include but are not limited to pinholes, crazing or cracking, loss of adhesion to substrate, deficient thickness, improper materials and workmanship.

1.9 EXTRA STOCK MATERIAL

A. Furnish under provisions of Section 01780.

B. Provide 1 unopened gallon container of each type of opaque top coating in each color and sheen used on Project.

C. Store where directed with labels intact.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:
   1. Benjamin Moore and Company, Montvale, NJ.
   2. ICI Paints, Cleveland, OH.
   3. PPG Industries, Inc., Pittsburgh, PA.
   4. Pratt and Lambert Specialty Products, Cleveland, OH.
   5. Tnemec Company, Inc., Kansas City, MO.
   6. Dunn-Edwards Corporation, Los Angeles, CA.
   8. KWAL Paints, Denver, CO.
   10. Ladehoff Paint and Manufacturing Company, Mesa, AZ.
   11. Wellborn Paint Manufacturing, Albuquerque, NM.

B. Listing of products by manufacturer's trade name is not intended to exclude equivalent products by other manufacturers identified above. For products not specifically named, submit substitution request in accordance with Section 01630.

2.2 COATING MATERIALS - GENERAL

A. Coatings:
   1. Ready-mixed, factory tinted, best professional grade produced by manufacturer.
   2. Fully grind pigments to maintain soft paste consistency in vehicle.
   3. Capable of being dispersed into uniform, homogeneous mixture.
   4. Possess good flowing and brushing properties.
5. Capable of drying or curing free of streaks or sags, and yielding specified finish.

2.3 PRIME COATINGS

A. Alkali Resistant Primer:
   1. Benjamin Moore and Company: Moore’s Latex Quick Dry Prime Seal No. 201-00
   3. PPG Industries, Inc.: Alkali Resistant Primer No. 6-3.

B. Alkyd Enamel Undercoater:
   3. PPG Industries, Inc.: Speedhide Quick Drying Enamel Undercoater, 6-6.

C. Alkyd-Phenolic Primer:
   1. ICI/Devoe Paints: Devguard Multi-Purpose Metal Primer No. 4160.
   2. PPG Industries, Inc.: Multiprime Universal Primer No. 97-682.

D. Etching Metal Primer:
   1. PPG Industries, Inc.: Polyclutch Wash Primer No. 97-687.
   2. Tnemec Company, Inc.: Tneme-Grip No. 32-1210.

E. Ethyl Silicate Zinc Primer:
   1. ICI/Devoe Paints: Catha-Coat Alkyl Silicate Inorganic Zinc Coating No. 304V.

F. Exterior Alkyd Primer:
   5. Tnemec Company, Inc.: Undercoater No. 36-603.

G. Galvanized Primer:
   1. ICI/Devoe Paints: Devguard Multi-Purpose Metal Primer No. 4160.
   2. PPG Industries, Inc.: Galvanized Steel Primer No. 6-209.

H. Latex Primer:
   2. ICI Paints: Ultra-Hide PVA Interior Primer-Sealer No. 1030.
   3. PPG Industries, Inc.: Speedhide Latex Wall Sealer No. 6-2.
   5. Tnemec Company, Inc.: PVA Sealer No. 51-792.
I. Long-Oil Alkyd Primer:
   1. ICI/Devoe Paints: Devguard All-Purpose Metal Primer No. 4120.
   2. PPG Industries, Inc.: Speedhide Alkyd Red Rust Inhibitive Steel Primer, 6-208.

2.4 WATER REDUCIBLE COATINGS

   A. Water Based Epoxy:
      2. ICI/Devoe Paints:
      3. PPG Industries, Inc.:
         a. Pitt-Glaze Water Based Acrylic Epoxy Enamel.
         b. Aquapon Waterborne Epoxy 98-1 series.

2.5 ACCESSORY MATERIALS

   A. Muriatic acid, mildewcide, TSP (tri-sodium phosphate), acidic-detergent, zinc sulfate, sodium metasilicate, and solvent: Commercially available, non-damaging to surface being cleaned; as specified in PDCA Specification Manual; acceptable to coating manufacturer.

   B. Metal Conditioner: Proprietary phosphoric acid based, etching type solution; acceptable to coating manufacturer.

   C. Rust Inhibitor: Water containing 0.32 percent of sodium nitrite and 1.28 percent by weight of secondary ammonium phosphate (dibasic); or water containing 0.2 percent by weight of chromic acid or sodium chromate or sodium dichromate or potassium dichromate.

   D. Spackling compound, putty, plastic wood filler, liquid de-glosser, latex patching plaster, latex base filler, thinners, and other materials not specifically indicated but required to achieve finishes specified: Pure, of highest commercial quality, compatible with coatings and acceptable to coating manufacturer.

   E. Do not use products of different manufacturers in combination.

2.6 MIXING

   A. Use factory prepared colors matching approved samples. Site tinting will not be permitted.

   B. Thoroughly mix and stir coatings before use to ensure homogeneous dispersion of ingredients. Prior to application, blend multiple containers of same material and color by pouring from one container to another several times to ensure uniform consistency, color, and smoothness.

   C. Mix only in clean mixing pails of material recommended by manufacturer to avoid contamination.
D. Remove film which may form on surface of material in containers and strain material before using. Stir frequently during use to maintain pigments in suspension. Do not stir film into material.

E. Apply coatings of consistency recommended by manufacturer. Thin only within recommended limits using thinners approved by coating manufacturer.

2.7 COLORS AND FINISHES

A. Finishes: Refer to finish coatings schedule at end of this Section.

B. Colors:
   1. Exterior Walls: Beige to match existing paint on B1 tilt-up concrete panels (Pantone 4685U).
   2. Exterior Doors and Frames: Beige to match existing paint on B1 doors and frames (Pantone 4685U).
   3. Interior walls: Off-white to match existing paint on Large Bottle Formulation Laboratory.
   4. Exterior stairs, railings, and other metal elements: Violet to match existing metal elements on Ventana site (Pantone 7661U).

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine conditions and proceed with work in accordance with Section 01700.

B. Measure moisture content of substrates using recently calibrated electronic moisture meter. Do not apply coatings if moisture content of surfaces exceeds lesser of percentages listed below or those required by coating manufacturer. If excess moisture content exists and cannot be reduced, obtain written approval of coating manufacturer before application of coatings.
   1. Gypsum board and gypsum plaster: 17 percent.

C. Prior to applying alkali and acid sensitive coatings, test surface pH with universal pH paper placed against wetted surface. Substrate pH shall not exceed pH of clean wash water.

D. Beginning of execution constitutes acceptance of existing conditions.

3.2 PREPARATION - GENERAL

A. Protect completed construction from damage. Furnish drop cloths, shields, and protective methods to prevent spray, splatter, or droppings from disfiguring other surfaces.

B. Remove surface hardware, mechanical diffusers, escutcheons, registers, electrical plates, light fixture trim, fittings, fastenings and similar items prior to preparing surfaces for finishing.
Provide surface-applied protective masking for non-removable items. Carefully store removed items for reinstallation.

C. Remove mildew by scrubbing with mildewcide. Rinse thoroughly with clean water.

D. Before beginning application of coatings, ensure surfaces are clean, dry, and free of dirt, dust, rust or rust scale, oil, grease, mold, mildew, algae, efflorescence, release agents, or any other foreign material which could adversely affect coating adhesion or finished appearance.

3.3 SURFACE PREPARATION FOR NEW WORK

A. General:
   1. Correct minor defects.
   2. Remove temporary labels, wrappings, and protective coverings from surfaces to be coated.
   3. Seal stains, marks, and other imperfections which may bleed through surface finishes.

B. Gypsum Board:
   1. Refer to Section 09250 for general surface preparation.
   2. Fill remaining cracks, depressions, holes and other irregularities with spackling compound.
   3. Sand rough or high spots left by joint cement or spackling compound without damaging paper face.
   4. Remove dust by wiping with damp cloths or vacuuming.

C. Steel - Uncoated:
   1. Remove weld spatter by chipping or grinding.
   2. Clean interior and weather protected steel in accordance with SSPC SP2 "Hand Tool Cleaning" and SP3 "Power Tool Cleaning". Clean areas of excessive corrosion or scale in accordance with SSPC SP7 "Brush-Off Blast Cleaning".
   3. Clean exterior steel permanently exposed to elements in accordance with SSPC SP6 "Commercial Blast Cleaning".
   4. Apply metal conditioner to bare surfaces in accordance with manufacturer's recommendations, paying particular attention to abrasions, welds, bolts, and nuts. Allow to set as recommended by solution manufacturer. Rinse with clean water with rust inhibitor mixed with water or applied immediately following rinse. Allow to dry.
   5. Prime coat immediately.

D. Steel - Prime Coated:
   1. Remove loose primer and rust to feather-edge at adjacent sound primer by cleaning in accordance with SSPC SP2 "Hand Tool Cleaning" and SP3 "Power Tool Cleaning".
   2. Apply metal conditioner to abrasions, welds, bolts, and nuts in accordance with manufacturer's recommendations. Allow to set as recommended by manufacturer. Rinse with clean water with rust inhibitor mixed with water or applied immediately following rinse. Allow to dry.
   3. Prime coat bare areas immediately.
E. Steel - Galvanized:
1. Remove white rust by cleaning in accordance with SSPC SP2 "Hand Tool Cleaning" and SP3 "Power Tool Cleaning". Exercise care not to remove galvanizing.
2. Pretreat surfaces to receive solvent reducible coatings immediately.

3.4 SURFACE PREPARATION OF PREVIOUSLY COATED SURFACES

A. General:
1. Remove cracked and deteriorated sealants and calking.
2. Remove chalk deposits and loose, blistered, peeling, scaling, or crazed finish to bare base material or sound substrate by scraping and sanding.
3. Wash surfaces with solution of TSP to remove wax, oil, grease, and other foreign material; rinse, and allow to dry. Exercise caution that TSP solution does not soften existing coating.
4. Abrade glossy surfaces by sanding or wiping with liquid de-glosser.
5. Remove mildew as specified above.
6. Test compatibility of existing coatings by applying new coating to small, inconspicuous area. If new coatings lift or blister existing coatings, request recommendation from Architect.
7. Apply specified primer to surfaces scheduled to receive coatings.

B. Concrete, Masonry, and Portland Cement Plaster:
1. [Etch floors with muriatic acid solution applied at rate of 4L per 9 m² to 13 m² [(1 gallon per 100 to 150 square feet)]. Allow solution to remain on floor approximately 20 minutes until it stops bubbling. Rinse thoroughly with large quantity of clean water, neutralize acid, and allow to dry thoroughly. Prohibit traffic until painted.]
2. Fill cracks and voids with latex base filler.
3. Apply masonry conditioner to masonry surfaces in accordance with manufacturer's instructions.
4. Apply primer over bare surfaces and filler material.

C. Gypsum Wallboard and Gypsum Plaster:
1. Fill cracks and voids with spackling compound.
2. Apply primer over bare surfaces and newly applied texture coatings.

D. Metal:
1. Remove rust from surfaces to bare metal in accordance with SSPC SP6 "Commercial Blast Cleaning".
2. Exercise care not to remove galvanizing.
3. Complete preparation as specified for new work.

3.5 APPLICATION

A. General Requirements:
1. Coat all surfaces specified, scheduled, illustrated, and otherwise exposed unless specifically noted otherwise.
2. Apply coatings of type, color, and sheen as scheduled or selected by owner.
3. Apply products in accordance with Section 01700. Use application materials, equipment, and techniques as recommended by coating manufacturer and best suited for substrate and type of material being applied.
4. Do not apply finishes to surfaces that are improperly prepared.
5. Number of coats specified are minimum number acceptable.
6. Apply coating systems to total dry film thickness scheduled. Apply material at not less than manufacturer's recommended spreading rate. Do not exceed maximum single coat thickness recommended by coating manufacturer. Do not double-back with spray equipment building up film thickness of two coats in one pass.
7. Ensure that edges, corners, crevices, welds, and exposed fasteners receive dry film thickness equivalent of flat surfaces.
8. Finish edges of coatings adjoining other materials or colors sharp and clean, without overlapping.

B. Prime Coats:
1. Apply initial coat to surfaces as soon as practical after preparation and before subsequent surface deterioration.
2. Backprime exterior woodwork with specified primer.
3. Backprime interior woodwork scheduled to receive transparent finish with gloss varnish reduced 25 percent with mineral spirits.
4. Apply primer to wood and metal sash before field glazing.

C. Intermediate and Top Coats:
1. Allow previously applied coat to dry before next coat is applied.
2. Sand and dust lightly between coats as recommended by coating manufacturer.
3. Apply each coat to achieve uniform finish, color, appearance, and coverage free of brush and roller marks, runs, misses, visible laps or shadows, hazing, bubbles, pin holes, or other defects.
4. If stains, undercoats, or other conditions show through final topcoat, correct defects and apply additional topcoats until coating film is of uniform finish, color, and appearance.

D. Finish Matching:
1. Finish closets same as adjoining rooms, unless otherwise specified.
2. Finish tops, bottoms, and edges of doors same as door faces. Apply sanding sealer to cut-outs. When faces are different colors, finish edges of doors to match space from which they are visible when door is in partly open position.
3. Finish other surfaces not specifically mentioned to match adjoining surfaces.

E. Mechanical and Electrical Items:
1. Refer to Division 15 - Mechanical and Division 16 - Electrical for schedule of color coding and identification banding of equipment, ductwork, piping, and conduit. Color code equipment, piping, conduit and exposed ductwork in accordance with requirements indicated.
2. Prior to finishing mechanical and electrical items, remove louvers, grilles, covers, and access panels and finish separately. Replace when dry.
3. Paint interior surfaces of ducts, and heating cabinets that are visible or reflective behind grilles and registers with one coat of flat black paint.
4. Finish dampers visible behind grilles and registers to match surface finish.
5. Paint both sides and edges of plywood equipment backboards before installing equipment.
6. Do not apply coatings over name plates, tags, or other equipment identification.

F. Reinstall trim, fittings, and other items removed for finishing.

3.6 FIELD QUALITY CONTROL

A. General: Comply with requirements of Section 01450.
B. Periodically test film thickness of each coat with wet film gage to ensure coatings are being applied to proper thickness.
C. Immediately prior to Substantial Completion, perform detailed inspection of painted surfaces and repair or refinish abraded, stained, or otherwise disfigured surfaces.

3.7 CLEANING

A. Promptly remove spilled, splashed, or spattered coatings. Clean spots, oil, and other soiling from finished surfaces using cleaning agents and methods which will not damage materials.
B. If completed construction is damaged beyond normal cleaning or repair by painting operations, replace damaged items at no additional cost to Owner.
C. Maintain premises and storage areas free of unnecessary accumulation of tools, equipment, surplus materials, and debris.
D. Collect waste, cloths, and material which may constitute fire hazards and place in closed metal containers; remove from site daily along with empty containers.

3.8 PROTECTION

A. Protect finished work in accordance with Section 01700.
B. Protect work of other trades against damage from coating activities. Correct damage by cleaning, repairing, replacing, and recoating as acceptable to Architect.
C. Provide "Wet Paint" signs and other methods to protect newly coated surfaces. Remove when directed or when no longer needed.

3.9 FINISH COATINGS SCHEDULE

A. Exterior Coating Systems:
   1. Concrete and Masonry Surfaces:
      a. Concrete Walls, Portland Cement Plaster:
1) System No. EC-3 (Alkyd Finish):
   Sheen: Eggshell (To match existing adjacent painted concrete walls).
   Prime Coat: Alkali Resistant Primer at .5 mil.
   Under Coat: Exterior Alkyd Enamel at 2.0 mils.
   Top Coat: Exterior Alkyd Enamel at 2.0 mils.
   System DFT: 5.5 mils.

2. Metal Surfaces:
   a. Non-Ferrous Metals and Zinc-Coated (Galvanized) Steel.
      1) System No. EM-1 (Silicone Alkyd Finish):
         Sheen: Semi-Gloss
         Pretreatment: Etching Metal Primer at 0.4 mils.
         Prime Coat: Galvanized Primer at 2.0 mils.
         Under Coat: Silicone Alkyd Enamel at 2.0 mils.
         Top Coat: Silicone Alkyd Enamel at 2.0 mils.
         System DFT: 6.4 mils.
   b. Ferrous Metals - Uncoated:
      1) System No. EM-3 (Silicone Alkyd Finish):
         Sheen: Semi-Gloss.
         Prime Coat: Alkyd-Phenolic Primer at 2.5 mils.
         Under Coat: Silicone Alkyd Enamel at 2.0 mils.
         Top Coat: Silicone Alkyd Enamel at 2.0 mils.
         System DFT: 6.5 mils.
   c. Ferrous Metals - Previously Coated:
      1) System No. EM-5 (Silicone Alkyd Finish):
         Sheen: Semi-Gloss.
         Prime Coat: Touch-up existing with compatible primer.
         Under Coat: Silicone Alkyd Enamel at 2.0 mils.
         Top Coat: Silicone Alkyd Enamel at 2.0 mils.
         System DFT: 4.0 mils (excluding existing and touch-up primer).

B. Interior Coating Systems:
   1. Concrete Surfaces: See Section 07190 for floor and stem wall sealant.

END OF SECTION
PART 1 – GENERAL

1.1 SUMMARY
A. This Section specifies the general interrelationship of Division 15 Work with general work provisions.
B. This project contains three Class 100,000 Clean Rooms. Adhere to sections 01737, 01740, and 01744 for Clean Room Procedures and Protocol

1.2 INTENT
A. It is the intent of the Contract Documents to call for finished work, tested and ready for operation including apparatus, appliances, materials, and work. Provide incidental accessories necessary to make work complete and ready for operation without additional expense to the Owner. Should there appear to be discrepancies between or questionable intent of the Contract Documents, consult the Architect for clarification, before any material or equipment is ordered or work is begun.
B. Manufacturers named within the Contract Documents have been selected for the specific purpose of describing the type, quality and design of equipment required. Various Project conditions have predicated selection of manufacturer scheduled on Drawings to meet specific design and dimensional criteria. Contractor may prepare his bid using other acceptable manufacturers named in the Specifications provided dimensions, space limitations, pad, support, curb, roof opening, electrical need and other manufacturer variations are fully coordinated with applicable drawings and specification divisions without additional cost to Owner.
C. Where contractors propose to substitute an item of equipment other than that specified or detailed on Drawings, which requires any redesign of the structure, partitions, foundations, piping, wiring or any other part of mechanical, electrical, or architectural layout, such redesign, and new Drawings and detailing required therefore, shall be prepared by the Contractor at his own expense and shall be submitted to the Architect for consideration. Where such approved deviation requires a different quantity and arrangement of ductwork, piping, wiring, conduit, and equipment from that specified or indicated on Drawings, Contractor shall provide any such ductwork, piping, structural supports, insulation, controllers, motors, starters, equipment, electrical wiring and conduit, and any other additional components required by the substituted system, at no additional cost to the Owner.

1.3 DRAWINGS AND SPECIFICATIONS
A. Drawings are generally diagrammatic, intended to define scope and general arrangement of work. Drawings do not show every offset, fitting, or structural difficulty that will be encountered during coordination and installation of work. P&IDs supplement the Drawings, and in addition to defining instrumentation requirements, identify valves, specialties, and details not necessarily shown on the Drawings. Specifications denote style and quality of
workmanship to be employed. Where a conflict exists between Drawings and Specifications, promptly notify Architect for interpretation and resolution.

1.4 WARRANTY

A. Provide manufacturer's written warranties covering defects in material and workmanship of products and equipment utilized for the project.

B. Warranties shall be for a period of 1 year from the date of substantial completion unless more stringently specified within individual Sections of this Division.

1.5 OWNER FURNISHED EQUIPMENT

A. Prepurchased and/or Owner furnished, Contractor installed equipment is identified on the Drawings.

PARTS 2 AND 3 – PRODUCTS AND EXECUTION

2/3.1 TRADE COORDINATION

A. General:
1. Refer to Division 1 for coordination drawing requirements. Review Contract Documents to verify the location of the various building components and items to be installed by other trades. Coordinate work schedule for a minimum of interference with work of other trades. Ascertain temporary opening sizes and locations necessary for admission of mechanical equipment and coordinate requirements with work of other Divisions. Should conditions require revisions to space requirements or major rearrangement to suit the equipment proposed for installation, submit detailed shop drawings showing changes and arrangements for space and revisions to work specified under other Divisions before proceeding with work. Do not decrease sizes or make radical changes in installation without obtaining prior written consent from the Architect. Changes to work, which become necessary due to failure to coordinate work, shall be done at the installer's expense.

2. Coordinate with installers for other Divisions and Sections to define space requirements and clearance requirements with respect to other equipment in the building. Architect reserves the right to determine space priorities where interferences occur between piping, conduit and equipment of various trades.

3. Penetration of fire walls and smoke barriers, refer to Section 07840 - Firestopping.

B. Visiting the Premises:
1. Visit premises and become thoroughly familiar with the general layout of the building Site and the location of existing lines to which connections are to be made before ordering material or starting work. Check present grades, ditches, pavements, and other conditions which might affect utility installations.

2. Verify measurements at the project to greatest extent possible prior to fabrication. Where sequence of measuring before fabrication would delay Project, proceed with fabrication allowing ample tolerances and providing offsets to accommodate as-built conditions. Contractor shall assume full responsibility for making a proper and thorough investigation of requirements. Submit significant differences found to Architect for consideration before proceeding with corrective measures.
C. Interferences:
   1. Locations of various parts of equipment, ductwork, and piping are diagrammatic and
      approximately correct. Determine exact locations on the job, being governed by
      structural conditions of the building and coordination with work of other trades.
   2. Do not prevent or disturb operation of active services which are to remain. If work
      makes temporary shutdown of services unavoidable, consult with Owner as to dates,
      procedures and estimated duration of down time period at least ten working days prior
      to date of shutdown. Arrange work for continuous performance to assure that existing
      operating services will be shut down only during time it is necessary to make
      connections. If a system cannot be shut down, install temporary bypasses until final
      connections are complete.
   3. Locations of existing utility services or installations have been obtained from the best
      available information. Determine exact location of existing service lines or installations
      encountered in performance of work and provide suitable protection, support and
      maintenance.
   4. Immediately repair or replace utility services or installations damaged in performance of
      work. Obtain written approval of repair or replacement from the Architect and utility
      company.
   5. If existing active utility services are encountered which require relocation, make request
      of proper authorities for determination of procedures. Properly terminate existing
      services to be abandoned in conformance with requirements of authorities having
      jurisdiction.
   6. All removed equipment shall remain the Owner's property unless otherwise stated in
      other articles of these Specifications.

D. Access to Mechanical Equipment:
   1. Work of this Article is limited to access of mechanical equipment through walls and
      inaccessible ceilings, and does not include access within mechanical equipment systems
      (see individual work Sections of Division 15). Furnish adequate access doors to other
      trades involved prior to performance of their work to minimize cutting and patching.
      Furnish units in conformance with applicable requirements of Access Doors
      Section 08310 in Division 8.
   2. Exact location of each access door shall be determined prior to installation and such
      information shall be submitted to Architect for review and approval. Visual impact
      shall be considered when determining access door locations. To largest extent possible,
      prearrange unit locations to minimize quantities. Ceiling access doors shall be no less
      than 600 mm by 600 mm [(24 inches by 24 inches)] and wall access doors shall be sized
      to suit equipment but not less than 300 mm by 300 mm [(12 inches by 12 inches)].
   3. Provide access doors in inaccessible ceilings and walls to gain access to all dampers,
      terminal units, coils, filters, valves, air vents, control devices, traps, cleanouts and other
      similar devices requiring periodic observation, adjustment, service or replacement.

E. Service Connections:
   1. Except as otherwise indicated by technical provisions of individual Sections within
      Division 15, final connection of mechanical services to general work
      (Divisions 2 through 14) is hereby defined as work of those Sections. Final hookup of
      Owner-furnished/contractor-installed (OFCI) equipment is hereby defined as work of
      Division 15 unless otherwise provided.
2. The Drawings indicate only approximate locations of utility rough-ins. Exact rough-in locations shall be determined from large scale certified Drawings. The contractor shall obtain large scale certified rough-in Drawings before progressing with any work for rough-in connections.

F. For the purpose of expediting delivery on certain "long lead" pieces of equipment, the Owner has elected to prepurchase these items for assignment to Contractor. Work of Contract includes installation of pre-purchased equipment identified herein unless specifically designated as supplier's responsibility. Comply with requirements for service connections specified by previous article and with technical provisions of related Specification Sections for installation, same as for Contractor-purchased equipment.

G. Excavating for Mechanical Work:
1. The work of this article is defined to include excavating and backfilling necessary for installation of mechanical work. Coordinate work of this article with other work in the same area, including: dewatering, flood protection, other temporary facilities, existing underground facilities, landscape development, paving, floor slabs on grade, and other underground services.
   a. Provide separate trenches for all lines unless otherwise noted.
   b. Place exterior underground water-bearing pipe (including drainage lines) a minimum of 0.76 m [(2'-6'')] below grade (measured to top of pipe) or below frost line, whichever is greater unless otherwise approved in writing by the Architect or unless noted otherwise or necessitated by drainage slope requirements.
2. Support pipe in sizes DN 125 [(5 inches)] and smaller directly on undisturbed soil. Support larger sizes and other prefabricated work (tanks, meters, etc.) on compacted and shaped subbase material not less than 150 mm [(6 inches)] deep. Bell holes shall be excavated so that pipe will rest directly on solid ground for its entire length. Compact previously disturbed subsoil to provide adequate and uniform support; excavate unsatisfactory subsoil to greater depth and replace with stable compacted subbase material or low slump concrete to assure adequate support. Backfill by hand and compact thoroughly with mechanical tamper.
3. Where piping located outside of the building, under drives, roads, or parking lots is less than 0.76 m [(2'-6'')] below final surface elevation, provide encasement consisting of Class 2500 concrete, 100 mm [(4 inches)] minimum coverage all around.
4. Do not backfill or encase underground piping until testing has been completed.

H. Concrete for Mechanical Work:
1. Provided under Division 3, Section 03300 - Cast-In-Place Concrete.
2. Provide anchor bolts, sleeves, templates, and other materials incidental to equipment and systems installation on concrete base, pads, or curbs. Anchor bolts shall be hook type, with diameter governed by the equipment baseplate holes. Bolts and nuts shall be ASTM A307, of a hexagon form, ASA B 1.1 Coarse Thread, Class 1 Fit. Exposed bolt-thread projection above top of nut shall not exceed 8 mm [(1/4 inch)] after placement and leveling of equipment base plate.
3. Provide steel shims and nonshrink grouting as necessary to ensure accurate leveling of base plates. Scarify, clean, and wet concrete and/or pad surfaces to assure bond.
4. Nonshrink grout shall be Sonneborn Sonogrout 10K.

I. Painting of Mechanical Work: Refer to Section 09900 for mechanical work painting requirements.
A. Testing Requirements:
   1. Arrange for testing of installed systems in accordance with requirements of authorities having jurisdiction and the requirements of Division 1 and Division 15. Testing procedures shall include provision of labor, materials, instruments, and power necessary for successful completion. Test duration shall be per Specifications except when the authority having jurisdiction requires a longer test period. Comply with additional testing requirements of Division 1 for Procedures and Controls.
   2. Specific Requirements:
      a. Test equipment and systems which normally operate during certain seasons of year during the appropriate season. Perform tests on individual equipment, systems and their controls. Whenever equipment or systems under test are interrelated with other equipment or systems, the latter shall be operated simultaneously with equipment or systems being tested.
      b. No piping or ductwork is to be closed up, furred in or covered before testing. Pressure test piping before connecting to equipment. Subject no piping, equipment, or accessories to testing beyond rated pressures.
      c. Drain water used for testing from system after tests are complete. Work required to repair or replace damage caused by freezing of water left in system shall be done at Contractor's expense.
      d. Repair or replace defective work and repeat tests until particular system and component parts thereof receive approval of the regulating authority. Repair any damage resulting from tests and replace damaged materials at no cost to Owner.
      e. Make final tests in presence of appropriate inspector.
      f. Refer to Section 15950 for rotating equipment balance requirements.
      g. Refer to Section 15071 for noise and vibration control requirements for rotating equipment and associated piping, ductwork, etc.
      h. Furnish copies of test reports and certificates of acceptance, signed by the inspector, to Architect before making claims for final payment; such claims will not be processed until these submittals have been made.

B. Submittals: Submit shop drawings, brochures, and schedules as defined by individual technical Sections of Specifications. Submit manufacturer's printed installation instructions for products and install in accordance therewith and as defined by individual technical Sections of the Specifications.

C. Codes, Fees, and Lateral Costs:
   1. Comply with applicable codes, rules, regulations, and building and safety laws relating to construction, public health and safety.
   2. Give necessary notices, obtain permits, and pay taxes, fees and other costs in connection with the work; file necessary plans, prepare documents and obtain necessary approvals of regulating authorities having jurisdiction; obtain Certificates of Inspection for work and deliver to Architect before request for acceptance and final payment of Contract.
   3. Provide all labor, materials, services, apparatus, and Drawings (in addition to Contract Documents) to comply with applicable laws, ordinances, rules, and regulations.
   4. Contract Documents take precedence when more stringent than codes, ordinances, standards, and statutes. Codes, ordinances, standards and statutes take precedence when more stringent or in conflict with Drawings and Specifications. The following industry
standards, Specifications and Codes are minimum requirements (latest issue as adopted by local jurisdiction as of date of Contract unless noted otherwise on Drawings):

a. Air Conditioning and Refrigeration Institute Standards.
d. Applicable municipal, county, and state mechanical, electrical, gas, plumbing, health and sanitary codes, laws and ordinances.
e. American Society of Heating, Refrigerating, and Air-Conditioning Engineers.
f. American Society of Mechanical Engineers Boiler and Pressure Vessel Codes.
g. American Society for Testing Materials Standards.
h. American Water Works Association.
i. American Welding Society.
j. Expansion Joint Manufacturers Association Standards.
k. Manufacturers Standard Society Standards.
l. National Commercial and Industrial Insulation Standards.
m. National Electrical Manufacturer's Association Standards.

D. Mechanical System Identification: Types of services and equipment requiring identification include, but are not necessarily limited to, the following: piping systems, air handling systems, ductwork, valves, dampers, switches, and other control units in piping, wiring systems, and mechanical equipment requiring operational identification; warning, instructional or maintenance signage.

2/3.3 MECHANICAL GENERAL EQUIPMENT PROVISIONS

A. Material and Equipment:

1. Provide materials and equipment that are standard products of a reputable manufacturer regularly engaged in the manufacture thereof. Multiple items shall be the product of the same manufacturer unless specified otherwise.

2. Install material and equipment in accordance with manufacturer's recommendations. Contact Architect immediately if variance occurs between Contract Documents and manufacturer's recommendations so that variations in installation can be known by all parties concerned.

3. Deliver materials or equipment to the Project in the manufacturer's original, unopened, labeled containers. Materials received in damaged, unsealed, or open containers shall be rejected immediately. Added costs associated with reordering, expediting orders, or project delays due to rejected materials shall be borne by the contractor. Protect from damage which may be caused by theft, weather, and building operations. Failure to protect materials and apparatus adequately shall be sufficient cause for rejection of any damaged material or equipment. Close pipe and equipment openings to prevent intrusion of obstructions and damage.

4. Replace work which is not in accordance with Contract Documents without delay and without additional cost to the Owner.
B. Electric Motors:

1. All electric motors shall be induction type, conforming with requirements of NEMA, UL and NEC, suitable for intended load, voltage, phase, frequency, service, and location. Comply with Section 15055 - Motors unless specified otherwise in equipment specification Section.

2. Limit maximum motor speeds to 1750 rpm, unless otherwise specified.

3. Motors 0.5 kW [(3/4 HP)] and larger shall be 3-phase, 60 Hz, squirrel cage induction motors unless specifically specified to the contrary in subsequent Sections of this Division. Refer to Drawings for voltage requirements. Totally enclosed motors rated 0.5 kW [(3/4 HP)], 1200 rpm, or 0.75 kW [(1 HP)] and larger, and all drip-proof motors shall have a 1.15 continuous-duty service factor at 40 degrees C. ambient temperature. Insulation system shall be NEMA Class B or Class F, with Class B temperature rise maximum. Provide double-shielded, grease-lubricated ball bearings with grease pockets on each side for regreasing in service. Provide inlet and outlet grease connections in 5kW [(7.5 HP)] and larger motor housings for each bearing. Motors 3.8 kW [(5 HP)] and smaller and all roof-mounted equipment motors shall be provided with factory sealed, permanently lubricated ball bearings.

4. Motors 0.38 kW [(1/2 HP)] and under shall be single phase, 115 volt permanent split-capacitor type with integral thermal overload protection. Bearings shall be factory sealed, permanently lubricated ball type.

5. Provide totally enclosed motors, or suitable protection per NEMA Standards, in locations exposed to the weather or dripping water. Other motors shall be open drip-proof.

6. Multispeed motors shall be provided where specifically scheduled.

7. Motor nameplate efficiencies shall be at rated load equal to or greater than those published by US Motors for their premium efficiency motors in the horsepowers and speeds normally available. Motors shall be General Electric, Lincoln, Reliance, Toshiba, US Motors, Westinghouse, or Magnetek.

C. Motor Starters:

1. Starters are provided under Division 16, unless furnished as an integral part of manufacturer's packaged equipment. Responsibility for providing starter compatible with motor furnished rests with starter supplier; however, equipment supplier shall provide sufficient data with shop drawings and submittals to clearly indicate all motor starter requirements.

2. Furnish Single Phase Motors with Manual Motor Starters Consisting of the Following:
   b. Thermal overload protection.
   c. Red "run" pilot light.
   d. NEMA Type 1 enclosure unless environment dictates a more restrictive NEMA rating type.

3. Furnish 3 phase motors with full voltage, magnetic across-the-line starters consisting of the following:
   a. Thermal overload protection for all 3-phase legs.
   b. Fail open auxiliary contacts, prewired to a terminal strip, for future remote alarm wiring and run-time totalization. Refer to Division 16.
   c. An adequate control transformer, complete with fuse protection, to supply 120 volt source for control circuit, regardless of line voltage.
d. Hand-Off-Automatic selector switches in cover.
e. Red "run" and green "off" pilot lights in cover.

D. Drives:
1. Generally belt drives shall be used with "V" belts provided with adjustment capability for tension and alignment. Belt speed not over 5,100 fpm. Belts shall be rated at 150 percent of the motor horsepower.
2. Sheaves shall be statically and dynamically balanced close grained cast iron free of sand holes or other defects. For fan motors up to 15 kW [(20 HP)] they shall be adjustable pitch with the driven sheave being a matched companion sheave by the same manufacturer. Initial design setting of the variable pitch sheave shall be at the mid-point with capability of adjustment from plus or minus 15 percent of design setting.
3. Multiple belts shall be factory matched sets. A metal tag showing manufacturers model number, size, and style of replacement belt set shall be attached to each belt guard. Belt guards are required for each belt-driven device even if integral to equipment.
4. Tachometer access shall be provided for each rotating axle through the guard.

E. Mechanical installation of electrical work, control work, running electrical raceways or conduits, even if used as mechanical protection for pneumatic lines, shall comply with Division 16 Specifications. Conduit used for such purposes shall be appropriately labeled.

F. Provide drip pans directly below overhead piping or similar sources of possible damage and located to protect electrical and electronic work which is sensitive to moisture. Pans shall be 50 mm [(2 inches)] deep, extending a minimum of 150 mm [(6 inches)] beyond each edge of overhead piping and lengthwise 18 inches beyond each side of electrical work to be protected. Fabricate pans of either 20 gauge copper or 16 gauge zinc-coated steel, with rolled edges and reinforced for proper support, soldered fully watertight, and fitted with a DN 20 [(3/4 inch)] copper drain pipe properly discharged to nearest piped drain appurtenance.

G. Flashing and counterflashing for mechanical penetrations of roofing membrane shall be coordinated with roofing membrane installer.

H. Apply rust proofing primer as work of this Section to all ferrous metal pipe duct or equipment racks, hangers, stands, brackets, supports, etc. Refer to Sections 09900 and 15090.

2/3.4 START-UP PROVISIONS FOR MECHANICAL WORK

A. Adjusting and Aligning Equipment: Adjust all equipment. Check all motors for proper rotation.

B. Cleaning:
1. Remove tools, scaffolding, surplus materials, barricades, temporary walks, debris, and rubbish from the Project promptly upon completion of the work of each Section. Leave the area of operations completely clean and free of these items.
2. During all phases of on-site storage and all courses of construction, protect open ends of ducts and cap pipe to ensure adequate protection against entrance of foreign substances.
3. Disconnect, clean and reconnect wherever necessary to locate and remove obstructions from any system stopped by any foreign matter after being placed in operation. Repair or replace any work damaged in course of removing obstruction at no additional cost to the Owner.
C. Lubrication:
1. Extend grease fittings, on bearings requiring routine lubrication, to points of ready and easy accessibility.
2. Lubricate motor and fan bearings, etc., before operation of any equipment.
3. Provide a final lubrication to equipment immediately before turning over to Owner.

D. Commissioning:
1. It is the intent of this Specification Article to ensure that installed equipment performance and operation meets all design criteria.
2. It is the responsibility of the manufacturers/vendors, to identify in writing, at time of submission, all options, differences, substitution, etc., which are included in their submission.
3. Equipment which is found not to function per design and submission criteria, shall be removed from the Project and replaced by the installing Contractor at his cost.
4. Field modifications and repairs to new equipment shall not be permitted.
5. All Project lateral cost and delay cost proven related to nonfunctioning equipment, shall be borne by the installing Contractor.
6. Startup personnel shall provide a check-out report providing detailed readout on equipment performance.
7. Equipment startup personnel shall coordinate their efforts with other trades so as to permit equipment to be checked-out in every mode of operation.
8. All equipment shall be commissioned under the supervision of a factory trained authorized representative. Separate letters of authorization from the manufacturers shall be provided to the Contractor, prior to starting equipment.
9. All components and control functions of equipment shall be thoroughly examined, tested, and proven 100 percent operational.
10. All inter-related controls, electrical connections, and service connection shall be completed and proven functional prior to starting equipment.
11. No temporary service hookups are permitted.

E. Operation by Owner:
1. Owner may require operation of certain systems or parts thereof, prior to Final Acceptance.
2. Operation is not to be construed as acceptance of work.

F. Instructions of Owner's Personnel:
1. Prior to acceptance of work, and during time designated by the Architect, provide necessary qualified personnel to operate each system for a period of 2 consecutive, full working days.
2. During operating period, fully instruct Owner's representative in complete operation, adjustment, care, and maintenance of each respective system and piece of equipment.

G. Instruction Manual: Prior to completion of installation and final inspection of work, furnish to Architect 3 copies of complete Instruction Manual, bound in booklet form and indexed for each respective Mechanical Specification Section. Manuals shall contain the following:
1. List of equipment with manufacturer's name, model number, local representative, service facilities, and normal channel of supply for each item.
2. Manufacturer's literature describing each item of equipment with detailed parts list.
3. Name, address, and phone number of contractors involved in work under this Division.
4. Detailed step-by-step instructions for starting, summer operation, winter operation, and shutdown of each system.
5. Detailed maintenance instructions for starting, summer operation, winter operation, and shutdown of each system.
6. Copy of valve chart.
7. Copy of each automatic control diagram with respective sequence of operation.
8. Individual equipment warranties.
9. Certificates of Inspection.
10. Record prints and related shop drawings.
11. Air and water balance report.

END OF SECTION
SECTION 15060
PIPE AND PIPE FITTINGS - GENERAL

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes pipe material schedules and general requirements for multiple piping systems. Specific piping system sections are listed for more detailed material descriptions.

1.2 DEFINITIONS

A. Design Pressure:
   1. The Design Pressure for each component in a piping system is equal to the system pressure at the most severe condition.
   2. Piping not protected by pressure relieving devices, and/or that can be isolated from a pressure-relieving device, shall be designed for the highest pressure that can be developed.
   3. Sources of pressure variation to consider include ambient influences, pressure oscillations and surges, improper operation, and failure of control devices.

B. Design Temperature: The design temperature for each component in a piping system is equal to the system temperature at the most severe condition.

1.3 SYSTEM DESCRIPTION

A. General: In addition to requirements shown and specified, comply with applicable provisions of the drawings for design, materials, fabrication, and installation of component parts.

B. Design Requirements:
   1. Drawings are diagrammatic and are intended to establish basic dimension of units, sight lines, and profiles of units.
   2. Accompanying Drawings are intended for Contractor's guidance, and he shall verify their accuracy and immediately notify the Architect of any discrepancies so that they may be resolved prior to actual fabrication or installation of work. Minor changes in position of piping to meet job conditions shall not be made the basis for change order. Changes affecting accessibility to and clearance about equipment or accessories shall be promptly communicated to the Architect.
   3. Construction Documents may include piping diagrams, riser diagrams and details as a part of the working Drawings. These diagrams and details are not for the purpose of giving physical dimensions and locations but rather to make clear the interconnections, by the piping, of the various units of the process. If mechanical components are shown on either the diagrams or the piping detail Drawings, but not on both, the Contractor shall include in his cost estimate, including installation thereof.
   4. Conflicts or inconsistencies of pipe sizes, arrangements, and details for final connections shall be resolved by the Architect.
1.4 SUBMITTALS

A. General: Submit in accordance with Division 1 Section - Submittal Procedures.

B. Product Data: Submit vendor product data for all valves, fittings and pipe material.

C. Certifications: Submit manufacturer’s certification that products furnished for Project meet or exceed specified requirements.

D. Submit following Informational Submittals:
   1. Test Reports:
      a. Written results of testing specified as part Field Quality Control articles.
      b. Certified test reports of cleaning and testing for each system.
   2. Submit certification of domestic water system disinfection.
   3. Qualification Data:
      a. Fabricator’s and installer’s qualifications verifying years of experience.
      b. Include list of completed projects having similar scope of Work identified by name, location, date, reference names, and phone numbers.
   4. Manufacturer’s Instructions:
      a. Manufacturer’s printed installation instructions.
      b. Indicate by transmittal that copies of instructions and recommendations have been distributed to installer.

1.5 QUALITY ASSURANCE

A. Welding materials and labor shall conform to ASME Codes, AWS Standards, and applicable state labor regulations.

B. Welders shall be fully qualified and certified. Each welder shall identify his work with a marking stamped on each weld joint of pipe, valve or fitting. A listing of the names of the welders, together with corresponding marks, shall be submitted. Welders making defective welds after passing qualification test shall be given a requalification test and upon failing to pass shall not be permitted to work on this Project.

C. Domestic water, drainage, and vent piping per each applicable building code.

D. Single Source Responsibility: To ensure quality of appearance and performance, obtain:
   1. Pipe for a system from a single manufacturer.
   2. Fittings for a system from a single manufacturer.
   3. Valves of a common size for a system from a single manufacturer.

1.6 PRE-INSTALLATION CONFERENCE

A. Conduct pre-installation conference in accordance with Division 1 Section - Project Management and Coordination.

B. Review requirements of Contract Documents and submittals.
C. Review requirements for inspection and testing, governing regulations, insurance requirements, and proposed installation procedures and sequencing.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with requirements of Division 1 Section - Product Requirements.

B. Protect finished surfaces as necessary to prevent damage.

C. Do not use adhesive papers or sprayed coatings, which become firmly bonded when exposed to sun.

D. Do not leave coating residue on any surfaces.

E. Replace damaged materials.

1.8 WARRANTY

A. Provide warranties in accordance with Division 1 Section - Closeout Submittals.

B. Provide written warranty jointly signed by manufacturer, installer and Contractor agreeing to repair and/or replace assemblies, which fail in material or workmanship during warranty period from date of Substantial Completion.

1.9 MAINTENANCE

A. Maintenance Materials:
1. Furnish under provisions of Division 1 Section - Closeout Submittals.
2. Furnish 2 extra valves for each type and size, up to DN 200 [(8 inches)] installed on project.

PART 2 – PRODUCTS

2.1 MATERIAL

A. Piping shall conform to the Material Class specifications listed in the following schedules:

<table>
<thead>
<tr>
<th>System Designation</th>
<th>Service</th>
<th>Design Pressure</th>
<th>Design Temp.</th>
<th>Material</th>
<th>Material Class</th>
<th>Specification Section</th>
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<tr>
<td>CD</td>
<td>Condensate Drain</td>
<td>69 kPa [(10 psig)]</td>
<td>37.8°C [(100°F)]</td>
<td>Type L, Drawn Copper</td>
<td>CU-01</td>
<td>15064</td>
</tr>
<tr>
<td>CHWS/ CHWR</td>
<td>Chilled Water Supply and Return - aboveground</td>
<td>1034 kPa [(150 psig)]</td>
<td>82°C [(180°F)]</td>
<td>Carbon Steel</td>
<td>CS-03 [CS-10*]</td>
<td>15061</td>
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<td></td>
<td>Chilled Water Supply and Return- underground</td>
<td>1034 kPa [(150 psig)]</td>
<td>82°C [(180°F)]</td>
<td>Carbon Steel</td>
<td>CS-03</td>
<td>15061</td>
</tr>
<tr>
<td>FPW</td>
<td>Fire Protection - aboveground</td>
<td>Per NFPA</td>
<td>37.8°C [(100°F)]</td>
<td>Carbon Steel</td>
<td>CS-06</td>
<td>15061</td>
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<tr>
<td>FPW</td>
<td>Fire Protection - underground</td>
<td>Per NFPA</td>
<td>37.8°C [(100°F)]</td>
<td>Ductile Iron</td>
<td>D1-01</td>
<td>15063</td>
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</table>
PLUMBING PIPING SERVICE SCHEDULE

<table>
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<th>System Designation</th>
<th>Service</th>
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<th>Design Temp.</th>
<th>Material</th>
<th>Material Class</th>
<th>Specification Section</th>
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</thead>
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<tr>
<td>DCW/DHW</td>
<td>Domestic Water Cold and Hot- aboveground</td>
<td>862 kPa [(125 psig)]</td>
<td>82°C [(180°F)]</td>
<td>Type L drawn copper</td>
<td>CU-01</td>
<td>15064</td>
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<tr>
<td></td>
<td>Domestic Water Cold and Hot- underground</td>
<td>69 kPa [(10 psig)]</td>
<td>82°C [(180°F)]</td>
<td>Type K annealed Copper</td>
<td>C1-01</td>
<td>15062</td>
</tr>
<tr>
<td>SS/VT</td>
<td>Soil waste and vent - aboveground</td>
<td>69 kPa [(10 psig)]</td>
<td>82°C [(180°F)]</td>
<td>Cast iron</td>
<td>C1-01</td>
<td>15062</td>
</tr>
<tr>
<td></td>
<td>Soil waste and vent - underground</td>
<td>69 kPa [(10 psig)]</td>
<td>82°C [(180°F)]</td>
<td>Cast iron</td>
<td>C1-01</td>
<td>15062</td>
</tr>
<tr>
<td>TP</td>
<td>Trap primer lines - underground</td>
<td>69 kPa [(10 psig)]</td>
<td>37.8°C [(100°F)]</td>
<td>Type K annealed Copper</td>
<td>CU-02</td>
<td>15064</td>
</tr>
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</table>

PROCESS SERVICE SCHEDULE

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<th>Material</th>
<th>Specification</th>
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<tr>
<td>Mineral Oil and Norpar Piping</td>
<td>150 psig</td>
<td>100 °F</td>
<td>304 Stainless Steel</td>
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<td>100 °F</td>
<td>Polypropylene</td>
<td>15371</td>
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<tr>
<td>De-Ionized Water Return</td>
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<td>100 °F</td>
<td>Polypropylene</td>
<td>15371</td>
</tr>
</tbody>
</table>

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine conditions and proceed with work in accordance with Division 1 Section - Execution Requirements.

B. Verify mechanical and electrical components provided by other Sections of Specification are properly located.

C. Verify supporting members are at proper elevation and are capable of supporting pipe loads.
3.2 DRAWINGS

A. Prepare coordination drawings in accordance with Division 1 Sections.

B. Prepare detailed fabrication and installation drawings for Contractor’s use on site showing all welded and assembly items. Show location and type of support, anchors, and guides, etc. Coordinate fabrication drawings with all applicable trades prior to fabrication and installation.

3.3 FABRICATION

A. General: Provide labor that has been qualified by training and experience to perform the specified work in accordance with the applicable codes and standards.

B. Contractor Quality Control: Designate a quality control representative to inspect the installation and document cleaning and testing of piping systems. The QC representative shall be qualified as welding inspector per AWS-QC2. Maintain on site records for Owner and/or Architect review.

C. Fabricate piping in accordance with the detailed drawings and applicable codes.

D. Vents and Drains:
   1. Vents and drains required for system operation are shown on the P&IDs. In addition, provide vents and drains at all high and low points in each system required for filling and draining the systems for testing, cleaning and operation.
   2. Vents and drains for pipes DN50 [(2 inches)] and less DN15 [(1/2 inch)] and for pipes DN65 [(2-1/2 inches)] and larger DN20 [(3/4 inch)]. Provide ball valve, hose connection and cap on drains.

E. High Purity and Specialty Piping: Refer to individual piping Specification Sections for fabrication procedures.

3.4 INSTALLATION

A. Preparation:
   1. Refer to individual pipe Specification Sections for Bulk Gas, Specialty Gas, Compressed Air, High Purity Water or Process Chemical piping.
   2. For all other piping systems ream pipes and tubes to full inside diameter. Clean off scale and dirt, inside and outside, before assembly. Remove welding slag or other foreign material from piping.

B. General:
   1. Install in accordance with fabrication drawings and applicable manufacturer’s drawings and instructions.
   2. Install components plumb, level, square, and free from warp or twist while maintaining dimensional tolerances and alignment with surrounding construction.
   3. Run piping straight and parallel with adjacent walls and foundations to present a uniform and neat appearance.
   4. In assembling piping systems, utilize longest available commercial standard piping lengths to minimize number of piping joints. Accurately cut pipe to field measurements.
to permit placement without forcing or springing, except for cold springing of expansion loop legs.

5. Install piping in accordance with applicable ASME B31 Series codes, NFPA, and building codes.

6. Install piping incorporating the requirements of applicable related Specification Sections as referenced in Paragraph 1.1.B.

7. Provide sleeves for penetrations through all building walls, floors, slabs, and roofs. Note: Fire rated penetration assemblies, which do not require sleeves are excluded.

8. Where pipes penetrate fire and/or smoke rated construction, provide fire stopping in accordance with Specification Section 07840 - Firestopping.

9. Provide chrome escutcheons for pipe penetrations in exposed finished areas.

C. Route and Grades

1. Route piping in orderly manner and maintain proper grades. Install to conserve headroom and interfere as little as possible with use of space. Run exposed piping parallel to walls. Group piping whenever practical at common elevations. Coordinate pipe routing, elevations and grades with the Work of other trades.

2. In case of conflict, the Architect reserves the right to designate priority for elevations, location, etc.

3. Slope steam piping 50 mm [(1 inch)] in 12 m [(40 feet)] in direction of flow and condensate return by piping 100 mm [(2 inches)] in 12 m [(40 feet)]. Provide drip trap assemblies at low points and points where condensate may back up ahead of control valves. Run condensate lines from traps to nearest condensate receiver. Where condensate lines form a trap, provide vent loop over the trapped section.

4. Make reductions in water pipes with eccentric reducing fittings installed to provide drainage and venting.

5. Grade horizontal drainage and venting.

6. Install piping to allow for expansion and contraction without stressing pipe or connected equipment.

D. Connections: Note, this Section does not apply to Bulk Gas, Specialty Gas, Compressed Air, High Purity Water or Process Chemical piping. Refer to individual piping Specification Sections for requirements.

1. Join piping sections by screwing, welding, brazing, sweating, or bolting in accordance with the pipe system material class specification requirements.

2. On threaded joints use full-cut standard taper pipe threads per ANSI/ASME B1.20.1. Make up joints using Teflon tape or nontoxic joint compound as related to the piping system involved. Apply to male threads only.

3. Use main-sized "Weld-O-Let" or "Thread-O-Let" branch connections or "Stub-in" in steel piping if main is at least 1 pipe size larger than the branch for up to 300 mm [(6 inch)] mains and if main is at least 2 pipe sizes larger than branch for 200 mm [(8 inches)] and larger mains. Do not project branch pipes inside the main pipe.

4. Joints for cast iron bell and spigot pipe shall have a neoprene gasketing system. Joints for plain end pipe shall have clamp-type mechanical fasteners and gaskets.

5. Make connections to equipment and branch mains with unions or flanges.

6. Provide nonconducting type connections wherever joining dissimilar metals in all systems. Brass adapters and valves are acceptable.

3.5 TESTING
A. General:
1. Pressure testing requirements apply to all piping systems unless specified in specific piping system Specification Sections.
2. Perform tests after erection and prior to insulation or other finish work. Do not cover work before acceptance.
3. Test piping systems that are governed by ASME B31.1, B31.3, or B31.9 in accordance with the applicable code. Where specific requirements exceed code requirements, conduct test in accordance with the specific system requirements.
4. Test fuel and fire protection systems in accordance with applicable NFPA codes.
5. Except where noted otherwise in specific Specification Sections, conduct pneumatic tests at 1.1 times the design pressure and hydrostatic tests at 1.5 times the design pressure. Design pressures are stated in the Piping Service Schedules.
6. Except where noted otherwise in specific Specification Sections, conduct tests for a 4 hour duration without pressure degradation.
7. Perform tests in the presence of the Construction Manager. Document all procedures and test results for record per Article 3.3.B.

B. Procedures:
1. Maintain calibration records for gauges utilized for pressure testing.
2. Conduct tests with 2 gauges installed as close as possible to the low point of the piping system.
3. Vent all air from hydronic systems before applying test pressure.
4. If pressure vessels are rated for conditions equal to or exceeding the maximum operating conditions of the connecting piping system, conduct tests including the vessel(s); otherwise, isolate vessels from the piping system for testing.
5. Do not test relief valves, pressure reducing valves, valves or other equipment beyond their rated capacity.
6. Do not use valves as blanking devices for pressure testing.
7. Provide all equipment, material and pipe taps required to perform pressure testing.
8. Visually examine all joints and connections for leaks. Repair to eliminate leak.
9. If pressure falls after shut down of pressurizing medium determine the source of pressure loss and repair to maintain pressure integrity.
10. Recognize the hazards associated with pneumatic pressure testing and take necessary precautions to protect all personnel and adjacent systems in the event of a joint failure.
11. Use fresh raw water for hydrostatic testing unless a definitive water quality is required under specific Specification Sections.
12. Upon completion of testing and acceptance, drain system and direct to appropriate waste system. Open all vents to avoid pulling a vacuum during draining.

3.6 LEAK REPAIR

A. Repair all defects, which develop under tests.

B. Repair leaks in soldered systems by melting out the joint, thoroughly cleaning parts, and/or replacing the fitting and resoldering the joint.

C. Repair minor leaks in welded joints by chipping out and rewelding.
D. Repair leaks in threaded joints by replacing the thread, the fitting or both.

E. On flanged joints replace defective or damaged gaskets during testing and flushing. Use new gaskets each time a flanged joint is made up.

F. Retest repaired piping systems until acceptance is obtained.

G. Repair leaks which occur during the warranty.

3.7 PIPE CLEANING/FLUSHING

A. Hydronic Systems:
   1. Insert temporary cone strainers upstream of equipment or components not directly protected by system strainers.
   2. Flush with water and EPA approved water treatment in accordance with the water treatment contractors recommendation.
   3. Maintain minimum flushing velocities of 0.76 mps [(2.5 fps)].
   4. Remove accumulated debris through drain valves 100 mm [(2 inches)] and larger and/or by dropping spools and valves. Remove and clean all strainers including reheat coil strainers.
   5. Repeat flushing until strainers show no signs of collecting additional debris.
   6. Install temporary bypass loops as required to maintain flushing velocities ensure complete system cleaning.

B. Passivation:
   1. After flushing carbon steel hydronic systems, provide additional cleaning utilizing Garratt-Callahan Company’s G-C Formula 248-L in accordance with the manufacturer’s instructions.
   2. Upon completion, drain and refill with water incorporating water treatment manufacturer’s recommended chemical treatment to prevent system oxidation prior to start up.

3.8 POTABLE WATER STERILIZATION

A. Disinfect all potable water lines before placing into service.

B. Utilize a chlorine-water solution having a free chlorine residual of 50 ppm. Prepare sterilizing mixture by injecting calcium or sodium hypochlorite and water mixture into pipeline at a measured rate while fresh water is allowed to go through the pipe line at a measured rate such that the combined mixture is of the specified concentration.

C. Operate all valves, hydrants, and other appurtenances during sterilization to ensure that the mixture is dispersed into all parts of the system.

D. Retain water in pipeline a minimum of 24 hours and long enough to destroy all nonspore-forming bacteria. Residual strength of mixture at end of retention period shall be not less than 10 ppm of chlorine.
E. Flush sterilizing solution from the system utilizing the permanent source of supply until the system is chemically and bacteriologically equal to the source water.

F. Provide adequate warning labels or signs at all points of possible use during the disinfection/flushing procedure.

3.9 SPECIFIC SYSTEM REQUIREMENTS

A. Sanitary Sewer - outside building, Storm drainage inside building, Storm sewer outside building, Trap primer lines, Soil waste and vent.
   1. Pressure test complete system with water. Visually inspect joints for leaks, repair or replace and retest.
   2. Flush pipe free of gross dirt and debris with clear water.

B. Domestic Water:
   1. Pressure test complete system with water. Use higher pressure where indicated or where required for building height or by authorities having jurisdiction. Visually inspect joints for leaks, repair or replace and retest.
   2. Flush pipe free of dirt and debris with fresh water.
   3. Disinfect lines with fluid chlorine or hypochlorite, introduce sufficient chlorine to provide an initial concentration of 50 ppm. Disinfect for 24-hour period, opening and closing valves in system at various points during disinfection. Following chlorination, thoroughly flush complete system until replacement water is same quality as incoming water. Submit certification.

C. Utility Compressed Air and Instrument Compressed Air piping systems:
   1. Testing - Refer to the General Purity Copper System specification.
   2. Cleaning - Refer to the General Purity Copper System specification.

D. High Purity Water Piping System:
   1. Testing - Refer to the High Purity Water system specifications.
   2. Cleaning - Refer to the High Purity Water system specifications.

E. Fire Protection: Clean and test as per applicable sections for Standpipes and Fire Suppression Sprinklers.

3.10 ACCEPTANCE

A. Maintain test records for each system tested, flushed, chemical treated or sterilized. Identify procedures, repairs, and test results.

B. Obtain signature and date for all personnel performing and witnessing tests.

C. Acceptance of each system is contingent upon sign off by the Construction Manager and Owner's Representative for all required tests.

3.11 IDENTIFICATION

A. Identify piping systems in accordance with Section 15020- Mechanical Identification.
SECTION 15064
COPPER PIPING SYSTEMS

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes pipe materials, fittings, and valves for copper piping systems.

1.2 SUBMITTALS

A. General: Submit in accordance with Division 1 Section - Submittal Procedures.
B. Submit vendor product data for pipe, fitting, and solder materials.
C. Submit test and certification reports required by Section 15060.

PART 2 – PRODUCTS

2.1 PIPING SYSTEM

A. Materials in accordance with Pipe Material Class Specification Sheet.

PART 3 – EXECUTION

3.1 FABRICATION, ASSEMBLY AND ERECTION - GENERAL

A. Install piping in accordance with Section 15060, related sections referenced therein, and manufacturer’s instructions.
B. Comply with applicable Building Codes, ASME B31.9, and ASTM B828.

3.2 TUBE PREPARATION

A. Cut tubing square.
B. Ream cut tube ends to full inside diameter to remove burrs. Remove burrs on outside of tubing.
C. Remove all oxides and surface oil from tube and fitting cups. Clean by lightly abrading using sand cloth or nylon abrasive pads.
D. Apply thin even coating of flux with a brush to both tube and fitting.

3.3 JOINING

A. Uniformly heat joint.
B. Take care to prevent annealing and burning flux by overheating.

C. When joining solder cup valves, fully open valve and/or remove Teflon and elastomer seats and seals to prevent damage.

3.4 INSTRUMENT AIR TUBING

A. Instrument supply air lines 10 mm [(3/8 inch)] minimum. Control air lines 8 mm [(1/4 inch)].

B. Route tubing and conduit runs a minimum of 300 mm [(12 inches)] away from hot pipes.

C. Continuously support instrument and control air tubing in channels, trays, and conduit to prevent physical damage. Refer also to Instrument and Control Sections in Division 13.

3.5 INSPECTION, EXAMINATION, AND TESTING

A. Comply with the requirements of Section 15060.

B. Comply with the Building Codes and ASME 31.9.

C. Comply with the most stringent requirement of the above.
1. Material Class: CU-01.

2. General Material: Copper.

3. Services:
   A. Domestic water, cold and hot.
   B. Condensate drain.
   C. Chilled water (nonclean areas).
   D. Heating water.
   E. Tempered water.
   F. Trap primer piping.
   G. Instrument air (nonclean areas).
   H. Industrial cold water.

4. Pressure Rating: 862 kPa [(125 psi)] cold water nonshock.

5. Design Temperature: 82 degrees C [(180 degrees F)].

6. Codes: B31.9, Building Codes.

7. Pipe:
   A. Aboveground, copper, Type L, hard drawn, ASTM B88, DN 100 [(4 inches)] maximum.
   B. Underground, copper, Type K, annealed, ASTM B88, DN 100 [(4 inches)] maximum.
   C. Condensate drain, copper, Type M, hard drawn, ASTM B88.

8. Fittings:
   A. Cast copper alloy threaded fittings ANSI/ASME B16.15.
   B. Wrought copper and copper alloy solder joint pressure fittings, ANSI B16.22.

9. Unions:
   A. DN 50 [(2 inches)] and Smaller: Socket joint, bronze ring nut.
   B. DN 65 [(2-1/2 inches)] and Larger: Use flanges.

10. Bolting:
    A. Bolts, ASTM A307, Grade B.
    B. Nuts, ASTM A563, Grade A, Heavy Hex.

11. Gaskets: Preformed microcellular PTFE, Garlock, Gaylon Style 3540, 7 mm [(1/16 inch)] thick, or equal.


13. Valves:
    A. Gate Valves:
1. **DN 50 [(2 inches)]** and Smaller: MSS-SP-80 Type 2, bronze body ASTM B61, Class 150, solid wedge, bronze disc, packing, rising stem, union bonnet with threaded or soldered ends.

2. **DN 65 to DN 100 [(2-1/2 inches to 4 inches)]:** MSS-SP-70 Type 1, cast iron body ASTM A126 Class B, Class 125, solid wedge bronze disc, bronze trim and seats, rising stem, bolted bonnet, O&Y, flanged ends.

**B. Globe Valves:**

1. **DN 80 [(3 inches)]** and Smaller: MSS-SP-80 Type 2, bronze body ASTM B62, Class 150, Teflon disc, union bonnet, threaded or soldered ends.

**C. Check Valves:**

1. **DN 50 [(2 inches)]** and Smaller: MSS-SP-80 Type 3, bronze body ASTM B62, Class 125, swing disc holder with TFE disc, threaded cap, threaded or soldered ends.

2. **DN 65 to DN 100 [(2-1/2 inches to 4 inches)]:** MSS-SP-80 Type 3, bronze body ASTM B62 Class 150, swing bronze disc, bolted cap, flanged ends.

**D. Butterfly Valves:**

1. **DN 65 to DN 100 [(2-1/2 inches to 4 inches)]:** MSS-SP-67, cast ductile iron ASTM A395, 1370 kPa [(200 psi)] rating, ductile iron nickel plated disc, EPDM sleeve, 316 stainless steel stem, lug body, lever operated.

**E. Ball Valves:**

1. **DN 50 [(2 inches)]** and Smaller: Bronze body ASTM B584, 2740 kPa [(400 psi)] rating, 3 piece, chrome-plated brass ball, full port opening, PTFE seats, lever operated, threaded or soldered ends.

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END OF SECTION
SECTION 15065

NONMETALLIC PIPE, FITTINGS, AND VALVES

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes pipe, fittings, and valves to be used in systems requiring nonmetallic piping and components.

1.2 SUBMITTALS

A. Submit shop drawings and samples in accordance with Division 1.

B. Submittals Shall Include the Following:
   1. Compliance with applicable ASTM codes.
   2. Manufacturer's installation instructions.

PART 2 – PRODUCTS

2.1 POLYVINYL CHLORIDE PIPE (PVC)-FLAME RETARDANT

A. Pipe: Schedule 40 or Schedule 80 per ASTM D1784, ASTM D1785, or ASTM D2241. Refer to Section 15060.

B. Fittings:
   2. Schedule 80, Socket Type: ASTM D2467.
   5. Thread Lubricant: As recommended by pipe and fitting manufacturer.

C. Valves:
   1. Valves shall be AsahiAmerica, Chemtrol, GF Plastics, Harrington, R & G Sloane or Ryan-Herco, having PVC bodies and handles.
   2. Diaphragm Valves: True union socket ends, EPDM elastomer diaphragm, and PVC body.
   4. Gate Valves: Buna-N seals and PVC encased shafts.
   6. Check Valves: Ball type with true union ends, Viton O-rings, and PVC body.
   7. Ball Valves: True union type with Teflon seats and stem sleeve and Viton seals.
   8. Butterfly Valves 2-1/2 inches and Larger: PVC body with Viton liner polypro disc with steel insert, 403 stainless steel stem and 316 stainless steel indicating monitor. Valves up to 6 inches shall be lever operated, valves 8 inches and larger shall be gear operated. Valves shall be provided with tapped lug body when used for isolating service.
9. Butterfly valves may be used interchangeably with gate valves and globe valves in sizes 2-1/2 inches and larger.
10. Provide extensions to clear insulation where required.
11. Provide valves located more than 7 feet above floor in equipment room areas with chain-operated sheaves. Extend chains to approximately 5 feet above floor and hook to clips arranged to clear walking aisles.
12. Valves shall be provided according to the following schedule. Ryan Herco valve numbers used.

<table>
<thead>
<tr>
<th>Valve Type</th>
<th>Threaded to 2&quot;</th>
<th>Socket to 2&quot;</th>
<th>Flanged 2-1/2&quot; up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate Valve</td>
<td>5482</td>
<td>5481</td>
<td>5450</td>
</tr>
<tr>
<td>Globe Valve</td>
<td>5200</td>
<td>----</td>
<td>5202</td>
</tr>
<tr>
<td>Check Valve</td>
<td>5101</td>
<td>5102</td>
<td>5103</td>
</tr>
<tr>
<td>Ball Valve (Viton)</td>
<td>5002</td>
<td>5002</td>
<td>5032</td>
</tr>
<tr>
<td>Ball Valve (EPDM)</td>
<td>5033</td>
<td>5033</td>
<td>5034</td>
</tr>
<tr>
<td>Butterfly Valve</td>
<td>----</td>
<td>----</td>
<td>5438</td>
</tr>
<tr>
<td>Diaphragm Valve</td>
<td>----</td>
<td>5279</td>
<td>----</td>
</tr>
<tr>
<td>Pneu. Diaphragm Valve</td>
<td>5753</td>
<td>----</td>
<td>----</td>
</tr>
</tbody>
</table>

2.2 POLYVINYL CHLORIDE PIPE (PVC)-DRAIN, WASTE, AND VENT

A. Pipe: Schedule DWV, ASTM D2665.

B. Fittings:
   2. Socket Type: ASTM D2665.
   4. Thread Lubricant: As recommended by pipe and fitting manufacturer.

2.3 CHLORINATED POLYVINYL CHLORIDE PIPE (CPVC) - FLAME RETARDANT

A. Pipe: Schedule 80 per ASTM F441, ASTM D1785, or ASTM D2241. Refer to Section 15060.

B. Fittings:
   1. Schedule 80, Socket Type: ASTM F439.
   5. Thread Lubricant: Teflon tape.

2.4 CPVC DRAIN, WASTE & VENT PIPING - FLAME RETARDENT

A. Pipe: Schedule 40 per ASTM F441, ASTM D1785, or ASTM D2241. Refer to Section 15060.
B. Fittings:
   4. Threaded Joints: Only use once per each line and only in vertical orientation.
   5. Thread Lubricant: Teflon® tape.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Refer to Section 15060.

END OF SECTION
SECTION 15072

MECHANICAL PIPE FLEXIBILITY, EXPANSION JOINTS, AND CONNECTORS

PART 1 – GENERAL

1.1 SUMMARY

A. Section includes pipe natural flexibility, expansion joints, connectors, guides, and anchors for mechanical piping systems.

1.2 DESIGN CRITERIA

A. General:
1. Design and provide systems to accommodate thermal pipe movement and relative motion between seismically independent structures.
2. Coordinate the requirements of this Section with the requirements of Section 15070 - Mechanical Seismic Control.

B. Expansion Devices:
1. Minimize use of mechanical joints by taking advantage of the natural flexibility of the piping system arrangement and layout.
2. Where space permits, add loops, offsets etc., to accommodate thermal movement before incorporating mechanical joints.
3. Do not use mechanical joints in process systems unless shown or specified.
4. Select joints that are maintenance free such as bellows type before selecting slip-type joints.
5. Select joints that will minimize pressure thrust forces.
6. Use a minimum safety factor of 1.3 for flexibility design.

C. Thermal Movement:
1. Base calculations for thermal expansion or contraction on the following:

<table>
<thead>
<tr>
<th>Pipe System</th>
<th>Service Temperature</th>
<th>Installation Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic hot water</td>
<td>60°C [(140°F)]</td>
<td>10°C [(50°F)]</td>
</tr>
</tbody>
</table>

2. Systems that operate in the range of 16 degrees C [(60 degrees F)] to 43 degrees C [(110 degrees F)] do not require engineered design for thermal movement.

B. Anchors:
1. Locate anchors consistent with the systems natural flexibility.
2. When mechanical joints are used, locate anchors in accordance with manufacturer’s instructions or EJMA Standards.
3. Locate anchors such that resultant loads can be efficiently and economically transferred to primary structural members.
4. Calculate anchor loads due to gravity, pressure, thermal movement, seismic, and wind effects where applicable. Where mechanical joints are used, include forces based on full rated deflection and the pressure thrust. If the joint is not isolated from the system
or other protective measures taken during system leak testing, base design pressure on the test pressure for calculating pressure thrust. System design pressure may be used if the forces due to seismic equal or exceed the differential pressure thrust resulting from test less design pressures.

5. Do not use pumps, tanks, or equipment as anchor points unless such equipment has been designed to accommodate the resultant loads.

C. Guides:
   1. Locate guides in accordance with applicable codes, standards, and manufacturer’s instructions.
   2. Select guides to permit required axial and/or lateral movements.
   3. Calculate loads on guides based on gravity, frictional and seismic forces.

D. Seismic Joints:
   1. Provide design and means to accommodate relative motion between independent structures for pipes crossing the seismic joint in both the X and Y directions.
   2. Seismic Movement: Base requirements to accommodate seismic movement on the following:

<table>
<thead>
<tr>
<th>Pipe Centerline Above Grade, m [feet]</th>
<th>Relative Displacement Between Structures in both X and Y Directions, mm [inches]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2 [(17)]</td>
<td>± 50 [(2)]</td>
</tr>
<tr>
<td>10.1 [(33)]</td>
<td>± 100 [(4)]</td>
</tr>
<tr>
<td>15.2 [(50)]</td>
<td>± 150 [(6)]</td>
</tr>
<tr>
<td>20.4 [(67)]</td>
<td>± 200 [(8)]</td>
</tr>
<tr>
<td>25.3 [(83)]</td>
<td>± 250 [(10)]</td>
</tr>
</tbody>
</table>

4. Devices:
   a. Use braid covered metal hose connectors arranged in a “V” configuration within the size, movement, pressure, and temperature limitations.
   b. Evaluate the use of universal expansion joints or slotted hinged expansion joints where size and movement precludes the use of V connectors.
   c. Where neither of the above is applicable, incorporate “L” bends or other acceptable off-setting arrangements to account for relative motion. Treat relative motion as an “effective” thermal movement.

1.3 PERFORMANCE REQUIREMENTS

A. Provide pipe expansion, pipe expansion joints and connectors, pipe alignment guides, and pipe anchors suitable for piping system fluids, materials, working pressures, and temperatures.

B. Fabricate and install expansion and anchor system capable of sustaining forces generated by gravity, thermal movement, and seismic events.

C. Design and obtain approval from authority with jurisdiction, seismic restraints for pipe expansion joints and pipe anchor system.
1.4 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Section 01330.

B. Product data for each type of pipe expansion joint and pipe alignment guide utilized.

C. Pipe expansion joint schedule showing manufacturer's figure number, size, location, and features for each required expansion joint.

D. Anchor, guide and restraint load calculations, locations, and details to transfer loads to structure.

E. Maintenance data for each type pipe expansion joint specified to be included in the "Operating and Maintenance Manuals" specified in the Division 1 Section - Closeout Submittals.

1.5 SITE RECORDS

A. Welder certificates signed by Contractor certifying that welders comply with requirements specified under the "Quality Assurance" Article.

B. Assembly-type shop drawings for each type of pipe expansion joint, pipe alignment guide, and anchor, indicating dimensions, weights, required clearances, and methods of component assembly.

1.6 QUALITY ASSURANCE

A. Qualify welding processes and welding operators according to AWS D1.1 "Structural Welding Code-Steel."
   1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

B. Qualify welding processes and welding operators according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

C. Licensed Engineer's Design Drawings and Calculations: Design and prepare drawings and calculations for seismic restraint of pipe expansion joints, pipe alignment guides, and pipe anchors. Include seal and signature of Registered Engineer, licensed in jurisdiction where Project is located, certifying compliance with specifications.

D. Comply with referenced codes and manufacturer’s standards.
   1. ANSI B31.1, Power Piping.
   2. ANSI B31.1, Process Piping.
   3. ANSI B31.9, Building Services Piping.
   4. Expansion Joint Manufacturers Association (EJMA) Standards.

PART 2 – PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Badger Industries, Inc.
   2. Hyspan Precision Products, Inc.
   3. Metraflex Co.
   5. Senior Flexonics, Expansion Joint Div.
   6. Unisource
   7. Wahlco Engineered Products, Inc.

2.2 PACKLESS-TYPE PIPE EXPANSION JOINTS

A. Metal-Bellows Packless-Type Pipe Expansion Joints: Pressure rated for 1200 kPa [(175 psig)] minimum; conform to the standards of Expansion Joint Manufacturers Association, Inc. (EJMA). Provide expansion joint type such as single, double, universal, hinged, etc., to suit each application. Provide covers or shrouds to protect bellows. Provide control rods, limit rods or tie rods to suit each application. Provide pipe guides, and anchors in accordance with manufacturer’s recommendations and EJMA Standards. Provide end connections to suit pipe size and material.

B. Expansion-Compensator Packless-Type Pipe Expansion Joints: Pressure rated for 1200 kPa [(175 psig)] minimum. Include 2-ply phosphor bronze bellows, brass shrouds, and end fittings for copper piping systems and 2-ply stainless-steel bellows, carbon-steel shrouds, and end fittings for steel piping systems. Include internal guides, antitorque device, and removable end clip for proper positioning.

2.3 FLEXIBLE CONNECTORS

A. General: Stainless steel flexible metal hose and braid with carbon steel ends, threaded or flanged based on pipe size for steel piping systems. Bronze hose and braid with copper ends for copper piping system. Minimum design pressure 862 kPa [(125 psig)]. Minimum cycle life, 2000 cycles.

B. Seismic Joints: Flexible braided hose as above arranged in a "V" configuration with two 45-degree E1 end connections and a 90 degree E1 return. Provide live length for up to 100 mm [(4 inch)] movement in all planes. Provide drain port for steam service.

2.4 PIPE ALIGNMENT GUIDES

A. Factory-fabricated cast semisteel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base. Include two-section guiding spider that bolts tightly to the pipe. Guide lengths based on pipe movement.

2.5 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A36M [(ASTM A36)], steel plates, shapes, and bars, black and galvanized.

B. Bolts and Nuts: ASME B18.10 or ASTM A183, steel, hex-head, track bolts and nuts.
C. Washers: ASTM F844, steel, plain, flat washers.

D. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used. Fasteners for fire protection systems include UL listing and FM approval. Do not use insert-type attachments in lightweight concrete or concrete slabs less than 100 mm (4 inches) thick.

E. Grout: ASTM C1107, Grade B, nonshrink, nonmetallic.
   1. Characteristics include post-hardening volume-adjusting dry hydraulic-cement-type grout that is nonstaining, noncorrosive, nongaseous and is recommended for both interior and exterior applications.
   2. Design Mix: 34.5 MPa [(5000 psi)], 28-day compressive strength.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions under which pipe expansion joints, pipe alignment guides, and pipe anchors are to be installed. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPE EXPANSION JOINT INSTALLATION

A. Install pipe expansion joints guides and anchors according to manufacturers written instructions.

B. Align expansion joints to avoid end-loading and torsional stress.

3.3 FABRICATED-TYPE PIPE EXPANSION COMPENSATION INSTALLATION

A. Install pipe expansion loops, offsets, Z bends, and L bends cold-sprung in tension or compression as required to absorb 50 percent of total compression or tension that will be produced during anticipated change in temperature. Note: No credit for cold spring is permitted in stress range calculation.

B. Connect risers to mains with at least 5 pipefittings including tee in main.

C. Connect risers to terminal units with at least 4 pipefittings including tee in riser.

3.4 PIPE ALIGNMENT GUIDE INSTALLATION

A. Install pipe alignment guides on piping that adjoins pipe expansion joints.

B. Install pipe alignment guides on piping that adjoins pipe expansion loops.

C. Install pipe alignment guides on piping elsewhere in accordance with joint manufacturer’s instructions and EMJA Standards.
D. Secure pipe alignment guides to building substrate.

3.5 PIPE ANCHOR INSTALLATION

A. Install pipe anchors at proper locations to prevent stresses from exceeding those permitted by ASME B31.1 or ASME B31.9 as applicable and to prevent transfer of loading and stresses to connected equipment.

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

C. Where pipe expansion joints are indicated, install pipe anchors according to expansion unit manufacturers written instructions to control movement to compensators.

D. Pipe Anchor Spacings: Where not otherwise indicated, install pipe anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends. Preset anchors as required accommodating both expansion and contraction of piping.

E. Use grout to form flat bearing surfaces for pipe expansion joints, pipe alignment guides, and pipe anchors that are installed on or in concrete.

3.6 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint and 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 by brush or spray to provide a minimum dry film thickness of 0.05 mm [(2.0 mils)].

B. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal is specified in Division 9 Section - Paints and Coatings.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

3.7 FIELD QUALITY CONTROL

A. Licensed Engineer's Installation Report: Prepare report covering installation of pipe expansion joints, pipe alignment guides, and pipe anchors. Include seal and signature of Registered Engineer, licensed in jurisdiction where Project is located, certifying compliance with specifications.

END OF SECTION
SECTION 15075
MECHANICAL IDENTIFICATION

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes: This Section includes mechanical identification materials and devices.

1.2 SUBMITTALS

A. Submit the following in accordance with Conditions of Contract and Section 01330.

B. Product data for identification materials and devices.

C. Samples of color, lettering style, and other graphic representation required for each identification material and device.

D. Valve Schedules: Submit valve schedules for each piping system. Reproduce on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on tag), location of valve (room or space), and variations for identification. Mark valves intended for emergency shutoff and similar special uses. Furnish extra copies (in addition to mounted copies) for Maintenance Manuals as specified in Division 1 Section - Closeout Submittals.

1.3 QUALITY ASSURANCE

A. Comply with ASME A13.1 "Scheme for the Identification of Piping Systems" for lettering size, length of color field, colors, and viewing angles of identification devices.

B. Comply with labeling requirements of Uniform Mechanical Code for fire and smoke dampers.

1.4 SEQUENCING AND SCHEDULING

A. Coordinate installation of identifying devices after completion of covering and painting where devices are applied to surfaces. Install identifying devices prior to installation of acoustical ceilings and similar concealment.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Brady; Signmark Div.; W.H. Brady Co.

B. Calpico, Inc.

C. Carlton Industries, Inc.

D. Emed Co., Inc.
2.2 IDENTIFYING DEVICES AND LABELS

A. General: Products specified are manufacturer's standard products of categories and types required for each application as referenced in other Division 15 Sections. Where more than single type is specified for listed application, selection is installer's option, but provide single selection for each product category.

B. Equipment Nameplates: Metal nameplate permanently fastened to equipment and having data engraved or stamped.
   1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data.
   2. Location: An accessible and visible location.


D. Pressure-Sensitive Pipe Markers: Manufacturer's standard pre-printed, color-coded, pressure-sensitive vinyl pipe markers, with permanent adhesive conforming to ASME A13.1.

E. Pipes DN 125 [(5 inches)] and Smaller: Full-band pipe markers, extending 360 degrees around pipe at each location.

F. Pipes DN 150 [(6 Inches)] and Larger: Either full-band or strip-type pipe markers, at least 3 times the letter height and of length required for label.

G. Lettering: Use piping system terms as indicated in Section 15060 and abbreviate only as necessary for each application length.
   1. Arrows: Either integral with piping system service lettering (to accommodate both directions), or as separate unit, on each pipe marker to indicate direction of flow.

H. Plastic Duct Markers: Manufacturer's standard laminated plastic, duct markers in the following color code:
   1. Green: Cold air.
   2. Yellow: Hot air.
   3. Yellow/Green: Supply air.
   4. Blue: Exhaust, outside, return, and mixed air.
   5. For hazardous materials exhausts, use colors and designs recommended by ASME A13.1.
6. Terminology: Include direction of airflow, duct system (makeup air, AHU-1, solvent exhaust, etc.), and duct service (supply, return, exhaust, etc.).

I. Plastic Tape: Manufacturer's standard color-coded, pressure-sensitive, self-adhesive, vinyl tape, at least 3 mils thick.
   1. Width: 40 mm [(1-1/2 inches)] wide on pipes with outside diameters (including insulation) less than 150 mm [(6 inches)]; [(2-1/12 inches)] wide for larger pipes.
   2. Color: Comply with ASME A13.1, except where another color selection is indicated.

J. Valve Tags: Stamped or engraved with [(1/4 inch)] letters for piping system abbreviations indicated on the Drawings, and 13 mm [(1/2 inch)] sequenced numbers. Provide a 7 mm [(3/16 inch)] hole for fastener.
   1. Material: 19 gage polished brass (except clean areas),
   2. Material: 0.64 mm [(0.025 inch)] stainless steel (clean and corrosive areas).
   3. Shape: As indicated for each piping system.
      a. Round: 40 mm [(1-1/2 inches)] plumbing services.
      b. Square: 40 mm [(1-1/2 inches)] HVAC services.
      c. Hexagonal: 40 mm [(1-1/2 inches)] fire protection services.
      d. Process services: 50 mm [(2 inch)] octagonal.

K. Valve Tag Fasteners:
   1. Brass chain (wire link or beaded type).
   2. Polished nickel over steel chain (clean and corrosive areas).

L. Access Panel Markers: 3 mm [(1/16 inch)] thick engraved plastic-laminate markers, with abbreviated terms and numbers corresponding to concealed valve. Provide 6 mm [(1/8 inch)] center hole for attachment.

M. Valve Schedule Frames: Glazed display frame, with screws for removable mounting on masonry walls for each page of valve schedule.
   1. Frame: Extruded aluminum.
   2. Glazing: ASTM C1036, 2.5 mm, single thickness, sheet glass.
      a. Type: Type I, flat transparent.
      b. Class: Class 1, clear.
      c. Quality: Glazing B, for general applications.

N. Engraved Plastic-Laminate Signs: ASTM D709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white (letter color) melamine subcore, except when other colors are indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
   1. Engraved with engraver's standard letter style, of sizes and with terms to match equipment identification.
   2. Thickness: 3 mm [(1/16 inch)], for units up to 20 square inches or 8 inches length; 6 mm [(1/8 inch)] for larger units.
   3. Fasteners: Self-tapping stainless steel screws or contact-type permanent adhesive.

O. Plastic Equipment Markers: Laminated-plastic, in the following color code:
   1. Green: Cooling equipment and components.
   2. Yellow: Heating equipment and components.
   3. Yellow/Green: Combination cooling and heating equipment and components.
5. Blue: Equipment and components that do not meet any of above criteria.
6. For hazardous equipment, use colors and designs recommended by ASME A13.1.
7. Terminology: Include following, matching schedules as closely as possible:
   a. Name and equipment number.
   b. Equipment service.
   c. Design capacity.
8. Size: Approximate 65 mm by 100 mm [(2-1/2 by 4 inches)] for control devices, dampers, and valves; and 115 mm by 150 mm [(4-1/2 by 6 inches)] for equipment.

P. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated. Use numbers, letters, and terms indicated for proper identification, operation, and maintenance of mechanical systems and equipment.
   1. Multiple Systems: Where multiple systems of same name are indicated, identify individual system number as well as service (such as Boiler No. 3, Air Supply No. 1H, or Standpipe F12).

PART 3 – EXECUTION

3.1 LABELING AND IDENTIFYING

A. Piping Systems: Install pipe markers on each system in accordance with manufacturer’s instructions. Include arrows showing normal direction of flow.

B. Locate pipe markers as follows wherever piping is exposed in finished spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior nonconcealed locations.
   1. Near each valve and control device.
   2. Near each branch connection, excluding short take-offs for fixtures and terminal units. Mark each pipe at branch, where flow pattern is not obvious.
   3. Near penetrations through walls, floors, ceilings, or enter nonaccessible 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 a maximum of 15 m [(50 feet)] intervals along each run. Reduce intervals to 7 m [(25 feet)] in congested areas of piping and equipment.
   7. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

C. Valve Tags: Install valve tag on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, plumbing fixture supply stops, shut-off valves, faucets, convenience and lawn-watering hose bibbs, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in valve schedule.
   1. [Schedule: Comply with requirements of “Valve Tagging Applications Schedule” in Part 3 of this Section.]
   2. Install mounted valve schedule in each major equipment room.
D. Equipment: Install engraved plastic laminate signs or equipment markers on or near each major item of mechanical equipment. Provide signs for following general categories of equipment:
   1. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
   2. Meters, gauges, thermometers, and similar units.
   3. Fuel-burning units including boilers, furnaces, heaters, stills, and absorption units.
   4. Pumps, compressors, chillers, condensers, and similar motor-driven units.
   5. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
   6. Fans, blowers, primary balancing dampers, and mixing boxes.
   7. Packaged HVAC central-station and zone-type units.
   8. Tanks and pressure vessels.
   9. Strainers, filters, humidifiers, water treatment systems, and similar equipment.

E. Duct Systems: Identify air supply, return, exhaust, intake, and relief ducts with duct markers; and arrows showing duct system service and direction of flow.
   1. Location: In each space where ducts are exposed or concealed by removable ceiling system. Locate signs near points where ducts enter into concealed space and at maximum intervals of 15 m ([50 feet]).

F. Fire and Smoke Damper Access Points: Identify access points with permanent labels on exterior.

3.2 ADJUSTING AND CLEANING

A. Relocate mechanical identification materials and devices, which have become visually blocked by work of this Division or other Divisions.

B. Clean face of identification devices, and glass frames of valve charts.

3.3 VALVE TAGGING SCHEDULE

A. Tag valves according to size, shape, color scheme, and with captions similar to those indicated in following “Valve Tagging Applications Schedule.”

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END OF SECTION
PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes pipe, duct, and equipment insulation.

B. References:
   1. National Commercial and Industrial Insulation Standards.

1.2 DEFINITIONS

A. Hot Surfaces: Normal operating temperatures of 38 degrees C [(100 degrees F)] or higher.

B. Cold Surfaces: Normal operating temperatures less than 16 degrees C [(60 degrees F)]. Note, domestic cold-water temperatures vary by season and insulation requirement is based on minimum temperature.

C. Thermal Conductivity (k-value): Measure of heat flow through a material at a given temperature difference; conductivity is expressed in units of W x m/sq. m x K [(Btu by inch/h by sq. ft. by degrees F)].

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Section 01330 - Submittal Procedures.

B. Product data for each type of mechanical insulation identifying k-value, thickness, and accessories.

1.4 QUALITY ASSURANCE

A. Coordination: Coordinate with the installing contractor for piping, hangers, and supports the insulation materials and thickness that will be furnished for each insulated system.

B. Fire Performance Characteristics: Conform to the following characteristics for insulation including facings, cements, and adhesives, when tested according to ASTM E84, by UL or other listing organization acceptable to the authority having jurisdiction. Label insulation with appropriate markings of testing laboratory.
   1. Interior Insulation: Flame spread rating of 25 or less and a smoke developed rating of 50 or less.
   2. Exterior Insulation: Flame spread rating of 75 or less and a smoke developed rating of 150 or less.

C. Job Condition:
1. Deliver material to project in original factory packaging, labeled with manufacturer’s density and thickness.
2. Perform work at ambient and equipment temperatures recommended by the adhesive manufacturer.

D. Field-Constructed Mock-Up: Before installation, erect mock-up of size and at locations indicated to demonstrate workmanship quality. Include method of attachment and finishing for each.
   1. Interior and exterior equipment.
   2. Interior and exterior duct systems.
   3. Interior and exterior piping systems.
   4. Retain and protect mock-ups during construction as a standard for judging completed unit of Work.
   5. Remove mock-ups from Project site when directed.
   6. Accepted mock-ups may become part of completed unit of Work.

1.5 SEQUENCING AND SCHEDULING

   A. Schedule insulation application after testing of piping and duct systems has been accepted.
   B. Schedule insulation application after installation and testing of heat trace tape.
   C. Schedule insulation application prior to concealment.

1.6 WARRANTY

   A. Installing contractor’s written warranty covering materials and labor furnished.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

   A. Manufacturers: Subject to compliance with requirements, provide products by the following:
      1. Glass Fiber:
         a. CertainTeed Mason.
         b. Knauf Fiberglass GmbH.
         c. Manville (Schuller International, Inc.).
         d. Owens-Corning Fiberglas Corporation.
      3. Calcium Silicate:
         a. Manville (Schuller International, Inc.).
         b. Owens-Corning Fiberglas Corporation.
         c. Pabco
      4. Phenolic Foam Insulation: (Koolphen K) Kooltherm Insulation Products, Ltd.
      5. PVC Fitting Covers and Jacketing:
         a. Ceel-Co.
         b. Manville (Schuller International, Inc.).
         c. Promat.
d. Proto Corp.

2.2 GLASS FIBER

A. Material: Inorganic glass fibers, bonded with a thermosetting resin.


C. Board: ASTM C 612, Type IB, semi-rigid jacketed board.
   1. Thermal Conductivity: 0.037 W x m/sq. m x K [(0.26 Btu by inch/h by sq. ft. by degrees F)] average maximum, at 24 degrees C [(75 degrees F)] mean temperature.
   2. Density: 192 kg/cu. m [(12 pcf)] average maximum.

D. Preformed Pipe Insulation: ASTM C 547, Class 1, rigid pipe insulation, jacketed.
   1. Thermal Conductivity: 0.037 W x m/sq. m x K [(0.26 Btu by inch/h by sq. ft. by degrees F)] average maximum at 24 degrees C [(75 degrees F)] mean temperature.
   2. Density: 160 kg/cu. m [(10 pcf)] average maximum.

E. Blanket: ASTM C 553, Type II, Class F-1, jacketed flexible blankets.
   1. Thermal Conductivity: 0.043 W x m/sq. m x K [(0.30 Btu by inch/h by sq. ft. by degrees F)] average maximum, at 24 degrees C [(75 degrees F)] mean temperature.
   2. Density: 16 kg/cu.m [(1.0 pcf)] average.

F. Adhesive: Produced under the UL Classification and Follow-up service.
   1. Type: Non-flammable, solvent-based.
   2. Service Temperature Range: Minus 29 to 82 degrees C [(Minus 20 to 180 degrees F)].

G. Vapor Barrier Coating: Waterproof coating recommended by insulation manufacturer for outside service.

2.3 CELLULAR GLASS

A. Material: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.

B. Facing:
   1. Aboveground: Factory or field applied all service jacket (ASJ).
   2. Underground: Factory or field applied Pittwrap®, in accordance with the applicable service temperature.

C. Form: The following as indicated:
   1. Blocks: ASTM C552, Type I.
   2. Boards: ASTM C552, Type IV.
   3. Preformed Pipe: ASTM C552, Type II, Class 2 (jacketed).
   4. Special Shapes: ASTM C552, Type III, in shapes and thicknesses as indicated.

D. Thermal Conductivity: 0.050 W x m/sq. m x K [(0.345 Btu x inch/h x sq. ft. x degrees F)] average maximum at 24 degrees C [(75 degrees F)] mean temperature.
E. Minimum Density: 107 kg/cu. m [(6.7 pcf)].

F. Maximum Density: 147 kg/cu. m [(9.2 pcf)].

G. Joint Sealant:
   1. Below ambient service temperature, Pittseal® 444.
   2. Above ambient service temperature, none.

2.4 PHENOLIC FOAM

A. Material: Closed cell, CFC free, phenolic foam.

B. Jacket: All-purpose (ASJ), factory applied, laminated glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil, having self-sealing lap.

C. Board and Preformed Pipe Insulation:
   1. Thermal Conductivity: 0.019 W x m/sq m x k [(0.13 Btu by inch/h by square feet by degrees F)].
   2. Density: 35 kg/cu m [(2.2 pcf)].
   3. High-density Pipe Supports: 160 kg/cu m [(10.0 pcf)].

D. Flame Spread, Smoke Developed: ASTM E84, 20/32 on 80 mm [(3 inch)] thickness faced with ASJ.

E. Joint Sealer: Manufacturer’s recommendation.

2.5 INSULATING CEMENTS

   1. Thermal Conductivity: 0.173 W x m/sq m x K [(1.2 Btu by inch/h by sq. ft. by degrees F)] average maximum at 204 degrees C [(400 degrees F)] mean temperature.
   2. Compressive Strength: 690 kPa [(100 psi)] at 5 percent deformation.

2.6 ADHESIVES

A. Flexible Elastomeric Cellular Insulation Adhesive: Solvent-based, contact adhesive recommended by insulation manufacturer.

B. Lagging Adhesive: MIL-A-3316C, non-flammable adhesive in the following Classes and Grades:
   1. Class 1, Grade A for bonding glass cloth and tape to unfaced glass fiber insulation, sealing edges of glass fiber insulation, and bonding lagging cloth to unfaced glass fiber insulation.
   2. Class 2, Grade A for bonding glass fiber insulation to metal surfaces.

2.7 JACKETS
A. General: ASTM C921, Type 1, except as otherwise indicated or recommended by manufacturer.

   1. Water Vapor Permeance: 1.2 ng/Pa/s/sq. m maximum, when tested according to ASTM E96.
   2. Puncture Resistance: 50 beach units minimum, when tested according to ASTM D781.

C. PVC Jacketing: High-impact, ultra-violet-resistant PVC, 0.50 mm [(20 mils)] thick, roll stock ready for shop or field cutting and forming to indicated sizes.
   1. Adhesive: As recommended by insulation manufacturer.

D. PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 0.50 mm [(20 mils)] thick, high-impact, ultra-violet-resistant PVC, preformed for elbows, tees, valves, flanges, reducers, end caps, etc.
   1. Adhesive: As recommended by insulation manufacturer.

E. Aluminum Jacket: ASTM B209, 3003 Alloy, H-14 temper, factory cut and rolled to indicated sizes.
   1. Finish and Thickness: Smooth finish, 0.25 mm [(0.010 inch)] thick.
   2. Finish and Thickness: Corrugated finish, 0.25 mm [(0.010 inch)] thick.
   3. Fitting Covers: Preformed 45-degree and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers and caps, etc., same material, finish, and thickness as jacket.

2.8 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Woven glass fiber fabrics, plain weave, presized a minimum of 272 gm per sq. m [(8 ounces per square yard)].
   1. Tape Width: 102 mm [(4 inches)].
   2. Cloth Standard: MIL-C-20079H, Type I.
   3. Tape Standard: MIL-C-20079H, Type II.

B. Bands: 19 mm [(3/4 inch)] wide, in one of the following materials compatible with jacket:
   1. Stainless Steel: Type 304, 0.5 mm [(0.020 inch)] thick.
   2. Galvanized Steel: 0.13 mm [(0.005 inch)] thick.
   3. Aluminum: 0.18 mm [(0.007 inch)] thick.

C. Wire: 1.6 mm [(14 gage)] nickel copper alloy, 1.6 mm [(16 gage)], soft-annealed stainless steel, or 1.6 mm [(16 gage)], soft-annealed galvanized steel.

D. Corner Angles: 0.3 mm [(28 gage)], 25 mm by 25 mm [(1 inch by 1 inch)] aluminum, adhered to 50 mm by 50 mm [(2 inches by 2 inches)] kraft paper.

E. Anchor Pins: Welded, cupped head pins. Provide pins of sizes and diameters as recommended by the manufacturer for insulation type and thickness.
2.9 SEALING COMPOUNDS

A. Vapor Barrier Compound: Water-based, fire-resistive composition.
   1. Water Vapor Permeance: 4.6 ng/Pa/s/sq m [(0.08 perm)] maximum.
   2. Temperature Range: Minus 29 to 82 degrees C [(Minus 20 to 180 degrees F)].

B. Weatherproof Sealant: Flexible-elastomer-based, vapor-barrier sealant designed to seal metal joints.
   1. Water Vapor Permeance: 1.2 ng/Pa/s/sq m [(0.02 perm)] maximum.
   2. Temperature Range: Minus 46 to 121 degrees C [(Minus 50 to 250 degrees F)].

PART 3 – EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean, dry, and remove foreign materials such as rust, scale, and dirt.

B. Mix insulating cements with clean potable water. Mix insulating cements contacting stainless-steel surfaces with demineralized water. Follow cement manufacturer's printed instructions for mixing and portions.

3.2 INSTALLATION, GENERAL

A. Perform work after acceptance of systems testing and installation of applicable heat tracing, and prior to concealment. Coordinate with other trades.

B. Refer to schedules at the end of this Section for materials, and thicknesses required for each mechanical system.

C. Select accessories compatible with materials suitable for the service. Select accessories that do not corrode, soften, or otherwise attack the insulation or jacket in either the wet or dry state.

D. Install vapor barriers on insulated pipes, including storm drains, ducts, and equipment having surface operating temperatures below 16 degrees C [(60 degrees F)].

E. Apply insulation material, accessories, and finishes according to the manufacturer's printed instructions and the National Commercial and Industrial Insulation Standards and specific installation requirements specified herein.

F. Install insulation with smooth, straight, and even surfaces.

G. Seal joints and seams to maintain vapor barrier on insulation requiring a vapor barrier.

H. Seal penetrations for hangers, supports, anchors, and other projections in insulation requiring a vapor barrier.

I. Seal Ends: Taper ends at 45-degree angle and seal with lagging adhesive.
J. Apply adhesives and coatings at manufacturer's recommended coverage-per-gallon rate.

K. Keep insulation materials dry during storage, application, and finishing. Protect materials from damage during construction.

3.3 PIPE INSULATION INSTALLATION, GENERAL

A. Tightly butt longitudinal seams and end joints. Bond with adhesive.

B. Stagger joints on double layers of insulation.

C. Apply insulation continuously over fittings, valves, and specialties, except as otherwise indicated.

D. Apply insulation with a minimum number of joints.

E. Apply insulation with integral jackets as follows:
   1. Pull jacket tight and smooth.
   2. Cover circumferential joints with butt strips, at least 76 mm [(3 inches)] wide, and of same material as insulation jacket. Secure with adhesive.
   3. Longitudinal Seams: Overlap seams at least 40 mm [(1-1/2 inches)]. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap.
   4. Vapor Barrier Coatings: Where vapor barriers are indicated, apply on seams and joints, over staples, and at ends butt to flanges, unions, valves, and fittings.
   5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor barrier coating.
   6. Repair damaged insulation jackets, except metal jackets, by applying jacket material around damaged jacket. Adhere and seal. Extend patch at least 50 mm [(2 inches)] in both directions beyond damaged insulation jacket and around the entire circumference of the pipe.

F. Roof Penetrations: Apply insulation for interior applications to a point even with the top of the roof flashing. Seal with vapor barrier coating. Apply insulation for exterior applications butted tightly to interior insulation ends. Extend metal jacket for exterior insulation outside roof flashing at least 50 mm [(2 inches)] below top of roof flashing. Seal metal jacket to roof flashing with vapor barrier coating.

G. Exterior Wall Penetrations: For penetrations of below grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor barrier coating.

H. Interior Walls and Partitions Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions. Apply an aluminum jacket with factory-applied moisture barrier over insulation. Extend 50 mm [(2 inches)] from both surfaces of wall or partition. Secure aluminum jacket with metal bands at both ends. Seal ends of jacket with vapor barrier coating. Seal around penetration with joint sealer. Refer to Division 7 Section - Joint Sealants.
1. Use same material and thickness as adjacent pipe insulation.
2. Overlap nesting insulation by 50 mm [(2 inches)] or 1-pipe diameter, which ever is greater.
3. Apply materials with adhesive; fill voids with mineral fiber insulating cement. Secure with wire or tape.
4. Cover insulation, except for metal-jacketed insulation, with PVC fitting covers and seal circumferential joints with butt strips.

J. Hangers and Anchors: Apply insulation continuously through hangers and around anchor attachments. Install saddles, shields, and inserts as specified in Section 15090 - Hangers and Supports. For cold surface piping, extend insulation on anchor legs and seismic bracing a minimum of 300 mm [(12 inches)], taper, and seal insulation ends.

3.4 BELOW GROUND PIPE INSULATION INSTALLATION
A. Install in accordance with manufacturer’s instructions for specific materials and/or preinsulated factory systems.

3.5 GLASS FIBER PIPE INSULATION INSTALLATION
A. Seal exposed ends with lagging adhesive.

B. Seal seams and joints with vapor barrier compound.

3.6 CELLULAR GLASS PIPE INSULATION INSTALLATION
A. Cellular Glass Insulation: Secure insulation with manufacturer's recommended adhesive. Seal joints with manufacturer's recommended joint sealer for below ambient service temperatures.
2. Finishing: Apply manufacturer's recommended jacketing for service temperature and exposure.
3. Finishing: In addition apply metal jacket for outdoor applications.

3.7 PHENOLIC FOAM INSULATION
A. Temperature Range of minus 73 degrees C to 21 degrees C [(minus 100 degrees F to 70 degrees F)]: Butter joints with manufacturer’s recommended joint sealer.

B. Secure foam sections with 20 mm [(3/4 inch)] wide pressure sensitive tape or stainless steel bands in accordance with manufacturer’s instructions.

C. Seal joints on ASJ covered insulation with matching tape.
3.8 EQUIPMENT INSULATION INSTALLATION, GENERAL

A. Install board and block materials with a minimum dimension of 300 mm [(12 inches)] and a maximum dimension of 1219 mm [(48 inches)].

B. Groove and score insulation materials as required to fit as closely as possible to the equipment and to fit contours of equipment. Stagger end joints.

C. Insulation Thicknesses Greater than 50 mm [(2 Inches)]: Install insulation in multiple layers with staggered joints.

D. Bevel insulation edges for cylindrical surfaces for tight joint.

E. Secure sections of insulation in place with wire or bands spaced at 225 mm [(9 inches)] centers.

F. Protect exposed corners with corner angles.

G. Manholes, Handholes, and Information Plates: Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

H. Removable Insulation: Install insulation on components that require periodic inspecting, cleaning, and repairing for easy removal and replacement without damage to adjacent insulation.

I. Pumps: Where insulation is indicated, fabricate removable galvanized steel boxes lined with insulation. Fit boxes around pumps and coincide joints in box with the splits in the pump casings. Fabricate joints with outward bolted flanges or cinch catches.

J. Finishing: Apply 2 coats of vapor barrier compound to a minimum thickness of 1.6 mm [(1/16 inch)]. Install a layer of glass cloth embedded between layers.

3.9 GLASS FIBER EQUIPMENT INSULATION INSTALLATION

A. Secure insulation with welded cupped head pins.

B. Space pins at maximum intervals of 450 mm [(18 inches)] in both directions and not more than 75 mm [(3 inches)] from edges and joints.

C. Apply a smoothing coat of insulating and finishing cement to finished insulation.

3.10 CELLULAR GLASS EQUIPMENT INSULATION INSTALLATION

A. Join sections of insulation with vapor barrier compound.

B. Secure insulation with manufacturer's recommended adhesive. Seal joints with manufacturer's recommended joint sealer.
C. Secure inner layer of multiple layer installations with glass fiber reinforced tape. Secure outer layers with 2 metal bands for each insulation section.

3.11 DUCT INSULATION

A. Install block and board insulation as follows:
   1. Adhesive and Band Attachment: Secure block and board insulation tight and smooth with at least 50 percent coverage of adhesive. Install bands spaced 300 mm [(12 inches)] apart. Protect insulation at exterior corners with metal corner angles. Fill joints, seams, and chipped edges with vapor barrier compound.
   2. Pin Attachment: Secure insulation tight and smooth with welded cupped head pins. Space anchor pins 450 mm [(18 inches)] apart each way and 75 mm [(3 inches)] from insulation joints. Apply vapor barrier coating compound to insulation in contact, open joints, breaks, punctures, and voids in insulation.

B. Blanket Insulation: Install tight and smooth. Secure to ducts having long sides or diameters as follows:
   1. Smaller Than 610 mm [(24 Inches)]: Bonding adhesive applied in 150 mm [(6 inches)] wide transverse strips on 300 mm [(12 inches)] centers.
   2. 610 mm [(24 Inches)] and Larger: Welded cupped head pins spaced 300 mm [(12 inches)] apart each way. Apply bonding adhesive to prevent sagging of the insulation.
   3. Overlap joints 75 mm [(3 inches)].
   4. Seal joints, breaks, and punctures with vapor barrier compound.

3.12 JACKETS

A. Foil and Paper Jackets (FP): Install jackets drawn tight. Install lap or butt strips at joints with material same as jacket. Secure with adhesive. Install jackets with 40 mm [(1-1/2 inches)] laps at longitudinal joints and 75 mm [(3 inch)] wide butt strips at end joints.

B. Seal openings, punctures, and breaks in vapor barrier jackets and exposed insulation with vapor barrier compound.

C. Interior Exposed Pipe Insulation: Install continuous PVC jackets and fitting covers:

D. Exterior Exposed Insulation: Install continuous aluminum jackets and fitting covers and seal all joints and seams with waterproof sealant.

E. Exterior Exposed Insulation: Install continuous stainless-steel jackets and fitting covers and seal all joints and seams with waterproof sealant.

F. Exterior Exposed Insulation: Install continuous PVC jackets and fitting covers and seal all joints and seams with waterproof sealant.

G. Install metal jacket with 50 mm [(2 inches)] overlap at longitudinal and butt joints. Overlap longitudinal joints to shed water. Seal butt joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel draw bands 300 mm [(12 inches)] on center and at butt joints.
H. Install the PVC jacket with 25 mm [(1 inch)] overlap at longitudinal and butt joints and seal with adhesive.

I. Install glass cloth jacket directly over insulation. On insulation with a factory-applied jacket, install the glass cloth jacket over the factory-applied jacket. Install jacket drawn smooth and tight with a 50 mm [(2 inch)] overlap at joints. Embed glass cloth between (2) 1.6 mm [(1/16 inch)] thick coats of lagging adhesive. Completely encapsulate the insulation with the jacket, leaving no exposed raw insulation.

3.13 FINISHES

A. Paint non-metal or PVC jacketed finished insulation as specified in Division 9 Section - Paints and Coatings.

3.14 APPLICATIONS

A. General: Materials and thicknesses are specified in schedules at the end of this Section.

B. Items Not Insulated: Unless otherwise indicated do not apply insulation to the following systems, materials, and equipment:
   1. Metal ducts with duct liner.
   2. Factory-insulated flexible ducts.
   3. Factory-insulated plenums, casings, terminal boxes, and filter boxes and sections.
   4. Flexible connectors for ducts and pipes, except chilled water piping.
   5. Vibration control devices.
   6. Testing laboratory labels and stamps.
   7. Nameplates and data plates.
   8. Access panels and doors in air distribution systems.
   10. Drainage piping located in crawl spaces, unless indicated otherwise.
   11. Below grade piping except chilled and heated water and steam piping.

C. Interior, Exposed and Concealed Piping Systems: Unless otherwise indicated, insulate the following piping systems:
   1. Domestic cold water.
   2. Storm and Overflow Water. Insulate only roof drain bodies and horizontal rainwater leaders of storm and overflow water piping.
   3. Domestic hot water supply and recirculated return.
   4. Chilled water systems.
   5. Heating water systems.

D. Exterior, Exposed Piping Systems: Unless otherwise indicated, insulate the following piping systems:
   1. Domestic cold water.
   2. Chilled water systems.

E. Below Grade Piping Systems: Unless otherwise indicated, insulate the following piping systems.
   1. Chilled water systems.
F. Equipment: Unless otherwise indicated, insulate the following indoor equipment:
1. Gas fired equipment flues and breechings.

G. Duct Systems: Unless otherwise indicated, insulate the following duct systems:
1. Interior concealed supply, return and outside air ductwork.
2. Interior concealed exhaust duct as noted.
3. Interior exposed supply, return, and outside return air ductwork.
4. Exterior exposed supply and return ductwork.

3.15 INSULATION THICKNESS SCHEDULES

A. General: Insulation thickness specified in the following piping systems Tables is based on glass fiber. Alternate, acceptable materials may be used as identified within the rated service temperature. Adjust insulation thickness by multiplying thickness for glass fiber with the thickness factor in the schedule below and rounding up to next commercially available thickness. Minimum insulation thickness for all materials, unless noted otherwise in the schedules, is 25 mm [(1 inch)].

<table>
<thead>
<tr>
<th>Material</th>
<th>Service Temperature</th>
<th>Thickness Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass Fiber (GF)</td>
<td>to 232°C [(450°F)]</td>
<td>1.0</td>
</tr>
<tr>
<td>Cellular Glass (CG)</td>
<td>to 427°C [(800°F)]</td>
<td>1.33</td>
</tr>
<tr>
<td>Phenolic Foam (PF)</td>
<td>to 120°C [(250°F)]</td>
<td>0.50</td>
</tr>
<tr>
<td>Poured-In-Place (PP)</td>
<td>to 249°C [(480°F)]</td>
<td>2.50</td>
</tr>
<tr>
<td>Urethane Foam (UF)</td>
<td>to 120°C [(250°F)]</td>
<td>1.0</td>
</tr>
</tbody>
</table>

PLUMBING PIPING SYSTEMS

<table>
<thead>
<tr>
<th>Service</th>
<th>Acceptable Materials</th>
<th>Insulation Thickness mm [(inches)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[(0-1)]</td>
</tr>
<tr>
<td>Domestic Cold and Hot Water</td>
<td>GF</td>
<td>13</td>
</tr>
<tr>
<td>Storm Drain and Overflow</td>
<td>GF</td>
<td>25</td>
</tr>
</tbody>
</table>

MECHANICAL PIPING SYSTEMS

<table>
<thead>
<tr>
<th>Service</th>
<th>Acceptable Materials</th>
<th>Insulation Thickness mm [(inches)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[(0-1)]</td>
</tr>
<tr>
<td>Condensate Drain Lines</td>
<td>GF, PF</td>
<td>25</td>
</tr>
</tbody>
</table>

NOAO Spectrograph
KITT Peak WIYN
Revision 0 – July 11, 2017
### MECHANICAL PIPING SYSTEMS

<table>
<thead>
<tr>
<th>Service</th>
<th>Acceptable Materials</th>
<th>Insulation Thickness mm [(inches)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pipe Sizes, DN [(Inches)]</td>
</tr>
<tr>
<td></td>
<td>0-25 [(0-1)]</td>
<td>32-50 [(1¼-2)]</td>
</tr>
<tr>
<td></td>
<td>65-100 [(2½-4)]</td>
<td>125-250 [(5 to 10)]</td>
</tr>
<tr>
<td></td>
<td>300 and up [(12 and up)]</td>
<td></td>
</tr>
</tbody>
</table>

#### Footnotes:

1. For mechanical equipment rooms ventilated with outdoor air (non-conditioned), insulate in accordance with outdoor schedule.
2. Urethane foam may only be used in conjunction with a preinsulated piping system with factory applied protective jacket.
3. Glass fiber and calcium silicate may be used for below grade application only in conjunction with a preinsulated piping system with factory furnished protective conduit.

### DUCTWORK AND FLUES

<table>
<thead>
<tr>
<th>Service</th>
<th>Acceptable Materials</th>
<th>Insulation Thickness mm [(inches)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Air Ducts:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside building, concealed</td>
<td>GF (Flexible)</td>
<td>38 [(1½)]</td>
</tr>
<tr>
<td>Inside building, exposed</td>
<td>GF (Board)</td>
<td>38 [(1½)]</td>
</tr>
<tr>
<td>Inside building, exposed within room served by duct</td>
<td>--</td>
<td>None</td>
</tr>
<tr>
<td>Downstream of terminal unit</td>
<td>GF (Lined)</td>
<td>25 [(1)]</td>
</tr>
<tr>
<td>Outside building</td>
<td>GF (Board)</td>
<td>50 [(2)]</td>
</tr>
<tr>
<td>Return Air Ducts:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside building, concealed, non-conditioned spaces</td>
<td>GF (Flexible)</td>
<td>38 [(1½)]</td>
</tr>
<tr>
<td>Inside building, exposed non-conditioned spaces</td>
<td>GF (Board)</td>
<td>38 [(1½)]</td>
</tr>
<tr>
<td>Inside building, conditioned spaces</td>
<td>--</td>
<td>None</td>
</tr>
<tr>
<td>Outside building</td>
<td>GF (Board)</td>
<td>50 [(2)]</td>
</tr>
<tr>
<td>Outside Air Ducts:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside building, concealed</td>
<td>GF (Flexible)</td>
<td>38 [(1½)]</td>
</tr>
<tr>
<td>Inside building, exposed</td>
<td>GF (Board)</td>
<td>50 [(2)]</td>
</tr>
<tr>
<td>Outside building</td>
<td>--</td>
<td>None</td>
</tr>
<tr>
<td>HVAC General Exhaust, within 4.5 m [(15 feet)] of fan</td>
<td>GF (Lined)</td>
<td>25 [(1)]</td>
</tr>
</tbody>
</table>

**END OF SECTION**
SECTION 15090
HANGERS AND SUPPORTS

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes hangers and supports for mechanical systems piping, ducts and equipment.

1.2 DEFINITIONS

A. Terminology used in this Section is defined in MSS SP-90.

1.3 PERFORMANCE REQUIREMENTS

A. General: Design and provide pipe hanger material and appurtenances conforming to the minimum level of acceptance set forth in Manufacturers Standardization Society (MSS) SP-58. This specification indicates general MSS types only and manufacturers’ other standard products are acceptable under Standard SP-58, if they meet dimensional and load rating limitation. Select hangers, supports, anchors, guides, and restraints to withstand all static and dynamic condition of loading to which piping and associated equipment may be subjected. Design supplementary structural members for the specific loads they are to support in accordance with the American Institute of Steel Construction (AISC) Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings. Use allowable stress levels listed in Table 2 of MSS SP-58 for Contractor’s application of hanger assemblies.

B. The Contractor shall design, submit, and obtain approval from authority with jurisdiction over hangers and supports for piping and equipment. A copy of the submittal and approval shall be sent to the Construction Manager. The Contractor shall not install supports without approval from the Authority Having Jurisdiction, the Engineer of Record, and the Construction Manager.

1.4 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data for each type of hanger, and support.

C. Submit pipe hanger and support schedule showing manufacturer's Figure No., size, location, and features for each required pipe hanger, and support.

D. Licensed Engineer's hanger and support installation report specified in the "Field Quality Control" Article.

1.5 SITE RECORDS
A. Maintain Site records for welder certificates signed by Contractor certifying that welders comply with requirements specified under the "Quality Assurance" Article.

1.6 QUALITY ASSURANCE

A. Coordination: Coordinate with the installing contractor for mechanical insulation to establish the insulation material and thickness that will be furnished for each insulated system.

B. Qualify welding processes and welding operators according to AWS D1.1 "Structural Welding Code-Steel."
   1. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

C. Qualify welding processes and welding operators according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

D. Comply with referenced codes and manufacturer’s standards.
   1. ANSI B31.1, Power Piping.
   3. ANSI B31.9, Building Services Piping
   4. MSS SP-58, Pipe Hangers and Supports - Materials, Design and Manufacturing.
   5. MSS SP-69, Pipe Hanger and Supports Selection and Application.
   6. MSS SP-89, Pipe Hangers and Supports Fabrication and Installation Practices.
   7. AWS D1.1, Structural Welding Code.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Hangers:
   1. B_Line
   2. Grinnell
   3. Tolco
   4. PHD
   5. Superstrut
   6. Unistrut

B. Channel Framing Systems:
   1. Unistrut
   2. B-Line Systems, Inc.

C. Insulated Pipe Supports:
   1. Pipe Shields.
   2. Rilco.

D. Sleeves:
   1. Thunderline Corp.
2.2 GENERAL REQUIREMENTS

A. Hangers, Supports, and Components: Factory-fabricated according to MSS SP-58.
   1. Components include galvanized coatings where installed for piping and equipment that will not have a field-applied finish.
   2. Pipe attachments include nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.

B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used. Size inserts to fit threaded hanger rods. Fasteners for fire protection systems include UL listing and FM approval. Do not use insert-type attachments in lightweight concrete or concrete slabs less than 100 mm [(4 inches)] thick.
   1. Inserts for use in poured-in-place concrete MSS Type 18 or equal, malleable iron cases or galvanized steel shells and expander plugs for threaded connection with lateral adjustment, top slot for reinforcing rods and lugs for attaching to forms. Provide manufactured threaded rod inserts for metal decks with concrete, retaining rod to extend 2 inches minimum above top of deck flutes. Inserts may not be used on roof decks without specific written acceptance by the Architect.
   2. Provide ICBO and ASTM E-488 tested drilled insert expansion shields, inserts, and fasteners on concrete walls and floors and sides of concrete beams. Fastener devices exposed to corrosive fluids shall be of 316 stainless steel material.
   3. Powder-driven fasteners, expansion nail type anchors, or friction spring-type clips will not be permitted.

C. In areas of metal decking, pipe and duct shall be supported from beams or joists and intermediate steel with UL/FM MSS Type 23 malleable iron "C" clamps with Grinnell Figure No. 89 retainer straps. Provide angles or channels to span between joists or beams as required to maintain support centers specified herein.

2.3 PIPE HANGERS AND SUPPORTS

A. Hangers for Uninsulated Pipe: An adjustable wrought steel clevis MSS Type-1.

B. Hangers for Cold Insulated Pipe, All Sizes: An adjustable wrought steel clevis, MSS Type-1, sized to suit 360 degrees high-density insulation inserts with MSS Type 40, galvanized protection saddle.

C. Hangers for Hot Insulated Pipe, Sizes DN15 to DN 40 [(1/2 inch to 1-1/2 inch)]: An adjustable wrought steel clevis, hanger, MSS Type-1, sized to suit a 180 degrees, with MSS Type-40, galvanized insulation protection saddle.

D. Hangers for Hot Insulated Steel Pipe, Sizes DN 50 [(2 inches)] and Larger: Adjustable roll hanger with MSS Type-43 steel yoke and cast iron roller, sized to suit 360 degrees high-density insulation inserts with MSS Type 40, galvanized protection saddle. or Type-3 double bolt pipe clamp as required for application.
E. Hangers for Hot Insulated Copper Pipe, Sizes DN 50 [(2 inches)] and Larger: Same as for steel except with 360 degrees high-density insert.

F. Support devices for all plastic pipes should not cause point-loading stresses on the piping. Pipe should be supported by means of clips, which do not fix the pipe in axial direction, such as Clic supports for DN 50 [(2 inches)] and smaller pipe sizes and Agru/Asahi polypropylene composite hanger for DN 65 [(2-1/2 inch)] and larger pipe sizes. For trapeze type supporting, Contractor may submit metal type pipe clamps for Construction Manager approval. If approved, Contractor shall install crush-strip between the metal clamp and plastic pipe to permit pipe movement and prevent surface scarring. Cush-stripe requirements shall apply for all pressurized plastic pipe systems. Cush-strips are not required for gravity plastic systems.

G. Provide roller MSS Types-41, 43, 44, or slide Type MSS-35 at significant movement location to permit free movement of piping where expansion and contraction of systems piping will occur.

H. Insulated pipe supports shall be utilized on insulated pipelines. Proper models to be selected by hanger load, hanger style, and permissible hanger span distances specified herein.
   1. Model designations are by Pipe Shields, Inc., or approved equal. Equals must submit documentation demonstrating compliance with applicable MSS and ANSI standards.
   2. Models:
      a. Insulated Pipe Supports:
         2) Pipe Supported on Flat Surfaces: Use Models A1000, A2000, A5000, A6000, and A7000 to A7400 Series.
         3) Pipe Supported on adjustable roll hangers and Pipe Rolls: Use Models A3000, A4000, A5000, A6000, and A8000 to A8400 Series.
         4) Pipe Risers: Models E1000 to E1300 Series and E2000 to E2300 Series.
   3. Seismic pipe supports locations shall require the following:
      a. Properly selected Pipe Shields, Inc., A9000 Series at all seismic support contact points to meet the seismic design specified and document with certified layout chart.
      b. Certified load capacity sheets, reviewed and stamped by registered engineer.


J. Vertical Support: Steel and copper pipe riser clamps, MSS Types-8 or -42 as applicable to service.

K. Rod Couplings: Grinnell straight Figure 136, UL/FM approved or equal.

L. Floor Support for Hot and Cold Pipes: Adjustable cast iron roll and stand with concrete pier or steel support, MSS Type-38.

M. Center Beam Clamps: MSS Types -21 or -28 as required by upper attachment application.

N. Copper-plated hangers, Grinnell Figure CT-65 for copper piping or Grinnell Figure CT-169 between hanger or support and piping.
O. Provide angles or channels to span joists and distribute load.

P. Welded Beam Attachments: MSS Types-22 or -57 as required to suit hanger application.

Q. Pipe Guides: Grinnell Figure 255 spider guide or equal.

R. Steel Pipe Slides: Grinnell Figure 257, MSS Type-35.

2.4 PIPE ISOLATORS

A. Provide each hanger or clamp for uninsulated piping with a metal backed pipe isolating material to isolate sound, vibration and electrolysis. Isolators are not required for fire protection, sprinkler piping, waste, vent, gas, and downspout piping.

2.5 HANGER RODS

A. Provide steel hanger rods, appropriately threaded. Provide connection points with jamb nuts or double nuts. For highly corrosive environment FRP hanger rods employing vinyl ester resin shall be used.

2.6 DUCT HANGERS AND SUPPORTS

A. Per SMACNA 1985 Standards.

B. Provide galvanized steel angles, channels, stays, rods, etc., for duct support and reinforcement unless painted where specified.

2.7 FLASHING

A. Steel Flashing: 26 gauge galvanized steel.

B. Lead Flashing: 20 kg/sq m [(4 lb/sq ft)] sheet lead for waterproofing; 5 kg/sq m [(1 lb/sq ft)] sheet lead for soundproofing.

C. Safes: 25 kg/sq m [(5 lb/sq ft)] sheet lead or 8 mil thick neoprene.

D. Caps: Steel, 22 gauge minimum, 16 gauge at fire-resistant structures.

2.8 SLEEVES

A. Sleeves for Pipes Passing Through Nonrated, Nonbearing Walls and Floors: 20 gauge, galvanized sheet metal tube with welded longitudinal joints.

B. Sleeves for Pipes Passing Through Beams and Footings: Schedule 40 black steel pipe. For waterproof sleeves, use Thunderline Link-Seal or Calpico Sealing Linx.

C. Sleeves for Ducts: Form with galvanized steel.

D. Size sleeves large enough to allow for movement due to expansion and to provide for continuous insulation.
2.9 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A36M [(ASTM A36)], steel plates, shapes, and bars, black and galvanized, ASTM A123.

B. Bolts and Nuts: ASME B18.10 or ASTM A183, steel, hex-head, track bolts and nuts.

C. Washers: ASTM F844, steel, plain, flat washers.

D. Grout: ASTM C1107, Grade B, nonshrink, nonmetallic.
   1. Characteristics include post-hardening, volume-adjusting, dry, hydraulic-cement-type grout that is nonstaining, noncorrosive, nongaseous and is recommended for both interior and exterior applications.
   2. Design Mix: 34.5 MPa [(5000 psi)], 28-day compressive strength.

E. Trapeze: Channel ASTM A570, Grade 33, Hot Rolled Structural Quality; finish ASTM B633.

F. Channels: Provide all channels located in clean spaces with factory-applied finish or field applied finish in accordance with Section 09960 suitable for cleanroom environment.

PART 3 – EXECUTION

3.1 INSERTS AND EXPANSION SHIELDS

A. Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams where continuous embedded insert type channel has not be provided.

B. Set inserts for poured-in-place-concrete in position in advance of concrete work. Provide reinforcement rod in concrete for inserts carrying pipe over DN 100 [(4 inches)] in diameter or ducts over 1500 mm [(60 inches)] wide.

C. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.

D. Locate expansion shields in concrete beams a minimum of 150 mm [(6 inches)] above bottom of beam.

E. Do not use power-driven fasteners or friction spring-type clips.

3.2 HANGER AND SUPPORT APPLICATIONS

A. General hanger selections and requirements are specified in this Section.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in this Section or in process piping specification Sections.
C. Coordinate the Work of this Section with the requirements of Section 15071 - Mechanical Vibration Control for systems requiring vibration isolation and Section 15070 for systems requiring mechanical seismic control.

D. Do not use wire for either temporary or permanent hangers or supports.

### 3.3 HANGER AND SUPPORT INSTALLATION

A. General: Comply fully with MSS SP-58, SP-69 and SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Arrange for grouping of parallel runs of horizontal piping supported together on field-fabricated, heavy-duty trapeze hangers where possible.

C. Install supports with maximum spacing complying with MSS SP-69, ASME B31 codes, and applicable building codes. For thermoplastic and process piping, see specific pipe Specification Sections.

D. Plastic Pipe Support Spans

<table>
<thead>
<tr>
<th>NOMINAL PIPE SIZE (INCHES)</th>
<th>FLUID UNDER 100°F. (FEET)</th>
<th>FLUID OVER 100°F. (FEET)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2, 3/4, and 1</td>
<td>4.0</td>
<td>4.0 with continuous support</td>
</tr>
<tr>
<td>1-1/2 and 2</td>
<td>5.0</td>
<td>4.0 with continuous support</td>
</tr>
<tr>
<td>3 and 4</td>
<td>6.0</td>
<td>5.0 may require cont. support</td>
</tr>
<tr>
<td>6</td>
<td>7.5</td>
<td>5.5</td>
</tr>
<tr>
<td>8 and Larger</td>
<td>8.0</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Note: For Drain/Waste and Vent applications, hangers and/or supports shall be spaced per local UPC code

E. Where pipes of various sizes are supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

F. Install building attachments within concrete or to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Install reinforcing bars through openings at top of inserts.

G. Install concrete inserts in new construction prior to placing concrete.

H. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install according to fastener manufacturer's written instructions. Do not use in lightweight concrete slabs or in concrete slabs less than 100 mm ([4 inches]) thick. Provide ICBO and ASTM E488 tested drilled insert expansion shields, inserts, and fasteners on concrete walls and floors and sides of concrete beams. Powder-driven fasteners, expansion nail type anchors, or friction spring-type clips will not be permitted. Provide fastener devices exposed to corrosive environments of 316 stainless steel material.
I. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

J. Heavy-Duty Steel Trapezes: Field-fabricate from ASTM A36 steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

K. Support fire protection systems piping independent of other piping.

L. Install hangers and supports to allow controlled movement of piping systems, permit freedom of movement between pipe anchors, and facilitate action of expansion joints, expansion loops, expansion bends, and similar units. Install supports to prevent disengagement of hanger by movement of the pipe.

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

N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so that maximum pipe deflections allowed by ASME B31 Series Codes is not exceeded.

O. Metal Decks: In areas of metal decking, support pipes and ducts from beams or joists and intermediate steel with UL/FM MSS Type 23 malleable iron “C” clamps with Grinnell Figure 89 retainer straps. Provide angles or channels to span between joists or beams as required to maintain support centers specified herein. Provide manufactured threaded rod inserts for metal decks with concrete, retaining rod to extend 50 mm [(2 inches)] minimum above top of deck flutes. Inserts may not be used on roof decks without specific written acceptance by the Architect. Provide steel hanger rods, appropriately threaded. Provide connection points with jam nuts or double nuts.

P. Uninsulated Piping: Provide each hanger or clamp for uninsulated piping with a metal-backed pipe isolating material to isolate sound, vibration, and electrolysis. Isolators are not required for fire protection sprinkler piping, waste, vent, gas, and downspout piping.

Q. The use of a common trapeze structural channel cross member to hang multiple piping systems is permissible with the following conditions:
   1. Size cross members to support the composite load of all pipes.
   2. Support pipes on topside of cross members only, no inverted lines.
   3. Width of cross members to be sufficient to secure full width base of pipe guides, roller chairs, pipe roll stand, pipe slide assemblies, etc.
   4. Pipes to be retained in place or guided as applicable by MSS Type 24 U-Bolt or Type 26 bolted clamp.
   5. Locate a support rod at each end of cross member. Cantilevered structural channel members to support pipes, is not acceptable.
   6. Seismically brace trapezes assemblies in accordance with Section 15070 - Mechanical Seismic Control.
   7. Permit pipes subject to thermal expansion to be free to roll axially or slide.
   8. Use structural type tubes for large bore pipe and common members when composite pipe loads exceed cross member structural channel design capability. Structural tube members layout and fabrication to be field determined to suit individual system applications.
R. Install hangers to provide minimum 40 mm [(1-1/2 inches)] clear space between finished covering and adjacent work.

S. Random hangers shall be provided at each change in direction, at ends of branches, at base and top of risers, pipes and drops, and wherever necessary to prevent sag, bending, or vibration, in addition to the above specified spacing. Provide MSS Type hangers.

T. Use hangers, which are vertically adjustable 40 mm [(1-1/2 inches)] minimum after piping is erected.

U. Support horizontal cast iron soil and vent pipe near each joint, with MSS Type-1, Grinnell Figure 590 or equal, at 1.5 m [(5 feet)] maximum spacing between hangers and with no more than 2 joints occurring between any 2 hangers. Cast iron piping joined with a shield and clamp assembly, where the top of pipe is 300 mm [(12 inches)] or more from the supporting structure, shall be braced on each side of a change in direction of 90 degrees or more.

V. Support steel and copper vertical piping at each floor. Support vertical cast iron pipe at each floor level with MSS Type-8 clamp. Provide joint stabilizers at cast iron pipe joints in between floors.

W. Where practical, support riser piping independently of connected horizontal piping.

X. Support nonmetallic piping with a sufficient number of hangers to prevent sagging and misalignment.

Y. All minor components such as straps, threaded rods, nuts, and washers shall be galvanized or cadmium plated. All other components, including angle iron, channels, and Unistrut, shall be factory or field painted. For applications in highly corrosive areas, FRP structural components and other parts in suitable plastic materials shall be provided.

Z. Anchors, guides, and other restraints shall be provided to secure the piping at their respective locations against movement in indicated planes or directions, while permitting free movement elsewhere. They shall be structurally suitable to withstand the thrusts, moments, and other imposed loads.

AA. Required Guides: Where bellows or slip-type expansion joints are used, appropriate anchors and guides shall be provided to direct expansion movement along the axis of the joint, in accordance with manufacturer’s recommendations and installation instructions.

BB. Piping and equipment anchors, stands, brackets, knee braces, supplementary steel and stanchions, are to be field constructed and erected to withstand required design loads and seismic loads.

3.4 DUCT HANGERS AND SUPPORTS

A. Duct hangers, supports, and installation per 1985 SMACNA Standards. All minor components such as straps, threaded rods, nuts, and washers shall be galvanized or cadmium plated.

B. Specific details shown on Drawings take precedence over 1985 SMACNA requirements.

3.5 EQUIPMENT SUPPORTS
A. Fabricate structural steel stands to suspend equipment from structure above or support equipment above floor.

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

3.6 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for pipe 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 procedures for manual shielded metal-arc welding, appearance and quality of welds, methods used in correcting welding work, and 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 that no roughness shows after finishing, and so that contours of welded surfaces match adjacent contours.

3.7 PRIMING

A. Prime coat exposed steel hangers and supports, which are not galvanized, cadmium plated, or factory painted. Hangers and supports located in crawl spaces, pipes shafts and suspended ceiling spaces are not considered exposed.

3.8 FLASHING

A. Flash and counterflash where mechanical equipment passes through weather or waterproofed walls, floors, and roofs.

B. Flash vent and soil pipes with 600 mm by 600 mm [(24 inches by 24 inches)] sheet lead, minimum 200 mm [(8 inches)] above roof. Counterflash with caulked stack flashing sleeve, Zurn Z-196.

C. Flash floor drains over finished areas and roof drains with lead, 250 mm [(10 inches)] clear on sides, minimum 900 mm by 900 mm [(36 inches by 36 inches)] sheet size. Fasten flashing to drain with clamping device.

D. Provide 200 mm [(8 inches)] minimum height curbs for roof-mounted mechanical equipment. Flash and counter flash with galvanized steel, soldered and waterproofed.

E. Provide continuous lead or neoprene safes below air supply unit casing, built-up mop sinks, shower stalls, shower room floors located above rooms. Solder at joints, flash into floor drains, and turn up 150 mm [(6 inches)] into walls or to top of curbs, and caulk into joints.

3.9 SLEEVES
A. Set sleeves in position in advance of concrete work. Provide suitable reinforcing around sleeves.

B. Where piping or ductwork passes through floor, ceiling or wall, close off space between pipe or duct and construction with noncombustible insulation. Provide tight-fitting metal caps on both sides and caulk.

C. Install chrome-plated escutcheons where piping passes through finished surfaces.

D. Provide pipe sleeves for all mechanical piping. Coordinate requirements with Section 07840 – Firestopping.

E. Adequately sleeve pipe passing through concrete or masonry walls or concrete slabs to receive both pipe and insulation pertaining thereto.

F. Waterproof sleeves shall be Thunderline Link-Seal or Calpico Sealing Linx.

G. Seal pipes passing through walls or slabs. Use mastic or oakum seal in the annular space in nonfire-rated walls.

H. Insulated pipe shall be insulated in sleeves, sealed, and pointed as above.

I. Install rated sleeves on pipes as they are being hung, ready for proper placement in rated walls as walls are being constructed.

J. Where sleeves have been inadvertently omitted in concrete floors, provide requisite pipe opening by using properly sized diamond core drills. Areas located below drilling operations shall be protected from possible damage.

3.10 PENETRATION SEALING (FIRE-RATED)

A. Coordinate the Work of this Section with the requirements of Section 07840 - Firestopping.

3.11 ADJUSTING

A. Hanger Adjustment:
   1. Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
   2. Coordinate adjustment with requirements of Section 15071 - Mechanical Vibration Control.

3.12 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint and paint exposed areas immediately after erection of hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

B. Apply by brush or spray to provide a minimum dry film thickness of 0.05 mm [(2.0 mils)].
C. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal is specified in Section 09900 - Paints and Coatings and Section 09960 - High Performance Coatings.

D. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION
SECTION 15120

PIPING SPECIALTIES

PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes meters, strainers, gages, pump suction diffusers, pump discharge valves, calibrated balancing valves, expansion tanks, pressure reducing valves, relief valves, steam traps, blowdown separators, flash tanks, and other specialty devices used in mechanical systems.

1.2 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data for each type of meter, gage, specialty device, and fitting specified. Include scale range, ratings, and calibrated performance curves. Submit a meter and gage schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gage.

C. Maintenance data to include in the "Operating and Maintenance Manuals" specified in Division 1 Section - Project Closeout. Include data for the following:

1. Flow measuring systems.
2. Flow meters.
4. Pressure reducing valves.
5. Relief valves.

1.3 QUALITY ASSURANCE

A. Comply with applicable portions of American Society of Mechanical Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gages.

B. The Drawings and diagrams are diagramatic are intended to identify scope and general location of specialty components. Include components shown on either the Drawings or diagrams.

C. Steam Traps: Meet standards of the Steam Heating Equipment Manufacturer’s Association.

D. Provide listing/approval stamp, label, or other marking on specialties made to specified standards and/or codes.

E. Comply with NFPA 70, National Electrical Code, for electrical components.

1.4 DELIVERY, STORAGE, AND HANDLING
A. Packing and Shipping: Protect specialties from damage by factory packing. Clearly mark packing for any related components shipped loose for field assembly and installation.

B. Acceptance on Site: Inspect and reject any damaged specialty and components upon arrival.

C. Storage and Protection: Store specialties to prevent damage, and protect from weather, dirt, fumes, water, and construction debris. Provide a clean dry space for packaged components not weather protected.

D. Handling: Handle specialties according to manufacturer’s rigging and installation instructions for unloading and transporting into the final location.

1.5 WARRANTY

A. Manufacturer’s written warranty covering parts and labor for all equipment and components furnished.

1.6 MANUFACTURER’S FIELD SERVICES

A. Installation assistance and acceptance inspection of the final installation.

B. Start-up assistance, specialty device testing, and commissioning as applicable.

1.7 OPERATIONS AND MAINTENANCE INSTRUCTIONS

A. O&M Manual Contents:
   1. List of specialties with manufacturer’s name, model number, serial number, local representatives address and phone number, service facilities, and normal channel of supply.
   2. Manufacturer’s literature describing each item with detailed parts list.
   3. Instructions for starting, operating, and shut down of equipment where applicable.
   4. Instructions for microprocessor controls where applicable including Owner adjustable features and setpoints.
   5. Detailed maintenance instructions for equipment including recommended frequency.
   6. Recommended spare parts list.
   7. Performance data for equipment furnished as applicable.

B. Submit one bound copy of the above for review. Upon review and acceptance, deliver required number of copies per Division 1 Sections incorporating review comments with Closeout Submittals.

1.8 MANUFACTURER’S ACCEPTANCE OF SPECIALTY DEVICES OPERATION

A. Review final installation by manufacturer or authorized factory representative.

B. Provide documentation stating installation and operation is satisfactory to the manufacturer.

1.9 CLOSEOUT SUBMITTALS
A. Provide the following in accordance with Division 1 Section - Closeout Submittals.
   1. Operation and Maintenance Manuals.
   2. Shop drawings, submittals, and performance data.
   3. Warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Liquid-in-Glass Thermometers:
   b. Marshalltown Instruments, Inc.
   c. Palmer Instruments Inc.
   d. H.O. Trerice Co.
   e. Weiss Instruments, Inc.
   f. Weksler Instruments Corp.

2. Pressure Gages:
   c. Marsh Instrument Co.
   d. Marshalltown Instruments, Inc.
   e. Palmer Instruments Inc.
   f. H.O. Trerice Co.
   g. Weiss Instruments, Inc.
   h. Weksler Instruments Corp.
   i. WIKA Instruments Corp.

3. Test Plugs:
   b. MG Piping Products Co.
   c. Peterson Equipment Co., Inc.
   d. Sisco Co., Spedco, Inc.
   e. H.O. Trerice Co.
   f. Watts Regulator Co.

4. Flow Indicators:
   a. Anderson by Dwyer Instruments, Inc.
   c. Ernst Gage Co.
   e. Penberthy, Inc.
   f. Visi-Flo by OPW Div., Dover Corp.

5. Y-Type Strainers:
   a. Armstrong
   b. Crane
   c. Hayward
   d. Hoffman
   e. Sarco

6. Automatic Balancing Devices:
7. Manual Balancing Devices:
   a. Armstrong
   b. Bell and Gossett
   c. Gerand
   d. Taco

8. Relief Valves:
   a. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. ITT McDonnell & Miller
   d. Sarco
   e. Spence Engineering Co.
   f. Watts Regulator Co.

2.2 THERMOMETERS, GENERAL

   A. Scale Range: Temperature ranges for services listed as follows:
      1. Domestic Cold Water: Minus 18 to 38 degrees C, with 1-degree scale divisions
         [0 to 100 degrees F, with 2-degree scale divisions].
      2. Chilled Water: Minus 18 to 38 degrees C, with 1-degree scale divisions [0 to
         100 degrees F, with 2-degree scale divisions].

   B. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to
      maximum of 1.5 percent of range span.

2.3 LIQUID-IN-GLASS THERMOMETERS

   A. Description: ASTM E1, liquid-in-glass thermometer.

   B. Case: Die-cast and aluminum-finished in baked-epoxy enamel, glass front, spring secured, 230
      mm [(9 inches)] long.

   C. Adjustable Joint: Finished to match case, 3.1 rad [(180 degree)] adjustment in vertical plane,
      6.3 rad [(360 degree)] adjustment in horizontal plane, with locking device.

   D. Tube: Red-reading mercury-filled with magnifying lens.

   E. Scale: White background with black embossed figures and markings.

   F. Stem: Copper-plated steel oraluminum for a separable socket of length to suit installation.

   G. Bulb Chamber: Tapered to fit match pair in sockets.

2.4 SEPARABLE SOCKETS

   A. Description: Fitting with protective socket for installation in threaded pipe fitting to hold
      thermometer stem.
B. Material:
   1. Brass for copper pipe.
   2. Stainless steel for steel pipe.

C. Pressure Rating: Not less than piping system design pressure.

D. Stem Length: To extend 50 mm [(2 inches)] into fluid.

E. Extension for Insulated Piping: 50 mm [(2 inches)] nominal, but not less than thickness of insulation.

F. Threaded Cap Nut: With chain permanently fastened to well and cap.

2.5 PRESSURE GAGES

A. Description: ASME B40.1, Grade A phosphor-bronze Bourdon-tube pressure gage, with bottom connection.

B. Case: Drawn brass with solid front and 115-mm [(4-1/2 inch)] diameter glass lens.

C. Connector: Brass, DN 8 [(1/4 inch)].

D. Scale: White-coated aluminum, with permanently etched black markings.

E. Accuracy: Plus or minus 1 percent of range span.

F. Range: Conform to the following:
   1. Vacuum: 100 kPa of vacuum to 100 kPa of pressure. [(30 inches Hg of vacuum to 15 psig of pressure.)]
   2. Fluids Under Pressure: 2 times operating pressure.

2.6 PRESSURE-GAGE ACCESSORIES

A. Syphons: DN 8 [(1/4 inch)] straight coil of brass tubing with threads on each end.

B. Snubbers: DN 8 [(1/4 inch)] brass bushing with corrosion-resistant porous-metal disc of material suitable for system fluid and working pressure.

2.7 TEST PLUGS

A. Description: Nickel-plated brass-body test plug in DN 8 [(1/4 inch)] fitting.

B. Body: Length as required to extend beyond insulation.

C. Pressure Rating: 3450 kPa [(500 psig)] minimum.

D. Core Inserts: 2 self-sealing valve types, suitable for inserting a 3-mm [(1/8 inch)] outside-diameter probe from a dial thermometer or pressure gage.
E. Core Material: According to the following for fluid and temperature range:
   1. Air and Water, Oil, and Gas: Minus 7 to 93 degrees C [(20 to 200 degrees F)], EPDM.
F. Test-Plug Cap: Gasketed and threaded cap, with retention chain.
G. Test Kit: Provide test kit consisting of 1 pressure gage and gage adapter with probe, 2 bimetal dial thermometers and a carrying case.
H. Pressure Gage and Thermometer Ranges: Approximately 2 times systems operating conditions.

2.8 FLOW INDICATORS

A. Description: Instrument for visual verification of flow made for installation in piping systems that measures flow directly in L/s [(gallons/minute)].
B. Construction: Bronze or stainless-steel body compatible with piping system, with sight glass and plastic pelton-wheel indicator.
C. Pressure Rating: 860 kPa [(125 psig)].
D. Temperature Rating: 93 degrees C [(200 degrees F)].

2.9 AIR VENTS

A. Manual Air Vent Assemblies: Construct of DN 15 [(1/2 inch)] diameter, 150 mm [(6 inches)] long, vertical pipe section. Terminate with bronze body and nonferrous internal parts, 1035 kPa [(150 psig)] working pressure air vent, screw driver or thumbscrew operated with DN 8 [(1/8 inch)] discharge connection and DN 15 [(1/2 inch)] inlet connection.
B. Float Type Automatic Air Vents: Provide bronze body, nonmetallic float, stainless steel valve, and valve seat. Rated for 1030 kPa [(150 psig)] and 115 degrees C [(240 degrees F)].
C. High Capacity Air Vent: Cast iron body with stainless steel, brass and EPDM internal components. Minimum capacity of 7 L/S [(15 scfm)] at 172 kPa [(25 psi)]. Rated for 1030 kPa [(150 psig)] and 120 degrees C [(250 degrees F)].

2.10 RELIEF VALVES

A. ASME labeled, direct spring loaded type, lever operated, nonadjustable factory set discharge pressure. Rating and capacity according to ASME BPVC Section IV.

2.11 Y-TYPE STRainers

A. Strainers Up to DN 50 [(2 inches)] in Size: 862 kPa [(125 psi)] pattern, cast brass body, screwed; stainless steel screen with 0.8 mm [(1/32 inch)] perforations.
B. Strainers DN 65 [(2-1/2 inches)] and Larger: 862 kPa [(125 psi)] pattern, cast iron body, flanged; stainless steel screen with 1.6 mm [(1/16 inch)] perforations.
C. Screen Free Area: Equal or exceed 3 times the area of the inlet pipe.

D. Blowdown Outlet: Provide with full port valve, threaded hose connection and cap in all other locations.
   1. Pipe blowdown to drain.
   2. Provide threaded hose connection and cap in all other locations.

2.12 BALANCING DEVICES

A. Basic Requirements:
   1. Balancing Devices: Either automatic or manual, Contractor's option. If automatic units are selected, hydronic balancing will not be required nor will any report be necessary for those components provided with automatic units. If manual units are selected, complete balancing will be required and full documentation prepared and included in the overall testing and balancing report. See Section 15950 - Testing, Adjusting and Balancing.
   2. Automatic or Manual Balancing Devices: Provided for each air handling unit coil.
   3. Readout Meter Kit: Match both the automatic and manual units balance devices installed. Include a pressure gauge, dual hoses, shutoff and vent valves, charts or calculators, instructions, and fitted carrying case.

B. Coil Balance Components:
   1. Provide isolation valves, strainers, flow control (balance) valves, unions, air vents, P/T test valves, drain valves, fittings, and connections.
   2. Automatic Flow Control Valves: Automatically control flow with plus or minus 5 percent accuracy over an operating pressure range of at least 14 times the minimum required for flow. Stainless steel one-piece valve cartridge with full travel linear coil spring, housed within forged brass or cast iron body and supplied with dual P/T test valves for verifying the pressure differential across the cartridge and system. End connections based on size and to suit piping.
   4. Flow Orifice: Cast iron wafer body with orifice insert for installation between ANSI Class 125/150/250/300 flanges. Provide 2 P/T test ports for measurement of differential pressure. Limit dynamic head loss to 20 kPa [(3 psi)].
   5. Isolation Valves: Ball, bronze body, threaded or soldered ends, DN 50 [(2 inches)] and smaller; butterfly, cast iron body, flanged ends DN 65 [(2-1/2 inches)] and larger.
   8. Hose Connections: Insulated, stainless steel braided over a fire retardant synthetic polymer liner. Threaded connections with swivel for connection to coil. Maximum size DN 40 [(1-1/2 inches)] with minimum rating of 1200 kPa [(175 psi)] at 93 degrees C [(200 degrees F)]. Maximum hose composite rating of 25 for flame spread and 50 for smoke developed.

PART 3 - EXECUTION

3.1 METER AND GAGE APPLICATIONS
A. General: Where indicated, install meters and gages of types, sizes, capacities, and with features indicated.

3.2 METER AND GAGE INSTALLATION, GENERAL

A. Install meters, gages, and accessories according to manufacturers' written instructions for each application.

3.3 THERMOMETER INSTALLATION

A. Install thermometers with matching sockets and adjust vertical and tilted positions.

B. Install in the following locations and elsewhere as indicated:
   1. At inlet and outlet of each hydronic zone.
   2. At inlet and outlet of each hydronic boiler and chiller.
   3. At inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
   4. At inlet and outlet of each hydronic heat exchanger.
   5. At inlet and outlet of each hydronic heat recovery unit.
   6. At inlet and outlet of each thermal storage tank.

3.4 PRESSURE GAGE INSTALLATION

A. Install pressure gages in piping tee with pressure gage valve located on pipe at most readable position. For measurement of equipment inlet and outlet pressure, use a common gage with an isolation valve in each sensing line.

B. Install in the following locations and elsewhere as indicated:
   1. At suction and discharge of each pump.
   2. At discharge of each pressure-reducing valve.
   3. At building water service entrance.
   4. At chilled water and condenser water inlets and outlets of chillers.
   5. At hot water boiler inlets and outlets.
   6. At hot water inlet and outlet of each heat exchanger

C. Pressure Gage Needle Valves: Install in piping tee with snubber. Install syphon instead of snubber for steam pressure gages.

3.5 TEST PLUG INSTALLATION

A. Install test plugs located on pipe at most readable position. Secure cap. Provide on equipment where permanent temperature and pressure devices are not installed.

3.6 FLOW-MEASURING SYSTEM, FLOW ELEMENT AND METER INSTALLATION

A. General: Install flow meters and indicators for piping systems located in accessible locations at most readable position. Locate and install in piping in accordance with manufacturer’s instructions.
B. Install connection fittings for attachment to portable flow meters in readily accessible locations.

C. Permanently Mounted Meters for Flow Elements: Install meters on walls or brackets in accessible locations.

D. Install connections, tubing, and accessories between flow elements and meters as prescribed by manufacturer's written instructions.

3.7 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. The Drawings indicate the general arrangement of piping, fittings, and specialties.

B. Install meters and gages adjacent to machines and equipment to allow servicing and maintenance.

C. Connect flow-measuring-system elements to meters.

D. Connect flow-meter transmitters to meters.

E. Coordinate electrical connections to power supply and electrically operated meters and devices.

3.8 PRESSURE AND AIR ELIMINATION

A. Install diaphragm-type compression tank to sense system pressure upstream of pump(s) and downstream of air separator. Locate pressure gage, air vent, and drains as shown on the Drawings.

B. Install air separator upstream of system pump(s). Connect source of makeup and air vent as shown on the Drawings. Pipe air vent and separator drain valve to drain. Adjust makeup PRV commensurate with compression tank pressure requirements.

3.9 AIR VENTS

A. Install high capacity air vent on air separator.

B. Install float type automatic air vent on compression tank.

C. Install manual air vents at all other locations as identified in other Division 15 Sections.

3.10 RELIEF VALVES

A. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, expansion tanks, and where shown on Drawings.

B. Pipe hydronic relief valve outlet to nearest floor drain.

C. Pipe steam relief valve vents to the outdoors.
3.11 STRAINERS

A. Install Y-type strainers upstream of heat exchangers, coils and temperature/pressure control valves and as shown on the Drawings. An inlet strainer may be used to protect both the equipment and control valve when the valve is close coupled to the equipment.

B. Install basket strainers where shown on the Drawings.

3.12 BALANCING DEVICES

A. Install at each coil, heat exchanger and as shown on the Drawings.

B. Install to facilitate access and adjustment.

C. Install based on Contractor selected options in accordance with manufacturer’s instructions.

3.13 ADJUSTING AND CLEANING

A. Install startup strainers at all pumps, flush and when proven clean, remove and install permanent strainer.

B. Remove and clean each strainer screen in all systems subsequent to systems flushing and prior to systems balance.

C. Calibrate meters according to manufacturers written instructions, after installation.

D. Adjusting: Adjust faces of meters and gages to proper angle for best visibility.

E. Cleaning: Clean windows of meters and gages and factory-finished surfaces. Replace cracked and broken windows and repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION
SECTION 15190

AIR AND WATER SYSTEMS BALANCING

PART 1 – GENERAL

1.1 SUMMARY

A. Total system balance, as defined by NEBB or AABC, which constitutes the process of testing, adjusting, and balancing each system component so that the entire system produces the results for which it was designed.

B. Work shall include the proper use of instruments, evaluation of readings, adjusting the systems to design conditions, full implementation of all test report forms, and providing unbiased opinions of the deficiencies encountered and proposing corrective action.

C. The Formulation, Gowning and Air lock are Class 100,000 clean rooms. Follow specification sections 01737, 01740, and 01744 during test and balance work in these areas.

1.2 REFERENCES

A. The following references and standards are applicable to the testing, adjusting, and balancing of mechanical equipment and systems and shall form a part of this Section. Publication references are to the latest issue of each, together with related additions and/or amendments pertaining thereto, as of the date of contract or purchase order. Sponsoring agency references are made in accordance with the following abbreviations:
   1. AABC: Associated Air Balance Council
   2. ADC: Air Diffusion Council
   3. AMCA: Air Moving and Conditioning Association
   4. ANSI: American National Standard Institute
   5. ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers
   6. ASNT: American Society for Nondestructive Testing
   7. NEBB: National Environmental Balancing Bureau

B. "Procedural Standards for Testing - Balancing - Adjusting of Environmental Systems"; published by NEBB.


D. ASHRAE Systems and Applications Handbook, Chapters 52 and 57 as applicable.


H. "National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems," published by AABC.

1.3 DEFINITIONS

A. Certification of Personnel is the action of determining, verifying, or attesting in writing to the qualifications of an individual.

B. Qualifications are the characteristics or abilities gained through training, experience, or both, that enables an individual to perform his work properly.

C. Qualified Procedures are the test procedures developed and published by AABC, AMCA, ASHRAE, NEBB, or other nationally recognized TAB Association or Agency.

D. Supervision means that tests performed under this contract in any of TAB categories stated herein shall be under the direction and supervision of a TAB Level III employee on the job site.

1.4 SUBMITTALS

A. Submit test reports in accordance with Division 1.

B. The TAB contractor shall perform equipment and systems tests, compile test data, and submit reports to the Architect. Specific procedures used in tests shall be performed in strict accordance with NEBB requirements and shall be included in the test report. Contractor shall identify equipment by Drawing identification code.

C. Submit data on printed report forms published by AABC or NEBB.

D. Reports shall be certified by a TAB Level III Engineer. Each individual reporting form submitted must bear the signature and TAB Level of the data recording Engineer.

PART 2 – PRODUCTS

NOT USED

PART 3 – EXECUTION

3.1 TESTING

A. Obtain air and water balancing performed by an independent air and water balance and testing agency currently certified by the AABC or NEBB. The testing agency shall be a specialist in the balancing and testing of mechanical systems.

3.2 PERSONNEL QUALIFICATIONS

A. A TAB personnel qualification and certification program, meeting the following requirements, shall be maintained by the Contractor.
   1. The Contractor shall establish a written practice for the control and administration of TAB personnel training, examination, and certification.
2. The Contractor's written practice shall include a written examination for each personnel TAB level.

B. There shall be 3 levels of qualifying TAB personnel for each Tab category hereinafter listed:

1. TAB Level I: A TAB Level I individual shall be a high school graduate and shall have sufficient training and experience to perform the necessary tests in the TAB Category for which he is certified. A TAB Level I individual shall take test data and shall be responsible to a TAB Level II or TAB Level III Engineer in the applicable TAB Category.

2. TAB Level II:
   a. A TAB Level II individual shall be (1) a graduate of a 4 year accredited engineering college or university, and shall have 2 years of experience in engineering, or equivalent in manufacturing, construction, and installation activities, or (2) be a high school graduate, having 4 years of experience in engineering activities or equivalent. In either case, 2 years of this experience shall be in TAB testing and procedures.
   b. A TAB Level II individual shall direct and carry out tests in the category for which he is certified. He must also be able to set up and calibrate instruments, interpret test results, modify procedures as necessary, analyze data, and record the test results on appropriate forms.

3. TAB Level III:
   a. A TAB Level III individual shall be (1) a graduate of a 4-year accredited engineering or science college or university, plus 5 years of experience in engineering, or equivalent manufacturing, construction, and installation activities, or (2) be a high school graduate, 10 years of experience in engineering, or equivalent manufacturing, construction, and installation activities. In either case, 2 years of this experience shall be in TAB testing and procedures.
   b. A TAB Level III Engineer shall establish test procedures, designate test methods and procedures, and interpret test results. He shall be capable of evaluating the results, not only in terms of existing procedures, but also shall possess sufficient practical background in applicable HVAC technology to assist in establishing test procedures when none are otherwise available. He shall be responsible for conducting examinations of TAB Level I and TAB Level II personnel.

C. TAB personnel shall be qualified and certified in the following generic TAB categories:
   1. Air Systems and Associated Equipment.

D. Certification requirements of all levels of TAB test personnel shall be performed by the Contractor. Certifications shall indicate the category and level of qualification in that category. Written statements verifying individual qualifications shall be available for review.

3.3 INSTRUMENTS

A. Instruments used in testing mechanical systems and equipment shall be as recommended by the AABC, AMCA, ASHRAE, or NEBB. Test instruments used shall be initially and periodically checked thereafter to verify their calibration accuracy as described in the AABC
or NEBB procedures. Provide calibration verification of each test instrument with each test report.

B. Test equipment shall be furnished by the Contractor and shall remain his property.

3.4 GENERAL PROCEDURES

A. Systems and equipment as listed in the Specifications shall be tested and balanced in accordance with qualified procedures from the AABC or NEBB Standards.

B. Procedures for each system test and equipment test shall be maintained on file by the Contractor and shall be readily available to the Architect if requested.

C. Procedures used in tests shall be included in the submitted report.

D. TAB contractor shall coordinate with the controls contractor for setting and/or positioning of control devices pertinent to facilitating testing and adjustment of all mechanical systems.

3.5 PRELIMINARY PROCEDURES

A. Do all initial planning, including procurement of all available data, study of all systems, instrument selection and calibration, assembling all requisite report forms, study of construction documents and recording pertinent data on report forms, and performing all calculations possible.

B. Inspect systems and equipment utilizing appropriate standards checklists to assure construction is complete and ready for balancing.

C. Confirm that equipment installed matches data on report forms, including manufacturer, model, type, size, capacity, motor horsepower, rpm, etc.

D. Maintain quality control during the execution of work through final completions.

3.6 AIR SYSTEM PROCEDURES

A. Follow appropriate AABC or NEBB procedures for testing and balancing supply, return and exhaust air systems and systems with economizers and other energy conservation features where included as part of the Project.

B. Specific systems shall include, but not necessarily be limited to, single duct constant or variable volume systems; pressure independent, variable volume systems; makeup air systems, recirculation air systems, associated return air systems, general, and process exhaust systems.

C. Conduct tests for central air-handling distribution systems at design air flow with simulated changeout filter resistance.

D. For variable volume systems, coordinate with equipment supplier to properly set maximum and minimum variable frequency drive speed settings. Maximum speed setting shall correspond to full load current times motor service factor or maximum airflow at specified fan head, whichever is limiting.
E. After each air system is balanced, indicate each damper set position with a fully visible, painted red or similar, permanent mark.

3.7 HYDRONIC SYSTEM PROCEDURES

A. Follow appropriate AABC or NEBB procedures for testing and balancing of individual systems involved.

B. Central Plant equipment, such as boilers, chillers, compressors, cooling towers, etc., shall be started by and operated under the direct supervision of the Owner. Project specific equipment installed in the FAB I expansion shall be started by and operated under the direct supervision of the responsible installing Contractor/Owner.

C. Specific systems shall include, but not necessarily be limited to, chilled and/or hot water systems, heat exchangers, pumps, and associated appurtenances.

D. Test and balance equipment provided with manual balancing devices, including air-handling unit heat exchanger coils, terminal reheat coils, fan coil units, and unit heaters. Note that if automatic balancing devices are used, testing and balancing of equipment specifically provided with such devices shall be omitted. Refer to Section 15710.

E. Mark or score balancing devices, gauges, and other adjustable devices at their final setpoints.

3.8 REPORT FORMS

A. Report forms, as they relate to the specific Project, shall be fully implemented, including a sealed certification. Report forms shall include, but not be limited to: coils, fans, duct systems, air outlets, terminal units, rooftop equipment, heat exchangers, pumps, and instrument calibration.

B. Report forms shall be standard forms as published by AABC or NEBB.

3.9 RETESTING

A. During the period following completion of a specific test, and within the Project time frame, the Architect may, at his discretion, request a recheck or resetting of any outlet, supply air fan, or exhaust fan as originally covered in the Scope of Work of this Specification. Retesting procedures, personnel qualifications, and report requirements shall be the same as the original requirements.

END OF SECTION
SECTION 15195
CLEANROOM CERTIFICATION

PART 1 - GENERAL

1.1 SUMMARY

A. Cleanroom testing and certification for following spaces, performed by an approved testing and certification agency (certification subcontractor). Refer to Drawings for areas to be tested, and classification of spaces:

<table>
<thead>
<tr>
<th>Room #</th>
<th>Room</th>
<th>Class</th>
<th>Certification</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1160A</td>
<td>Formulation</td>
<td>100,000</td>
<td>As-Built</td>
<td>Non-Unidirectional</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Certification</td>
<td></td>
</tr>
<tr>
<td>1160</td>
<td>Gowning</td>
<td>100,000</td>
<td>As-Built</td>
<td>Non-Unidirectional</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Certification</td>
<td></td>
</tr>
<tr>
<td>1160B</td>
<td>Air Lock</td>
<td>100,000</td>
<td>As-Built</td>
<td>Non-Unidirectional</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Certification</td>
<td></td>
</tr>
</tbody>
</table>

B. Unit Prices: Submit unit pricing involving Work of this Section.
1. Require field engineer for certification subcontractor visit Project Site a minimum of 1 day during construction of cleanroom installation.
2. Require subsequent Project Site visits to be arranged with Construction Manager by certification subcontractor at mutually agreeable times, and at unit price included in Bidder’s Proposal.
3. Require certification subcontractor to offer per diem rates to be applied to additional fieldwork requested.

1.2 REFERENCES


1.3 DEFINITIONS

A. As-Built Cleanroom: A cleanroom that is complete and ready for operation, with all services connected and functional, but without production equipment or operating personnel.

B. At-Rest Cleanroom: A cleanroom that is complete, with all services functioning and with equipment installed and operable or operating, as specified, but without operating personnel in the facility.

C. Calibrated Equipment: Test equipment that has been calibrated in accordance with the equipment manufacturer’s recommendations or accepted industry practices.

D. Cleanroom: A room in which the air supply, air distribution, filtration of air supply, materials of construction, and operating procedures are regulated to control airborne particle concentrations so that appropriate air cleanliness levels, as defined by FED-STD-209E, can be met.

E. Clean Zone: A defined space in which the concentration of airborne particles is controlled to a specified airborne particle cleanliness class, as defined by FED-STD-209E.

F. Designated Leak: A leak that should be detectable during scanning of a filter installation with a discrete-particle counter. The designated leak is characterized by a designated number of counts, chosen to establish statistical probabilities related to its detection.

G. Discrete-Particle Counter: A light-scattering instrument with display or recording means to count and size discrete particles in the air, as defined by ASTM-F50.

H. HEPA Filter: A throwaway (High Efficiency Particulate Air) filter with extended medium, dry-type filter in a rigid frame having a minimum particle-collection efficiency of 99.97% for 0.3 micron size airborne particles, and a maximum clean-filter pressure drop of 1 inch water gauge, when tested at rated airflow capacity. HEPA filters may be specified by type and grade according to IES-RP-CC001.

I. Mixed Airflow Cleanroom: A hybrid cleanroom containing both unidirectional and non-unidirectional types of airflow within the same enclosure.

J. Non-unidirectional Airflow Cleanroom: A cleanroom in which the filtered air entering the room or passing through the work zone is characterized by nonuniform velocity or turbulent flow. Such rooms exhibit nonuniform, random airflow patterns throughout the enclosure.

K. Operational Cleanroom: A cleanroom in normal operation, with all services functioning and with equipment and personnel, if applicable, present and performing their normal work functions in the facility.
L. Parallel Airflow: Unidirectional (laminar) airflow through specified cleanroom which exhibits its measured deviation of not more than 14 degrees from straight line flow.

M. Filter Scanning: A method for disclosing leaks in HEPA or ULPA filter units in which the probe inlet of a particle counter is held approximately 2.5cm (1 in.) from the filter face and moved in overlapping strokes across the test area at a rate based on the leak penetration to be detected and the upstream challenge concentration.

N. ULPA Filter: A throwaway (Ultra Low Penetration Air) filter, with extended medium, dry-type filter in a rigid frame having a minimum particle-collection efficiency of 99.999% for particles 0.12 micron and larger.

O. Unidirectional Airflow Cleanroom: A cleanroom in which the filtered air entering the room makes a single pass through the work area in a parallel-flow pattern, with a minimum of turbulent-flow areas. Unidirectional airflow rooms typically have HEPA or ULPA filter coverage of 80% or more of the ceiling (vertical flow) or one wall (horizontal flow).

P. Uniform Airflow: A unidirectional airflow pattern in which the point-to-point readings are within plus or minus 20 percent of the average airflow velocity for the total area of the unidirectional flow work zone.

1.4 ITEMIZED TESTS PROCEDURES FOR CLEANROOM CERTIFICATION

A. The choice of tests may be based in part on factors such as the design of the cleanroom or clean zone, its operational status, and the required level of certification. These factors are further classified in the paragraphs that follow. Table 1 lists tests appropriate to initial certification of cleanrooms and clean zones of three principal design types in various operational phases.

B. There are 3 distinctly different types of cleanroom designs. Particular type of design may affect methodology of some of tests. The 3 types are:
   1. Unidirectional Airflow Cleanrooms.
   2. Non-unidirectional Airflow Cleanrooms.

C. Refer to Drawings for type of cleanroom design for each space to be tested. The choice of tests and test methods will be affected by the type of design used in the cleanroom to be tested (See Table 1)

Table 1

<table>
<thead>
<tr>
<th>Tests Performed</th>
<th>Unidirectional Airflow</th>
<th>Nonunidirectional Airflow</th>
<th>Mixed Airflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bench Scanned Filter Leakage</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Installed Filter Leakage</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Airborne Particle Counts</td>
<td>1</td>
<td>2</td>
<td>1, (2&amp;3 OPT)</td>
</tr>
</tbody>
</table>
### Tests Performed

<table>
<thead>
<tr>
<th>Tests Performed</th>
<th>Unidirectional Airflow</th>
<th>Nonunidirectional Airflow</th>
<th>Mixed Airflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bench Scanned Filter Leakage</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Airflow Volume</td>
<td>1, (2&amp;3 OPT)</td>
<td>2</td>
<td>1, (2&amp;3 OPT)</td>
</tr>
<tr>
<td>Airflow Velocity</td>
<td>1, (2&amp;3 OPT)</td>
<td>1</td>
<td>OPT</td>
</tr>
<tr>
<td>Airflow Uniformity</td>
<td>1, (2&amp;3 OPT)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Airflow Parallelism</td>
<td>1, (2&amp;3 OPT)</td>
<td>N/A</td>
<td>OPT</td>
</tr>
<tr>
<td>Room Pressurization</td>
<td>1, (2&amp;3 OPT)</td>
<td>2</td>
<td>1, (2&amp;3 OPT)</td>
</tr>
<tr>
<td>Installed Air Handler HEPA Leakage</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

D. The order in which tests are performed is optional, but some sequences are optimal.
   1. N/A: Not applicable to this situation.
   2. 1: Test is performed during as-built phase.
   3. 2: Test is performed during at-rest phase.
   4. 3: Test is performed during operational phase.
   5. OPT: Test is optional, depending on process requirements and Owner’s needs.

### 1.5 CERTIFICATION PROCEDURES AND FIELD TESTS

#### A. Bench Scanned HEPA/ULPA Filter Leakage Test:
   1. Clarification: This scope may be combined with the scope noted in Par. 1.5.G
   2. Purpose: To determine the integrity of all HEPA/ULPA filters prior to installation, which will detect any possible damage which may occur during shipping and handling.
   3. Test Procedure: Test and Certification Subcontractor shall provide a flow test bench and optical laser particle counter. Place HEPA/ULPA filter on the down stream side of the flow bench, introduce PSL challenge spheres from the generator into the upstream side of the flow bench, with a challenge of at least 1,000,000 particles per cubic foot sized at 0.2 to 0.3 micron. Scan each joint and the entire downstream filter face area in overlapping strokes, moving the probe at a scan rate of 2 inches per second, spaced a distance of 1 inch from the filter face.
   4. Acceptance Criteria: Reject filter modules with direct leaks detected, or any physical damage. Repack and store rejected filters for the filter manufacturer to claim and repair/replace. Create statistical documentation and identify the model and serial number, with the nature and location of the leak.

#### B. Airborne Particle Count:
   1. Purpose: Determine particle count levels at reference particle size to ensure systems operate within design criteria.
   2. Test Procedure: Measure and record the airborne particle counts throughout every cleanroom of any class as identified in project specifications. Record the particle counts at a distance of 42 inches above the finished floor, in the center of each test sector or 12 inches above any process equipment obstructing the standard test station. Airflows must be balanced, and final filter leak tests completed and passed, prior to performance of this test. Allow ample time span and sample volume as stated in FED-STD-209E. Collect several one minute samples at each location to show repeatability.
   3. Acceptance Criteria: Secure airborne particle counts in accordance with the cleanroom class identification as listed in FED-STD-209E.
Cleanliness Level Performance Criteria:

<table>
<thead>
<tr>
<th>Particle Count (per cu ft) for Measured Particle Size (micrometer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class    0.1     0.2     0.3    0.5    5.0</td>
</tr>
<tr>
<td>M1  9.91  2.14  0.875  0.283  NA</td>
</tr>
<tr>
<td>M1.5/1  35    7.5    3     1     NA</td>
</tr>
<tr>
<td>M2.5/10  350   75    30    10    NA</td>
</tr>
<tr>
<td>M3.5/100 NA    750   300   100    NA</td>
</tr>
<tr>
<td>M4.5/1,000 NA   NA    NA    1,000    7</td>
</tr>
<tr>
<td>M5.5/10,000 NA   NA    NA    10,000    70.0</td>
</tr>
<tr>
<td>M6.5/100,000 NA  NA    NA    100,000  700.0</td>
</tr>
</tbody>
</table>

Minimum air volume sampling rates shall be in accordance with following table, extracted from Federal Standard 209E, Paragraph 5.1.3.4.1.

<table>
<thead>
<tr>
<th>Volume of Sample (cu ft), Required for Measured Particle Size (micrometer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class    0.1     0.2     0.3    0.5    5.0</td>
</tr>
<tr>
<td>M1    2.0  9.4  22.9  70.7  NA</td>
</tr>
<tr>
<td>M1.5/1  0.6  3.0  7.0  20.0  NA</td>
</tr>
<tr>
<td>M2.5/10 0.1  0.3  0.7  2.0  NA</td>
</tr>
<tr>
<td>M3.5/100 NA    0.1  0.1  0.2  NA</td>
</tr>
<tr>
<td>M4.5/1,000 NA   NA    NA    0.1  3.0</td>
</tr>
<tr>
<td>M5.5/10,000 NA   NA    NA    0.1  0.3</td>
</tr>
<tr>
<td>M6.5/100,000 NA  NA    NA    0.1  0.3</td>
</tr>
</tbody>
</table>

C. Room Pressurization:

1. Purpose: Confirm capability of cleanroom air-handling systems to maintain cascaded air pressure regime within the Clean Zone.

2. Test Procedure: Measure differential air pressure between each cleanroom area and the adjacent entry passage, vestibule, or corridor. Using a micromanometer at each connecting doorway and pass-through, measure and record differential pressures between various cleanroom areas. Also measure between the cleanroom areas and the surrounding ambient area.

3. Acceptance Criteria: Pressurization acceptance levels are according to project design specifications and are listed on a table in the back of this section. Measure and record the relative positive pressure sequentially from the area with the highest cleanliness requirement outward.

Differential pressures shall be set as follows:

- Main Cleanroom to Building: (Plus) 0.04 inch wc.
- Main Cleanroom to Gowning Vestibule: (Plus) 0.02 inch wc
- Main Cleanroom to Air Lock Vestibule: (Plus) 0.02 inch wc
- Gowning/Air Lock to Building: (Plus) 0.02 inch wc
Recorded Data shall include: Relative room pressure differentials mapped on a room layout.

D. Installed Air Handler HEPA Leakage:
1. Purpose: Determine the integrity of HEPA/ULPA filter modules after installation the makeup air-handler final filter frame.
2. Test Procedure: Scan the final filter assembly in every makeup air handler after completion of the installation when the units are operating. Provide an optical laser particle counter, PSL generator, isokenetic sample probes, and accessories. Introduce PSL spheres from the generator into the upstream plenum of the final filter assembly. A challenge of greater than 1,000,000 particles per cubic foot sized 0.2 to 0.3 micron is required at the filter.
3. Acceptance Criteria: Reject any filter modules that do not pass the designed efficiency rating of the final filters.

E. Integrity (Induction Leak Test):
1. Purpose: To determine if there is intrusion of unfiltered air into the cleanroom.
2. Test Procedure: Check the construction seams and joints in the cleanroom by scanning with a laser discrete particle counter to determine if any contamination is entering the cleanroom caused by venturi effects.
3. Acceptance Criteria: Construction joints and seams are sealed, and no intrusion of unfiltered air is detected.

1.6 SUBMITTALS

A. General: Submit in accordance with Section 01330.

B. Submit test reports in accordance with Specification requirements.

C. Qualifications of testing and certification personnel.

D. Instrument calibration documentation.

E. Sample test report for Construction Manager’s evaluation and approval, including forms. refer to IES-RP-CC 006.2, and FED-STD 209E.

F. Within 5 days of testing, a preliminary certification report shall be submitted with collected data and statistical analysis provided for review. This report shall be reviewed by the Construction Manager and returned within 10 days of receipt.

G. Within 15 calendar days of receipt of review comments, additional testing and analysis shall be completed and a final certification report shall be submitted.

H. Produce detailed and easily comprehensible final certification report, which shall serve as database for future reference by engineering, quality assurance, and maintenance personnel. Certification report shall include:
1. Typed or computerized field reports, charts, and forms completed with measured data.
2. Description of operating condition of clean areas.

3. Reduced set of architectural floor plan drawings, maximum size, 279 by 432 mm [(11 by 17 inches)] showing sample points referred to on other field data sheets. Total area certified does not have to be on a single sheet.

4. Separate section in report outlining operating or contamination problems remaining at end of testing and certification procedures. Describe condition and its effect on room cleanliness levels of performance.

5. A list of instrumentation and test equipment actually used in certification process including manufacturer, model, and last calibration date.

6. Description of tests performed, including purpose, instrumentation, procedure, results, and analysis of data.
   a. Present complete, concise data, graphically displayed, to permit full understanding of tests.
   b. Include dates and times tests were taken and name of field technicians performing tests.

7. Submit five bound copies of completed certification report to Construction Manager for Owner's review and acceptance, including computer disks of statistical analysis.

1.7 QUALITY ASSURANCE

A. Certification Subcontractor Qualifications: Cleanroom testing and certification agency shall be an independent service company, specializing in cleanroom testing and certification, and not involved in the manufacturer or sales of cleanrooms, cleanroom related equipment, or cleanroom related accessories.

1. Certification subcontractor's project manager shall have a minimum of 4 years of testing and certification experience and shall be familiar with facility design, shall be responsible for selection of appropriate test methods and techniques used in testing and certification of the cleanroom under the Construction Manager's direction. Additionally the Cleanroom Director (Construction Manager) shall be responsible for review and approval of final certification report.

2. Certification subcontractor's field engineer shall have a minimum of 2 years of testing and certification experience as a field technician. Field engineer shall be responsible for on-site testing and data acquisition as well as supervision of field technicians.

3. Field technician is an entry-level position with previous training in general theory and operation of cleanrooms and cleanroom test equipment. Field technicians shall be competent in facets of data acquisition and shall be supervised by the certification subcontractor's project manager or field engineer.

4. At a minimum there shall be a project manager or field engineer, in addition to field technicians on site at all times while certification testing is on-going.

5. Cleanroom Test Equipment: Test equipment used in cleanroom certification shall be state-of-the-art. Where applicable, satisfactory proof of instrumentation calibration and traceability to NIST Standards within previous 6 months shall be required. Each instrument shall have its own certification sticker.

B. Special Pre-Certification Requirement: Subcontractor shall notify Construction Manager 2 weeks in advance of testing for cleanroom certification and conduct pre-certification meetings as requested.
C. Certification Subcontractor’s Project Manager: is a single source contact who reports to the Construction Manager, and who shall be responsible for coordinating work of related Sections above.

1.8 WARRANTY

A. Certifying subcontractor shall be retained by the Construction Manager to measure and record the operating status of cleanroom. In that capacity, the certification contractor is being retained in an advisory role and not expected to guarantee the satisfactory performance of room nor its support systems.

B. Service to be furnished by certifying subcontractor shall be considered complete and accepted when Final Certification Report has been approved by the Construction Manager.

PART 2 - PRODUCTS

2.1 MATERIALS, ACCEPTABLE CERTIFIERS

A. Certifying subcontractor shall supply materials, tools, equipment, and instrumentation required to perform cleanroom system testing and certification as described in these Specifications.

B. Dioctyl Phthalate (DOP) shall not, at any time, be used for challenge of HEPA filters. Filter challenges shall be accomplished with polyspheric latex (PSL).

2.2 INSTRUMENTATION

A. Test equipment used in certification procedure shall be latest model. Calibration of equipment shall be within previous 6 months. Calibration records shall be subject to approval by Construction Manager who will indicate if further calibration is required prior to use on Site. Following test equipment is specified in some cases, recommended in others. Detailed information on any proposed alternate test equipment must be included with Bid.

B. Particle counters for room certification tests shall be laser based instruments with a sample rate of $0.47 \text{ L/s} \ (1.0 \text{ cfm})$ and minimum detectable particle sizes of 0.10 micrometer. Furnish counter with printed output data that records ranges with lower limits starting at 0.1, 0.2, 0.3, 0.5, and 1.0 micrometer and larger. Particle counter shall not add more than 10 particles per $0.0283 \text{ cu m} \ (\text{cu ft})$ larger than 0.1 $\mu$m to space measured at back (outlet) of machine. Recommended Manufacturers are Particle Measuring Systems, and Met-One.

C. Pressure Differential Tests shall be taken with an electronic self-averaging micromanometer. A minimum resolution of $0.05 \text{ mm Hg} \ (0.001 \text{ inch w.g.})$ is required. Acceptable equipment shall be a Shortridge Instruments (Air Data Multimeter Model ADM 870).

PART 3 - EXECUTION
3.1 CLEANROOM PROCEDURES

A. Give certifier's personnel a copy of Section 01744 and require they read, and follow applicable requirements.

3.2 ACCEPTANCE CRITERIA

A. Verification Procedures: Certification subcontractor's project manager shall be present and review field data with Owner and Construction Manager to ensure that a full understanding is transferred to Owner's staff of Base Operating Condition of cleanrooms.

B. Documentation:
1. Certification subcontractor's project manager shall oversee any changes or corrections required of final report, then stamp final sets signifying his approval of final certification log.
2. Deliver 5 bound copies to the Construction Manager, who will forward three copies to the Owner, and one copy to the Architect.

3.3 SCHEDULE

A. Classification of spaces.

<table>
<thead>
<tr>
<th>ROOM</th>
<th>CLASSIFICATION AT REST</th>
<th>CLASSIFICATION AS-BUILT</th>
<th>CLASSIFICATION OPERATIONAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulation</td>
<td>X</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Gowning</td>
<td>X</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Air Lock</td>
<td>X</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

END OF SECTION
SECTION 15840
HVAC SHEET METAL DUCTWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Sections includes sheet metal materials, fasteners, supports and duct construction classification for supply, return, and exhaust systems.

B. The Formulation, Gowing and Air lock are Class 100,000 clean rooms. In addition to this specification provide in accordance with specification sections 01737, 01740, and 01744 for all work in Clean Rooms.

1.2 DEFINITIONS

A. Ductwork sizes on Drawings state inside clear dimensions. For acoustically lined and internally insulated ductwork, maintain ductwork sizes inside lining or insulation.

1.3 REFERENCES, CODES, STANDARDS

A. Construct ductwork in accordance with referenced codes and standards as listed below, unless herein modified and limited otherwise.
2. 1992 SMACNA Round and Rectangular Industrial Duct Construction Standards.
3. 1993 SMACNA Accepted Industry Practice for Industrial Duct Construction.
5. 2000 International Mechanical Code, Chapter 6, Duct Systems.
11. 1993 ASHRAE, Chapter 32, Duct Design.
16. ASTM 90, Test Method for Weight of Coating on Zinc Coated Iron or Steel Articles.
19. ASTM A480, Flat-Pulled Stainless and Heat-Resistant Steel Plate, Sheet and Strip.
20. ASTM A568, Steel, Sheet, Carbon and High Strength Low Alloy; Hot Rolled and Cold Rolled.
22. ASTM A653, Steel Sheet, Zinc Coated (Galvanized) or Zinc Iron Alloy Coated (Galvanized) by the Hot-Dip Process.

1.4 DUCT CONSTRUCTION CRITERIA MODIFICATION AND LIMITATIONS

A. Formed-on flanges shall be constructed as a SMACNA T-24 flange, whose limits are defined on Page 1-25 1985 SMACNA Manual, First Edition. Formed-on flanges shall only be accepted for use on ductwork 42 inches wide or less and subjected to 2 inch w.g.s.p. or less. No other construction pertaining to formed-on flanges, will be permitted. Formed-on flanges TDC/TDF/T-24A/T-25A/T-25B shall not be permitted.

B. Construct round and rectangular exhaust system ductwork 2 inch w.g. static negative or greater, in accordance with applicable classification of SMACNA industrial duct standards.

C. Construct rectangular return systems ductwork 3 inch w.g. static negative or greater, in accordance with SMACNA Class 1 industrial duct standards.

D. Construct round return systems ductwork 2 inch w.g. static negative or greater, in accordance with SMACNA Class 1 industrial duct standards.

E. Oval ductwork shall not be used for negative duct systems.

F. When SMACNA 1985 First Edition is applicable, rectangular duct intermediate reinforcement shall be in accordance with Tables 1-3 through 1-19.

G. Transverse joints and intermediate reinforcements shall maintain their structural integrity within the operating range of the system. No duct deformation or deflection which exceeds 1985 SMACNA Manual First Edition deflection criteria will be permitted.

H. SMACNA 1985 First Edition tie rod option construction, Page 1-27, shall not be permitted on negative pressure duct applications.

I. The following HVAC duct construction means and methods shall not be permitted.
   2. Proprietary system equivalency procedures discussed under Section 7 of 1985 SMACNA First Edition.
   3. Conduit type tie-rods with threaded friction inserts.
   4. Snap lock longitudinal seams on 2 inch w.g. static positive or greater ductwork.
   5. Tie-rod option reinforcement on negative systems.
   6. Contractor’s duct construction tables not in compliance with 1985 SMACNA Tables 1 through 13.
   7. PVC clips on flange systems. PVC clips may be used only for listed fire damper breakaway connections.

J. Proprietary duct construction means shall be permitted only as follows:

15840-2 HVAC SHEET METAL DUCTWORK
Advantech Facility Design Inc
NOAO Spectrograph
KITT Peak WIYN
Revision 0 – July 11, 2017
11607.00
1. Slide-on connectors Ductmate 35, Ward J., or WDCI flange systems with metal clips and bolted corners. Components shall be manufactured by a single source. Each component shall be stamped with manufacturer’s name or mark. PVC clips are not allowed.

2. Duct shall be constructed using 1985 SMACNA First Edition, Construction Tables 1 through 13. Proprietary system’s duct construction tables and methods, will not be permitted.

3. Tie-rods to be minimum 3/8 inch galvanized rod. Rod to be attached to the duct wall or to reinforcement and the duct wall, using internal and external nuts. The attachment of tie-rods by welding or bolting is also permitted.

1.5 SUBMITTALS

A. Submit in accordance with Division 1.

B. Submit typical shop standards and/or SMACNA details for each class of duct specified, including particulars such as gauge sizes, welds, joint details, and fitting configurations prior to start of work.

C. Submit written report confirming ductwork has been fabricated and installed in accordance with SMACNA Standards.

D. Submit shop drawings of ductwork only when it is necessary to deviate from the intent of the design Drawings. Minor changes in routing or duct aspect ratio to avoid field conflicts do not require shop-drawing submittals.

1.6 DIAGRAMS

A. Construction Documents may include diagrams as a part of the working Drawings. These diagrams are not for the purpose of giving physical dimensions or locations but rather to identify system components, controls and to make clear the interconnections, by the duct systems, of the various units of the process. If an item is shown on either the diagram drawings or the plan drawings, but not on both, it will be assumed that the contractor has included such item in his estimate of the cost of the work and that he shall provide same.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufactured Round and Flat Oval Ductwork Including Preinsulated Double Wall and Acoustical Duct:
   1. Semco
   2. Spiral Metal Corporation
   3. United McGill Corp.

B. Proprietary Manufactured Duct Joints Rectangular, Round, Flat Oval:
   1. Ductmate Industries (D.M. 35).
   2. Ward J-Class.
   3. W.D.C.I.
2.2 MATERIALS

A. Galvanized Ductwork: Fabricated using galvanized steel sheet of lock forming quality, having zinc coating of 1.25 ounces per square foot for each side per ASTM A 653, G 90. All ductwork, supports, and reinforcement shall be galvanized unless otherwise noted.
   1. Carbon Steel Sheets: ASTM A 366, cold-rolled sheets, commercial quality, with oiled, exposed matte finish.

B. Reinforcement Shapes and Plates: Unless otherwise indicated, provide galvanized steel reinforcing where installed on galvanized sheet metal ducts.

C. Support Materials: Refer to Section 15090.

D. Fasteners: Use galvanized blind rivets and bolts throughout; sheet metal screws are acceptable on low-pressure ducts only.

E. Proprietary Duct Joint Systems: Components consisting entirely of metal components. PVC components will not be acceptable.

F. Sealant Material: Duct sealer shall be flexible, water-based, adhesive sealant designed for use in all pressure duct systems. After curing, it shall be resistant to ultraviolet light and shall seal out water, air, and moisture. Sealer shall be UL listed and conform to ASTM E 84.

G. Joints, Seams:
   1. All joints shall be in accordance with Referenced Code and Standards based upon size and pressure classification except as modified.
   2. Welded joints shall be in accordance with the Welding Sheet Metal Code.
   3. Manufactured joints, where applicable may be used as herein specified.
   4. Make up all laboratory exhaust system ductwork joints with Rachem Thermofit wrap around duct bands installed in strict accordance with manufacturer's instructions.

H. Flanged Interior Gasket:
   1. Ductmate 440 or a Butyl Rubber Gasket which meets MIL-C 18969B, Type II Class B, TT-C-1796 A, Type II Class B, and TTS-S-001657 must also pass UL 723.

2.3 DUCT CONSTRUCTION CLASSIFICATIONS

A. General: Construct and seal ductwork in accordance with SMACNA pressure classifications and seal classes listed for ductwork systems involved.

<table>
<thead>
<tr>
<th>System Description</th>
<th>Pressure Class, &quot;W.G.&quot;</th>
<th>Seal Class</th>
<th>Duct Material</th>
<th>Reference Spec. Section</th>
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<td>Supply Air Ducts (upstream terminal units)</td>
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<td>A</td>
<td>GSM</td>
<td>15840</td>
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<tr>
<td>System Description</td>
<td>Pressure Class, &quot;W.G.&quot;</td>
<td>Seal Class</td>
<td>Duct Material</td>
<td>Reference Spec. Section</td>
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<td>-------------------------------------------------------</td>
<td>------------------------</td>
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<td>-------------------------</td>
</tr>
<tr>
<td>(downstream terminal units or reheat coils)</td>
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<td>C</td>
<td>GSM</td>
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<tr>
<td>Exhaust Air Ducts (Toilet, etc)</td>
<td>-1</td>
<td>B</td>
<td>GSM</td>
<td>15840</td>
</tr>
</tbody>
</table>

KEY FOR THE ABOVE: W= ALL WELDED CONSTRUCTION. S= SHRINK FIT COUPLING
GSM= GALVANIZED SHEET METAL. PVS= PVC COATED SHEET METAL.

2.5  SHEET METAL PLENUMS

A. Construct single wall plenums and equipment casings in accordance with latest SMACNA standards except that sheet metal shall be 16 gauge minimum throughout. Sheet metal shall be in accordance with Article 2.2A.

2.5  ACOUSTICAL DUCT

A. Provide where shown on the Drawings.

B. Construction:
   1. Round duct with spiral lockseam construction.
   2. Outer shell to be solid with perforated inner liner.
   3. Provide acoustical material between inner and outer shells with a fiberglass cloth between inner shell and acoustical material. Acoustical material shall be 1 inch or 3 inches in depth as shown on Drawings.
   4. Pressure rating shall be 2 inches.

C. Product shall be United McGill Acoustic-K27 round duct or equal.

D. Outer shell shall comply with 15840, 2.2C when buried.

E. Inner liner shall comply with 15840, 2.2C when used for laboratory exhaust.

2.6  SEISMIC DUCT JOINT

A. Where shown on the Drawings and/or required due to building structural separations, provide flanged rubber joints made of chlorobutyl elastomer with polyester reinforcing fabric rated for 300 degrees F operating temperature, 3 psi air pressure, and 83 inches H2O vacuum.
B. Use General Rubber Corporation Series 3000, Style 1097 joints on rectangular duct and Style 1098 double bellow on round duct.

PART 3 - EXECUTION

3.1 FABRICATION

A. General: Fabricate ductwork in accordance with applicable SMACNA HVAC and Industrial Duct Construction Standards and ASHRAE handbooks unless more stringently specified or detailed.
   1. Construct ductwork to comply with Section 15840, Articles 1.3 and 1.4.
   2. Ductwork which is fabricated and installed without coordination is subject to removal and replacement at contractors cost. Coordination drawings are required to be prepared in accordance with Section 01040.
   3. Fabricated ductwork sections and fittings shall have an identification sticker applied at fabrication shop. Sticker shall indicate size and metal gauge of component.

B. Minor variation of duct configuration or size is permitted provided system resistance does not increase. See Article 3.1.L.

C. Complete metal ducts within themselves with no single partition between ducts. Open corners are not acceptable.

D. Lap metal ducts in direction of air flow. Hammer down edges and slips to leave smooth duct interior.

E. Fabricate tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on center line. Where rectangular elbows are used, provide turning vanes. All mitered elbows shall have single thickness turning vanes; dual wall airfoil type blades are not acceptable. Turning vanes shall be secure and stable in track. Track section shall be attached to fitting on each side with 2 sets of screws or bolts.

F. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Maximum divergence upstream of equipment to be 30 degrees and 45 degrees convergence downstream.

G. Rigidly construct metal ducts with joints mechanically tight, substantially airtight, braced and stiffened so as not to breathe, rattle, vibrate, or sag. Seal duct joints and connections with sealant as ducts are being assembled.

H. Provide necessary baffling in mixed air plenums to ensure good mixed air temperature.

I. Fabricate round and oval duct fittings with spiral or continuously welded seams. Joints shall be 2 inches slip type, cemented, brazed, electric welded, or with shrink bands. Prime coat welded joints. Fabricate elbows of 5-piece construction. Provide standard 45-degree takeoffs unless otherwise indicated.
J. Minimum size of access doors into plenums shall be 24 inches W by 60 inches H unless dimensioned otherwise on Drawings. Doors shall swing to seat with pressure gradient.

K. Coordinate ductwork systems layout with other trades prior to fabrication. Provide offsets, transitions and stream-liners as required to clear structural interferences and mechanical or electrical systems. Working plans do not indicate all fittings, offsets, transitions and stream-liners that are required to install ductwork systems.

L. Balancing dampers are required at every branch of all ductwork systems. Use of O.B.D.s in ceiling diffuser outlet, shall not be used for systems balance.

3.2 INSTALLATION

A. Duct System Pressure Class: Construct and install each duct system for the specific duct pressure classification indicated.

B. Provide openings in ductwork to accommodate thermometers and controllers. Provide pivot tube openings for testing of systems, complete with metal cam with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

C. Install ducts with the fewest possible joints.

D. Use fabricated fittings for all changes in directions, changes in size and shape, and connections.

E. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.

F. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install duct systems in shortest route that does not obstruct useable space or block access for servicing building and its equipment.

G. Mount duct-type smoke detectors on the ductwork under this Section of the Specifications. All mounting arrangements, holes cut into ductwork, sealing of openings along with ceiling and access doors for each duct-type detector shall be provided under this Section of the Specifications. Duct detectors along with all sampling tubes and accessories shall be furnished under Division 16.

H. Clean ductwork as it is installed to remove dirt and dust. During installation, close duct openings and open ends with temporary covers to keep construction dust out of duct systems.

I. Construct ductwork with sufficient clearance around equipment to allow normal operating and maintenance activities of equipment.

J. At each point where ducts pass through partitions, provide sleeves and seal joints around duct with noncombustible material. Refer to Section 15090.
K. Where manufactured duct joint systems such as "Ductmate" are employed, install components in strict accordance with the manufacturer's recommendations. Bolt-metal corner pieces. PVC clips are not allowed.

L. Install ducts and supports in accordance with SMACNA Standards. Adequately attach hangers to the building structure. Refer to Section 15090. For seismic joint crossings, refer to Section 15090. Vibration isolate ductwork as specified in Section 15211. Seismic restraint shall not short-circuit vibration isolation systems.

M. Prior to operation or test and balance, clean duct systems with high power vacuum machines. Protect equipment, which may be harmed by excessive dirt, with filters or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes spaced no more than 50 feet on center.

N. Shrink-Fit Coupling: Where specified, use joints in strict accordance with manufacturer's instructions. Raychem Thermofit wrap or equal.

O. Temporary sheet metal screws are not permissible at fire or smoke damper breakaway joints.

P. Ducts shall not be insulated prior to observation of sealed joints and for duct leak testing.

Q. Set plenum doors 6 inches to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

3.3 QUALITY ASSURANCE

A. Maximum Allowable Leakage: As described in ASHRAE 1993 Handbook, “Fundamentals” Volume, Chapter 32, Table 7 and Figure 10. Comply with requirements for leakage classification 3 for round and flat oval ducts, leakage classification 12 for rectangular ducts in pressure classifications less than and equal to 2 inches water gage (both positive and negative pressures), and leakage classification 6 for pressure classifications greater than 2 inches water gage and less than and equal to 10 inches water gage.

B. Remake leaking joints as required and apply sealants to achieve specified maximum allowable leakage.

C. Leakage Test: Perform volumetric measurements and adjust air systems as described in ASHRAE 1995 “HVAC Applications” Volume, Chapter 34, and Division 15 Section - Testing, Adjusting, And Balancing.

D. Owner’s Representative shall witness all leakage tests with 48 hours notice provided before any leak test or retest is conducted.

E. All leakage tests shall be documented and submitted for record within 72 hours after testing. Ductwork shall not be fully concealed or made inaccessible for repair until after Owner acceptance of leak test report.

END OF SECTION
PART 1 - GENERAL

1.1 DEFINITIONS
   A. Ductwork sizes on Drawings state inside clear dimensions.

1.2 REFERENCES
   A. Fabricate ductwork in accordance with latest edition of SMACNA HVAC Duct Construction Standards and ASHRAE handbooks unless more stringently detailed.
   B. Construct ductwork to conform to NFPA 90 A, NFPA 90 B, UL 181 Class 1, SBCC, ICBO and BOCA.

1.3 SUBMITTALS
   A. Submit in accordance with Division 1.
   B. Submit technical data, acoustical performance, UL 181 listing, and typical shop standards and/or SMACNA details including particulars such as joint details, and supporting methods prior to start of work.
   C. Submit written report confirming ductwork has been fabricated and installed in accordance with SMACNA Standards.
   D. Submit shop drawings of ductwork only when it is necessary to deviate from the intent of the design Drawings.

1.4 FLOW DIAGRAMS
   A. Predicated upon Project magnitude, Construction Documents may include flow diagrams as a part of the working Drawings. These flow diagrams are not for the purpose of giving physical dimensions or locations but rather to make clear the interconnections, by the duct systems, of the various units of the process. If an item is shown on either the flow diagram or the Drawings, but not on both, it will be assumed that the contractor has included such item in his estimate of the cost of the work and that he shall provide same.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS
   A. Insulated Flexible Duct:
      1. General Flex Corp., SLR-25M
      2. Thermaflex, M-KE
B. Acoustical Flexible Duct:
   1. Cody West NIL
   2. Casco Silent-flex II
   3. J Plamborn Type APF-07

2.2 MATERIALS

A. Insulated Flexible Duct:
   1. Insulated flexible duct acoustically designed to provide high insertion loss characteristics. Published flexible duct acoustical data shall be obtained in accordance with Air Diffusion Council Flexible Air Duct Test FD72R1, paragraphs 3.2.1, Sound Attenuation; 3.2.2, Sound Generation; 3.2.3, Radiated Noise Reduction. Duct shall be rated for 4000 FPM velocity minimum.
   2. Flexible ducts shall consist of an exterior reinforced metalized laminated vapor barrier, nominal 1-1/2 inches thick fiberglass insulation (K = 0.23 at 75 degrees F) with a 0.1 ASTM 96A perm rating, encapsulated zinc coated high carbon steel Helix and an impervious, smooth, nonperforated interior vinyl liner to shield the airflow from fiberglass erosion.
   3. Individual lengths of flexible ducts shall contain factory fabricated steel connection collars. Flexible ducts may be used to cross seismic joints without offsets.
   4. Construction in accordance with SMACNA flexible ductwork classification for minus 1 inch to 4 inches WG.

B. Acoustical Flexible Duct: Acoustical flexible duct shall be an insulated flexible duct acoustically designed to provide high insertion loss characteristics.
   1. Duct Shall Provide Insertion Loss Equal To or Greater Than the Following:

<table>
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<tr>
<th>OCTAVE BAND</th>
<th>1</th>
<th>2</th>
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<tr>
<td>Duct Diameter</td>
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<td>19</td>
<td>18</td>
<td>15</td>
<td>16</td>
<td>15</td>
</tr>
</tbody>
</table>

   2. Acoustical performance shall be determined in accordance with Air Diffusion Council Test Code FD-72 (or most recent revision).
   3. Duct shall be supplied with a minimum 1 inch fiberglass insulation blanket, an exterior vapor barrier with a perm rating of .10 ASTM E96-A, and a continuous full internal liner to shield the air flow from fiberglass erosion. Duct shall be rated for 4000 FPM velocity and minus 1/2 inch to plus 2 inches WG. Duct shall be provided with a factory
installed clamp on CC fittings on each end, designed for positive connection to oval or round outlets.

4. Duct Shall Conform to the Following Codes: UL-181, NFPA 90A and 90B, SBCC, ICBO, and BOCA.

2.2 DUCTWORK APPLICATION

A. Insulated Flexible Ductwork: Use for supply air ductwork connections to air devices and inlet ductwork connections to terminal units.

B. Acoustical Flexible Ductwork: Use for supply air connections to air devices except in laboratories.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Clean ductwork as it is installed to remove dirt and dust. During installation, close duct openings and open ends with temporary covers to keep construction dust out of duct systems.

B. Construct ductwork with sufficient clearance around equipment to allow normal operating and maintenance activities of equipment.

C. At each point where ducts pass through partitions, seal joints around duct with noncombustible material.

D. Connect diffusers, troffer boots, registers, and grilles to low pressure ducts with 5'-0" maximum length of flexible duct.

E. Independently support terminal devices connected by flexible duct.

F. Attach flexible duct to collars having a minimum length of 2 inches. Securely attach inner core to collar.

G. Insert collars into flexible duct a minimum of 1 inch and secure flexible duct to collar using a worm drive draw band.

H. Securely attach insulation and vapor barrier to the collar.

I. Support flexible duct at manufacturer's recommended intervals and at or near the mid-point of the duct length. Maximum permissible sag is 1/2 inch per foot of spacing between supports.

J. Provide 28 gauge steel formed hangers or saddles of sufficient width to prevent restriction of duct internal diameter when the weight of the supported section rests on the hanger or saddle. In no case will the material contacting the flexible duct be less than 2 inches wide. Narrower hanger material may be used in conjunction with a sheet metal saddle, which meets the aforementioned specifications. This saddle must be formed to cover 1/2 the circumference of the outside diameter of the flexible duct and must be rolled to fit neatly around the lower half of the duct's outer circumference.
K. To prevent tearing of vapor barrier, do not support entire weight of flexible duct on any one hanger during installation. Avoid contact of flexible duct with sharp edges of hanger material. Damage to vapor barrier may be repaired with system compatible tape. If internal core is penetrated, replace flexible duct or treat as a connection.

L. Factory-installed suspension systems integral to the flexible duct are an acceptable alternative hanging method when manufacturer's recommended procedures are followed.

M. Install ducts and supports in accordance with SMACNA Standards. Adequately attach hangers to the building structure. Refer to Section 15090.
SECTION 15860

DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submit in accordance with Division 1.
B. Submit shop drawings of factory-fabricated assemblies.
C. Submit manufacturer's printed installation instructions.
D. Submit damper manufacturer's printed instructions for metal stud framing for fire dampers in fire rated drywall partitions.
E. For each type of fire damper and combination fire-smoke damper, provide a field mock-up installation assembly complete with wall framing, wallboard, wall opening filler pieces, perimeter mounting angles, sleeve, breakaway duct connections, and access door. Obtain Architect's approval of mock-up prior to starting damper installation.
F. Provide a field mock-up smoke damper installation complete with damper operator, linkage, limit switch, and access door. Obtain Architect's approval of mock-up prior to starting smoke damper installation.

1.2 QUALITY ASSURANCE

A. Construct and test fire dampers in accordance with UL Standard 555. Each fire damper shall have a 1-1/2 or 3 hour UL fire protection rating, as required, and shall include a UL label in accordance with established UL labeling procedures.
B. Construct fire damper fusible links to UL Standard 33, Fusible Links for Fire Protection Service, for service intended.
C. Demonstrate resetting of fire dampers to authorities having jurisdiction and Owner's representative.
D. Smoke dampers shall be classified by UL as a leakage rated damper for use in smoke control systems, under UL 555 S, and shall bear a UL label attesting to same.
E. The Owner reserves the right to test all constant volume valves for performance. If they do not meet specifications, the valves shall be sent back to the manufacturer and replaced at the manufacturer's expense.

1.3 REFERENCES

A. Accessories shall meet the requirements of NFPA 90 A and NFPA 101, as applicable.
B. Fabricate in accordance with ASHRAE handbooks and SMACNA duct manuals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Fire Dampers:
   1. Air Balance
   2. Greenheck
   3. Phillips
   4. Prefco
   5. Ruskin

B. Smoke Dampers:
   1. Air Balance
   2. Greenheck
   3. Johnson Controls
   4. Phillips
   5. Prefco
   6. Ruskin

C. Combination Fire/Smoke Dampers:
   1. Air Balance
   2. Greenheck
   3. Phillips
   4. Prefco
   5. Ruskin

D. Control Dampers:
   1. Johnson Controls
   2. Greenheck
   3. Ruskin

E. Balancing Dampers:
   1. Air Balance
   2. Greenheck
   3. Phillips
   4. Ruskin
   5. Contractor fabricated

F. Access Doors - Ductwork:
   1. Ductmate
   2. Milcor
   3. Ruskin
   4. Contractor fabricated

G. Sound Attenuators:
   1. Industrial Acoustics
   2. Rink
2.2 CURTAIN TYPE FIRE DAMPERS

A. Construction: Galvanized or stainless steel, with blades weighted to close and lock in closed position when released by fusible link. Dampers shall have UL label consistent with fire rating of the partition in which they are installed.

B. Configuration: Vertical or horizontal, as predicated by installation location. Retain curtain-type blades in a recess to maintain connecting ductwork free area.

C. Release: Set or select fusible links for 212 degrees F.

D. One and One-half Hour Rating Dampers: Ruskin 1BD2, Style B or C for rectangular ducts; Ruskin IBD2, Style CR for round ducts.

2.3 SMOKE DAMPERS

A. General:
1. Provide smoke dampers at air handling unit supply and return ducts, in outside air ducts of units capable of 100 percent OA operation, and in smoke partitions in accordance with NFPA 90 A and NFPA 101. Refer to Drawings.
2. Each damper shall be classified by Underwriter's Laboratories as a leakage rated damper for use in smoke control systems under the latest version of UL Standard 555 S, and shall bear a UL label attesting to same. Damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes. Having a single damper size tested and UL qualified is not acceptable. The leakage rating under UL 555 S shall be no higher than leakage class II (10 CFM/sq ft at 1 inch wg).
3. As part of the UL qualification, smoke dampers shall have demonstrated a capacity to operate (to open and close) under HVAC system operating conditions, with pressures of at least 4 inch wg in the closed position, and 3500 fpm air velocity in the position for normal operation.
4. Dampers and their operators shall be qualified under UL 555 S to an elevated temperature of 250 degrees F with pneumatic operators. Operators shall be installed by the damper manufacturer at time of fabrication. The assembly shall meet UL 555 S qualifications for dampers and operators.
5. Operators shall be pneumatic type operating on 20 psi instrument air pressure of the spring return type such that damper will be closed upon power interruption.
6. Provide damper limit switches for interlocking purposes, which shall activate when the damper is in the 100 percent open position.

B. Rectangular Dampers:
1. Blades shall be airfoil-shaped, double skin, with 14 gauge equivalent thickness, maximum 6 inches wide, having shafts/bearings designed to meet temperature requirements and minimum 3-1/2 inches by 16 gauge galvanized channel frame. Seal blade edges with silicone rubber and jamb with flexible metal compression.
2. The pressure drop for a 24 inch by 24 inch damper handling 8500 CFM shall be 0.08 inch wg or less under standard air conditions.
3. Dampers shall be Ruskin SD60 or Johnson Controls SD-1300.

C. Round Dampers:
   1. Blades shall be 14 gauge galvanized steel having shafts/bearings designed to meet
dynamic and temperature requirements and 18 gauge reinforced galvanized steel frame
10 inch long. Seals shall be silicone rubber, sandwiched between blade discs.
   2. Pressure drop for a 12 inches diameter damper handling 2500 CFM shall be
0.10 inch wg or less under standard air conditions.
   3. Dampers shall be Ruskin SDRS25.

2.4 COMBINATION FIRE/SMOKE DAMPERS

A. General:
   1. Provide combination fire/smoke dampers at fire rated/smoke partitions and walls in
 accordance with NFPA 90 A and NFPA 101. Refer to Drawings.
   2. Each combination fire/smoke damper shall be 1-1/2 hour fire rated under UL 555 S, and
 further classified by Underwriter's Laboratories as a leakage rated damper for use in
 smoke control systems under the latest version of UL 555 S, and bear a UL label
 attesting to same. Damper manufacturer shall have tested, and qualified with UL, a
 complete range of damper sizes. Having a single damper size tested and UL qualified is
 not acceptable. The leakage rating under UL 555 S shall be no higher than Leakage
 Class II (10 CFM/sq ft^2 at 1 inch wg).
   3. As part of the UL qualification, dampers shall have demonstrated a capacity to operate
 (open and close) under HVAC system operating conditions, with pressures of at least 4
 inches wg in the closed position, and 3500 fpm air velocity in the open position.
   4. Dampers and their operators shall be qualified under UL 555 S to an elevated
 temperature of 250 degrees F with pneumatic operators. Operators shall be installed by
 the damper manufacturer at time of fabrication. The assembly shall meet UL 555 S
 qualifications for dampers and operators.
   5. Operators shall be 2-position pneumatic type operating on 0 and 20 psi instrument air
 pressure. Provide spring-return, fail closed type operators that close damper upon
 power interruption. Damper operators shall be UL listed as fire damper operators, and
 shall bear the appropriate UL operator label.
   6. Provide damper limit switches for interlocking purposes to activate when the damper is
 in the 100 percent open position.
   7. Furnish each combination fire/smoke damper with a factory sleeve of length and gauge
 required for satisfactory installation, with damper operator and limit switch factory
 installed on exterior sleeve and properly linked to damper operating shaft. Mount
 operator and switch outside of the firewall to prevent interference with rated installation
 retaining angles.
   8. Equip each combination fire/smoke damper with a fusible link, which melts at
 212 degrees F causing damper to close and lock in a closed position.

B. Rectangular Dampers:
   1. Provide airfoil-shaped, double skin blades, with 14 gauge equivalent thickness,
 maximum 6 inches wide, having shafts/bearings designed to meet temperature
 requirements. Provide 5 inches by 16 gauge galvanized channel frame. Seal blade
 edges with silicone rubber and jamb with flexible metal compression.
   2. The pressure drop for a 24 inches by 24 inches damper handling 8500 CFM shall be
 0.08 inch wg or less under standard air conditions.

15860 – 4
DUCT ACCESSORIES
NOAO Spectrograph
KITT Peak WIYN
Revision 0 – July 11, 2017
3. Dampers shall be Ruskin FSD60 with fusible link.

C. Round Dampers:
   1. Construct dampers similar to rectangular dampers except with sleeve and connection for round ducts.
   2. Dampers shall be Ruskin FSD60 with round connection style CR and with fusible link.

2.5 CONTROL DAMPERS

A. General:
   1. Provide control dampers with parallel or opposed blades to suit application.
   2. Provide quarter turn spring return pneumatic operator with electro-pneumatic positioner, 4 to 20 mA dc input, as manufactured by Hy-Tork/E.S.M.E. Coordinate with control subcontractor for operators, control accessories, and sequence of operation.

B. Rectangular Dampers:
   1. Provide airfoil-shaped, double skin blades, with 14 gauge equivalent thickness, maximum 6 inches wide, having shafts/bearings designed to meet temperature and maximum velocity (3500 fpm) requirements. Provide minimum 3-1/2 inches by 16 gauge galvanized channel frame. Seal blade edges with extruded vinyl and jamb with flexible metal compression.
   2. The pressure drop for a 24 inches by 24 inches damper handling 8500 CFM shall be 0.08 inch wg or less under standard air conditions.
   3. Dampers shall be Ruskin CD60 with fusible link.

C. Round Dampers:
   1. Construct blades with 2 layers galvanized steel 14 gauge equivalent thickness, neoprene seals sandwiched between blade sheets, and shafts/bearings designed to meet dynamic and temperature requirements. Provide 12 gauge reinforced galvanized steel frame, neoprene sandwiched between blade sheets.
   2. Pressure drop for a 12 inches diameter damper handling 2500 CFM shall be 0.10 inch wg or less under standard air conditions.
   3. Dampers shall be Ruskin CDRS-25.

D. Exhaust Fan Round Isolation Dampers:
   1. Rolled, steel channel frame with through bolt holes.
   2. Steel blade, stiffened as required. Plate thickness not less than 1/4 inch. Neoprene blade seal retained by seal ring bolted to blade.
   3. Continuous steel axle, angle reinforced as required. Extend shaft to accommodate required operator.
   4. Grease lubricated ball bearings externally mounted with adjustable packing gland.
   5. Bonded, industrial epoxy enamel.
   6. When closed, leakage shall not exceed 0.029 cfm/inch blade circumference at a pressure differential of 10 inches w.g.
   7. Dampers shall be Ruskin CDR 192.

2.6 BALANCING DAMPERS

A. General:
   1. Provide dampers throughout the duct systems to facilitate complete balancing.
2. Dampers may be vendor purchased or contractor fabricated.

B. Rectangular Dampers With Either Width or Height Dimension Less Than 24 inches:
   1. Butterfly type dampers with 18 gauge galvanized steel or duct casing angle reinforced as required.
   2. Provide single thickness 16 gauge minimum, galvanized steel blades, welded or bolted to 1/2 inch minimum diameter through shaft. Permanently mark end of shaft to indicate blade position and fit with a locking quadrant mounted on outside of frame. Bearings shall be pressed into frame and designed for dynamic requirements.

C. Rectangular Dampers With Both Width and Height Dimensions Greater Than 24 inches:
   1. Frame, 5 inches by 1 inch, 16 gauge galvanized steel channel. Blades, 8 inches maximum width, 16 gauge galvanized steel, opposed blade, having shafts/bearings designed to meet dynamic requirements, positively locked to shafts.
   2. Control shaft shall be 3/8 inch square, plated steel, permanently marked to indicate blade position, and fitted with locking quadrant mounted on outside of frame.
   3. Pressure drop for a 28 inches by 28 inches damper handling 7600 CFM shall be 0.05 inch wg or less under standard air conditions.
   4. Dampers shall be Ruskin MD-35.

D. Round Dampers Up to 24 inches Diameter:
   1. Frame shall be 18 gauge galvanized steel, or duct casing reinforced.
   2. Provide single thickness 16 gauge galvanized steel blades, welded or permanently bolted to 1/2 inch minimum diameter through shaft. Permanently mark end of shaft to indicate blade position and fit with a locking quadrant mounted on outside of frame. Bearings shall be pressed into frame and designed for dynamic requirements.

E. Identification: Provide 1 inch wide nylon ribbon for each damper, color as follows: supply air, red; return air, blue; exhaust air, yellow. Tie through hole at end of damper quadrant, leaving at least 12 inches of ribbon hanging free. Attach ribbons at the time each damper is installed.

2.7 ACCESS DOORS - DUCTWORK

A. Construction: Close fitting rigid galvanized steel assemblies with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum 1 inch thick insulation with sheet metal cover.

B. Locking Devices: Provide 2 hinges and 2 sash locks or 2 spring loaded threaded knobs and bolts for sizes up to 18 inches square; 2 hinges and 2 compression latches with outside and inside handles for sizes up to 24 inches by 48 inches. Provide an additional hinge for larger sizes.

C. Option: Doors may be vendor purchased or contractor fabricated.

2.8 SOUND ATTENUATORS

A. Sound Attenuators: Construct in accordance with NFPA 90A standards. Provide outer casings and internal perforated sheet metal not less than 22 gauge and comply with high velocity ductwork recommendations of the current ASHRAE Guide.
B. Acoustical Fill Materials: Acoustical quality glass fiber packed behind partitions to eliminate voids caused by material settling. Where hospital sound attenuators are required, provide an impervious liner, suitable for hospital applications and in compliance with NFPA 90A and UL 181, between the acoustical fill and the air stream. Provide airtight construction, leak proof against a differential pressure of 8 inches wg.

C. Losses: Refer to Drawings for minimum insertion loss, maximum static pressure loss, and maximum self-generated noise schedule.

D. Testing: A fully independent testing firm shall provide documentation and test results certifying compliance with specifications herein. Standard module testing shall be conducted in accordance with industry standards. The sound attenuator shall be acoustically tested with metal inlet and outlet duct sections while under the rated air flow conditions. The noise reduction data shall include the effects of flanking paths and vibration transmission. Test results shall be certified by the testing agency and be made available to the Architect for approval. The test results shall include a complete description of test conditions and measurement procedure.

E. Packaging: Sound attenuators shall be blown clean, bagged, and sealed for shipment. Do not remove attenuators from original cartons until ready for installation.

F. Sound attenuators in exhaust systems shall be constructed of materials suitable for the intended application including potential exposure to corrosive materials.

2.9 PRESSURE INDEPENDENT CONSTANT VOLUME VALVE

A. Construction: 16 gauge spun aluminum valve body, continuous welded seam, with baked on meresite. 316L stainless steel shaft, solid Teflon shaft bearings.

B. Pressure Independent Cone Assembly: Maintain the cfm set point constant over a static pressure drop range of 0.6 to 3.0 inches wc. No single point airflow or velocity pressure sensors shall be employed.

C. Flow Control: Factory set to desired airflow, which shall be maintained to plus or minus 5 percent of the specified air quantity.

2.10 FLEXIBLE CONNECTIONS

A. Fabricate of neoprene coated flameproof fabric tightly crimped into metal edging strip and attach to ducting and equipment by screws or bolts at 6-inch intervals. Flexible duct connections shall be provided with a sufficient material width to prevent interference with free operation of fan vibration isolation systems.

2.11 APPLICATION

A. Access Doors: Provide for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, smoke dampers, and combination fire/smoke dampers. Review locations prior to fabrication. Doors shall be square, sized to 3/4 of the larger of the duct width or height, but no smaller than 8 inches by 8 inches nor no larger than 24
inches by 24 inches. Provide 4 inches by 4 inches quick-opening duct access doors for inspection at balancing dampers.

B. Fire Dampers: Provide at locations, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Provide fire dampers complete with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings, and hinges.

C. Balancing Dampers, Low Pressure: Provide balancing dampers at all points where supply, return, and exhaust system submains, branch mains and branches are taken from larger ducts, and as shown in typical details, Drawings, and diagrams.

D. Balancing Dampers, Medium and High Pressure: Provide balancing dampers on systems as shown in typical details, Drawings, and diagrams. Do not use splitter dampers except where specifically indicated on Drawings.

E. Flexible Connections: Provide immediately adjacent to equipment in ducts associated with fans and equipment subject to forced vibration. In addition, provide flexible connections where ductwork crosses building expansion joints and where ductwork crosses separations between new and existing construction.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install items in accordance with manufacturer's printed instructions and SMACNA standards.

B. Sound attenuators shall be supported from structural members. No rigid connection shall exist between sound attenuators and partitions, walls, ceilings, etc.

C. For connections to medium and high-pressure fans, install 1/8-inch thick neoprene pad over fabric and hold in place with additional metal strips.

D. Locate duct access doors for easy access. Locate doors above accessible ceilings whenever possible. Coordinate locations of ceiling access doors with ceiling installer and with other trades such that conduit and pipe does not prevent or interfere with access to ductwork. Refer to Section 15010 for access door requirements in ceilings and walls.

E. Install fire dampers, smoke dampers, and combination fire/smoke dampers in accordance with manufacturer's printed installation instructions including provisions for any supplementary framing and blocking of metal or wood studs in drywall partitions. Coordinate requirements for this work with Division 9. Costs of all such supplemental framing shall be borne by this contractor. Placement of framing units shall remain work of Division 9.

F. Mount damper operators, control devices, thermometers, and gauges upon extension brackets or devices to prevent interference with insulation or vapor barrier integrity.

G. Constant volume valves to be field adjustable to any desired flow by manually positioning pivot arm.
SECTION 15870
AIR DEVICES

PART 1 - GENERAL

1.1 SUMMARY
A. Section includes grilles, diffusers, particulate control systems, and roof hoods associated with air distribution systems.

1.2 SUBMITTALS
A. Submit in accordance with Division 1.
B. Submit product data and shop drawings covering each item together with schedule of air devices.
C. Submit manufacturer's installation instructions.

1.3 QUALITY ASSURANCE
A. Make airflow tests and sound level measurements in accordance with applicable ADC equipment test codes and ASHRAE standards.
B. Manufacturer shall certify cataloged performance and ensure correct application of air device types.

1.4 COORDINATION
A. Review requirements of air devices as to size, finish, and type of mounting prior to submitting shop drawings and air device schedules.
B. Check location of outlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS
A. Air Devices:
   1. Krueger
   2. Titus (except perforated face diffusers)
   3. Tuttle & Bailey (except perforated face diffusers)
   4. Price Industries
   5. Anemostat

B. Air Distribution and Airborne Particulate Control System:
   1. Krueger Steriflo or Total Air Diffusion (TAD)
2. Spec Systems Air Curtain Model AC
3. Precision Air

C. Roof Hoods:
   1. Greenheck
   2. Jenn-Air
   3. Loren Cook
   4. Penn
   5. Vent Products Inc.

D. Perforated Duct Air Outlets: United McGill.

2.2 GENERAL REQUIREMENTS

A. Rate units in accordance with ADC standards.

B. Base air device application on space noise level of NC 35 maximum.

C. Provide supply devices with sponge rubber seal around edges.

D. Provide baffles to direct air away from walls, columns, or other obstructions within radius of diffuser operation.

E. Provide air device frames compatible with adjacent finish surfaces involved. Refer to Drawings and reflected ceiling plans.
   1. In Modular Ceilings: Snap-in T-bar, inverted T-bar or spline type as required.
   2. For Perforated Face Devices in Hard Ceilings: Curved, surface mounted.
   3. For All Other Devices in Hard Ceilings or Walls: Flat face frames, with 1-1/4 inches wide margins and countersunk screws.
   4. Diffusers in Rough-textured Ceilings such as Acoustical Plaster: Provide antimudger frames.
   6. Devices in Concrete Floors: Cast-mounting frames in place.

F. Construction Change: Change aluminum air devices to all steel construction when utilized in conjunction with ceiling type fire dampers. Since ceiling type fire dampers are capable of balancing airflow, omit opposed blade dampers.

G. Performance: Refer to Drawings for air device types, sizes, and capacities.

2.3 SUPPLY GRILLES

A. Construct grilles using minimum 20 gauge extruded aluminum frames and individually adjustable streamlined vanes spaced on 3/4-inch centers. Keep vanes under tension to maintain set points.

2.4 INDUSTRIAL SUPPLY GRILLES

A. Construct grilles using minimum 20 gauge extruded aluminum frames and individually adjustable streamlined blades. Keep vanes under tension to maintain set points.
2.5 LINEAR SUPPLY GRILLES

A. Construct grilles using extruded aluminum components consisting of frame and fixed 1/8 inch by 3/4-inch grille bars.

2.6 LINEAR SUPPLY DIFFUSERS

A. Diffusers: Construct of extruded aluminum, incorporating fully adjustable air pattern and flow control vanes capable of deflecting air from full horizontal to straight down or at any intermediate setting.

B. Airflow Rate: Variable, without changing the air pattern. Provide vanes capable of controlling air patterns and flow rates without the use of an additional damper.

C. Assembly: Install each length of diffuser without any visible means of fastening. Assemble multiple lengths with concealed aligning devices. Provide appropriate end caps.

D. Diffuser Fastening Methods: Compatible with ceiling type used.

E. Boots: TBSI insulated, provide where applicable for 1 or 2 slot diffusers in T-bar ceilings.

2.7 SQUARE OR RECTANGULAR DIFFUSERS

A. Construct diffusers of welded steel square or rectangular, assembled in a louvered pattern with a 1, 2, 3, or 4 way throw, with each side delivering proportional air quantities to space. Provide removable cores.

2.8 PERFORATED FACE DIFFUSERS

A. Construct diffusers of welded steel, with a removable perforated faceplate having concealed hinges and latches, removable diffuser core having curved adjustable blades capable of delivering air in 1, 2, 3, or 4-way pattern.

2.9 RETURN AND EXHAUST GRILLES

A. Construct grilles with extruded aluminum frames and stationary vanes spaced on 3/4-inch centers.

2.10 GRID CORE RETURN AND EXHAUST GRILLES

A. Construct grilles with extruded aluminum frames and grid core.

2.11 LINEAR RETURN OR EXHAUST GRILLES

A. Construct grilles with extruded aluminum frames and fixed 1/8 inch by 3/4-inch grille bars.

2.12 PERFORATED RETURN OR EXHAUST GRILLES
A. Construct grilles of steel, with removable perforated faceplate having concealed hinges and latches.

2.13 DOOR GRILLES

A. Grilles: Construct using extruded aluminum double frames and V-shaped nonvision deflecting vanes spaced on 1/2-inch centers.

B. Double Frames: 1-1/4 inches margins, adjustable to fit door thicknesses from 1-3/8 inches to 2 inches.

2.14 ROOF HOODS

A. Air Inlet or Exhaust Hoods: Provide removable hood, curb flange and 1/2 inch mesh galvanized steel bird screen.

B. Fabrication: Galvanized steel, minimum 16 gauge base and 20 gauge hood, or aluminum, minimum 16 gauge base and 18 gauge hood, suitably reinforced.

C. Curb: Minimum 12 inches high with insulation between duct and curb.

D. Finish: Factory baked enamel. Final finish shall be selected by Architect.

2.15 GOOSENECKS

A. Fabrication: Minimum 18 gauge galvanized steel, in accordance with SMACNA standards.

B. Curb: Minimum 12-inch high curb base where size exceeds 9 inches by 9 inches.

C. Finish: Prime coat and finish with corrosion resistant epoxy paint, color selected by Architect.

2.16 PERFORATED DUCT AIR OUTLETS

A. Construct units of galvanized sheet steel, similar to manufactured round duct, circular cross-section, with perforations located within a portion of the circumference. Provide with or without a rotating damper as scheduled on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install items in accordance with manufacturer's printed instructions.

B. Paint ductwork visible behind air outlets matt black.

END OF SECTION
SECTION 15880
AIR FILTERS

PART 1 - GENERAL

1.1 SUMMARY
A. Section includes filters, housings, and gauges required to meet specific air quality criteria.

1.2 SUBMITTALS
A. Submit shop drawings and product data in accordance with Division 1.
B. Submit manufacturer's installation instructions.
C. Submit written confirmation that new filters have been installed throughout the Project prior to final acceptance.

1.3 QUALITY ASSURANCE
A. Provide filter media that is UL 900, Class 1 listed and approved by local authorities.
B. All filter efficiencies shall be in accordance with ASHRAE Standard 52-76.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS
A. Prefilters:
   1. Airguard Industries, Inc.
   2. American Air Filter
   3. Farr
   4. Koch
   5. Purolator

B. Final Filters - Rigid Type:
   1. Airguard Industries, Inc.
   2. American Air Filter
   3. Donaldson
   4. Farr
   5. Luwa
   6. Purolator

C. Final Filters - Bag Type:
   1. American Air Filter
   2. Donaldson
   3. Farr
   4. Flanders
5. Koch
6. Purolator

D. HEPA Filters:
1. American Air Filter
2. Donaldson
3. Farr
4. Flanders

E. Activated Carbon Filters:
1. Donaldson
2. Barneby & Sutcliffe
3. Extraction Systems
4. Farr
5. Flanders

F. Filter Gauges:
1. Davis
2. Dwyer

G. Housings:
1. Air Seal
2. American Air Filter
3. Farr

H. Assemble filter components to form filter banks from products of one manufacturer.

2.2 PERFORMANCE

A. Size, media face area, test efficiency, initial and final air resistance shall be as scheduled on the Drawings.

2.3 PREFILTERS

A. Air filters shall be 2 inches deep, medium efficiency, pleated media, and disposable panel type. The filter media shall be self-extinguishing nonwoven cotton and synthetic fibers. The filter media shall be bonded to a 28-gauge corrosion resistant, expanded metal support grid with a 95 percent open face area. The media grid assembly shall be bonded to all interior surfaces of the heavy duty, high wet strength beverage board frame. Filters shall have a rated average efficiency of 25 to 30 percent and an average arrestance of 90-93 percent when tested in accordance with ASHRAE 52-76 Test Standard. The filter shall be listed and rated by the Underwriter Laboratories, Inc. as Class 2.

B. 1 inch: There shall be a minimum of 16 pleats per lineal foot and shall contain not less than 2.3 sq ft of effective filtering media per sq ft of face area. The filter shall be capable of operating at face velocities of up to 500 FPM with an initial resistance not to exceed .40-inch w.g.

C. 2 inches: There shall be a minimum of 15 pleats per lineal foot and shall contain not less than 4.6 square feet of effective filtering media per square feet of face area. The filter shall be
capable of operating at face velocities of up to 500 FPM with an initial resistance not to exceed .26-inch w.g.

D. 4 inches: There shall be a minimum of 13 pleats per lineal foot and shall contain not less than 7.0 square feet of effective filtering media per square feet of face area. The filter shall be capable of operating at face velocities of up to 625 FPM with an initial resistance not to exceed .28-inch w.g.]

2.4 FINAL FILTERS - RIGID TYPE

A. Air filters shall be high efficiency, deep pleated, disposable, rigid cell type. The filter media shall be a high loft blanket composed of randomly oriented ultra fine glass fibers laminated to a nonwoven backing continuously bonded to a heavy duty, 28 gauge, corrosion resistant, galvanized steel, expanded metal grid with an open face area of not less than 95 percent. The media grid assembly shall be bonded to all interior surfaces of the enclosure frame. The support grid shall be formed into a wedge configuration to optimize usage of the filter media. Diecut pleat spacers shall be permanently installed. Filters shall be listed and rated by Underwriter's Laboratories, Inc., as Class 2. Filters shall have an average atmospheric dust spot efficiency of 95 percent.

B. Air filters shall be of rigid structure consisting of 4 "V" shaped cells incorporating a mini pleat cellular design. The filter medium shall be nonshedding, wet-process, glass fiber paper. A polyurethane sealant shall be used to encapsulate the media to the filter casing preventing any bypass.

C. Filters shall be capable of operating to a final pressure resistance of 6 inches water gauge without showing any structural damage.

D. The filter shall be capable of withstanding 100 percent relative humidity. The filter shall not support combustion and be classified UL 900 Class II.

2.5 ASHRAE FILTER HOUSING

A. Final Filter Housings: Shall be constructed of not less than 16 gauge-galvanized steel, equipped with polyurethane foam gaskets, fasteners, and filter centering dimples. Secure flush mitered sealing corners to for a uniform sealing and gasketing surface. Provide in-line depth of not less than 2.69 inches to effect adequate bearing surface for filter banks. Filter fasteners shall be capable of being installed without requiring tools, nuts, or bolts.

B. Prefilter Housings: Panel type, provided on inlet side of intended media filters.

2.6 HEPA FILTERS

A. Standard Capacity: Filter media shall be composed of a continuous sheet of glass microfiber, waterproofed to withstand a 100 percent RH factor and shall not contain asbestos. Filter media is available to comply with MIL F-51079 (latest issue).

B. High Capacity 2000 CFM: Filter media shall be composed of a high alpha, modified matrix, 100 percent microglass media, waterproofed to withstand a 100 percent RH factor and shall not contain asbestos.
C. Filters shall be factory constructed by using closely spaced low fluted aluminum separators between the pleated media. Adhesive sealers shall be fire retardant rubber base and fire retardant urethane. The media pack shall be permanently sealed within a rigid 3/4 inch high density zinc coated steel filter frame. Filter frame corners shall be rabbeted, glued, and double stapled. Overall dimensions shall be correct to within plus or minus 1/8 inch and squareness to be within 1/8 inch. Each filter to be supplied with a SCE 43 closed cell neoprene gasket on the downstream filter face.

D. Each filter shall be individually tested and certified on the manufacturer’s Q107 penetrometer to have an efficiency of not less than 99.97 percent or 99.99 percent when tested with 0.3 micron thermally generated DOP smoke. Testing of efficiency and resistance to air flow are performed per MIL Std. 282 at nominal rated capacity (CFM as listed in Paragraph 1.2.1 of MIL F-51068 (latest issue). Test results shall be recorded on each filter. Clean filter static pressure drop shall be no greater than 1 inch w.g. when operated at rated capacity.

2.7 HEPA FILTER HOUSING

A. HEPA Filter Housings: Shall be constructed of not less than 14 gauge-galvanized steel with 1 inch wide flanges on both sides of filters, providing a flush exterior. Provide access doors having closed cell neoprene rubber gasketing and positive pressure latches on both sides of housing. Seal entire filter face periphery against its respective gasket surface. Provide 3/4 inch wide closed cell hollow core neoprene rubber gaskets. Provide sealing pressure through positive pressure spring loaded locks. Factory leak test housing at 3 inches w.g.

2.8 FILTER GAUGES

A. Provide 3-1/2 inches diameter diaphragm activated gauges to measure airflow resistance through each media filter bank. Provide with white dial, black figures and zero pointer adjustment. Include static pressure tips, tubing, and mounting hardware.

B. Performance: Provide gauges with normal system operating pressure occurring at the mid-point of the scale and indicate maximum allowable pressure by a red line marking on the gauge face.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All filter banks shall be constructed and assembled to prevent passage of unfiltered air. Provide appropriate felt, rubber, or neoprene gaskets as necessary.

B. Fan systems shall not be operated unless all filter banks are in place. At Substantial Completion, prior to final approval, all filters used during construction, shall be removed and replaced with new filters throughout.

C. After new filters have been installed in place, a second complete set of filters, in original cartons, shall be provided to the Owner for future use.
END OF SECTION
PART 1 - GENERAL

1.1 SUMMARY

A. Furnish a totally native BACnet-based system, including a Microsoft Vista compatible operator’s workstation. The operator’s workstation, all building controllers, application controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135–2008, BACnet. In other words, all workstations and controllers, including unitary controllers, shall be native BACnet devices. No gateways shall be used for communication to controllers installed under this section. Gateways may be used for communication to the Lakeshore system or to systems installed under other sections.

B. The building does not have an existing controls system and shall be provided with a new complete system with open protocol BACnet for the HVAC control system provided.

C. Provide all necessary BACnet-compliant hardware and software to meet the system’s functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.

D. Prepare individual hardware layouts, interconnection drawings, and software configuration from project design data.

E. Implement the detailed design for all analog and binary objects, system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.

F. Design, provide, and install all equipment cabinets, panels, data communication network cables needed, and all associated hardware.

G. Provide and install all interconnecting cables between supplied cabinets, application controllers, and input/output devices.

H. Provide and install all interconnecting cables between all operator’s terminals and peripheral devices (such as printers, etc.) supplied under this section.

I. Provide complete manufacturer’s specifications for all items that are supplied. Include vendor name of every item supplied.

J. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, startup, and commissioning.

K. Provide a comprehensive operator and technician training program as described herein.

L. Provide as-built documentation, operator’s terminal software, diagrams, and all other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.

M. Provide new sensors, dampers, valves, and install only new electronic actuators. No used components shall be used as any part or piece of installed system.

N. Digital control system.

O. Control devices, components, wiring and material.

P. Owner Training.

Q. Any of the above may be referenced herein as "Instrumentation and Control System" or "I&C."

R. Warranty, guarantee, and extended service contract responsibilities.

1.2 INSTRUMENTATION AND CONTROL SYSTEM CONTRACTOR
A. The control contractor shall have a local office within 100 miles of the Job Site, staffed with trained personnel capable of providing instruction and maintenance service on system components. A 5 year experience record in the design and installation of building systems similar in performance to this Project is required.

B. Formal software licensing agreements will not be considered.

1.3 SYSTEM DESCRIPTION

A. A distributed logic control system complete with all software and hardware functions shall be provided and installed. System shall be completely based on ANSI/ASHRAE Standard 135-2008, BACnet and achieved listing under the BACnet Testing Laboratories BACnet - Advanced Workstation Software (B-AWS). This system is to control all mechanical equipment, including all unitary equipment such as VAV boxes, heat pumps, fan-coils, AC units, etc., and all air handlers, boilers, chillers, and any other listed equipment using native BACnet-compliant components. Non-BACnet-compliant or proprietary equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.

B. Operator’s workstation software shall use Microsoft Windows 7, Microsoft Windows 8, or Microsoft Windows 10 as the computer operating system. The Energy Management and Control System (EMCS) application program shall be written to communicate specifically utilizing BACnet protocols. Software functions delivered on this project shall include password protection, scheduling (including optimum start), alarming, logging of historical data, full graphics including animation, after-hours billing program, demand limiting, and a full suite of field engineering tools including graphical programming and applications. Systems using operating systems other than that described above are strictly prohibited. All software required to program application specific controllers and all field level devices and controllers will be left with the owner. All software passwords required to program and make future changes to the system will also become the property of the owner. All software required to make any program changes anywhere in the system, along with scheduling and trending applications, will be left with the owner. All software passwords required to program and make future changes to schedules, trends and related program changes will also become the property of the owner. All software required for all field engineering tools including graphical programming and applications will be left with the owner. All software passwords required to program and make future changes to field engineering tools, including graphical programming and applications will be left with the owner.

C. Building controllers shall include complete energy management software, including scheduling building control strategies with optimum start and logging routines. All energy management software and firmware shall be resident in field hardware and shall not be dependent on the operator’s terminal. Operator’s terminal software is to be used for access to field-based energy management functions only. Provide zone-by-zone direct digital logic control of space temperature, scheduling, runtime accumulation, equipment alarm reporting, and override timers for after-hours usage.

D. Room sensors shall be Lakeshore PT102-AL with Lakeshore 240 sensor input module that integrates into the new controls system NOTE: the lake shore sensors are only probes, they have no adjustability, adjustment is achieved from the PLC interface.
E. All application controllers for every air handler, all central plant equipment, and any other piece of controlled equipment shall be fully programmable. Application controllers shall be mounted next to controlled equipment and communicate with building controller through BACnet LAN.

1.4 APPROVED MANUFACTURERS
A. The base bid shall be the Ascent Compass system from Alerton. Other manufacturers may bid based upon meeting all requirements of the specification and receiving approval from the engineer 30 days prior to bid. A paragraph-by-paragraph comparison of based bid specified system versus alternative system—along with three references of similar 3rd party integration projects (include project name, contact, phone number, location, consultant, value of contract, and a brief description of the control system and how it operates)—shall be submitted 45 days prior to bid for review process. If approved, other manufacturers’ bids shall be shown as an add or deduct on the bid form.

B. Approved Control Manufacturers
   1. Alerton
   2. Johnson controls
   3. Trane

A. The Building Automation System (BAS) system shall be designed, installed, commissioned, and serviced by manufacturer authorized and trained personnel. System provider shall have an in-place support facility within 2 hours response time of the site with technical staff, spare parts inventory, and necessary test and diagnostic equipment.

B. The contractor shall provide full-time, on-site, experienced project manager for this work, responsible for direct supervision of the design, installation, start-up and commissioning of the BAS system.

C. The Bidder shall be regularly engaged in the design, installation and maintenance of BAS systems and shall have demonstrated technical expertise and experience in the design, installation and maintenance of BAS systems similar in size and complexity to this project. Bidders shall provide a list of at least 10 projects, similar in size and scope to this project completed within the past 3 years.

D. Materials and equipment shall be manufacturer's latest standard design that complies with the specification requirements.

E. All BAS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX.

F. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

1.6 REFERENCE STANDARDS
A. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
4. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
6. FCC Part 15, Subpart J, Class A.

B. City, county, state, and federal regulations and codes in effect as of contract date.

C. Except as otherwise indicated, the system supplier shall secure and pay for all permits, inspections, and certifications required for his work, and arrange for necessary approvals by the governing authorities.

1.7 SUBMITTALS

A. Drawings
1. The system supplier shall submit engineered drawings, control sequence, and bill of materials for approval.
2. Drawings shall be submitted in the following standard sizes: 11” x 17” (ANSI B).
3. Eight complete sets (copies) of submittal drawings shall be provided.
4. Drawings shall be available on CD-ROM.

B. System Documentation
1. Include the following in submittal package:
   a. System configuration diagrams in simplified block format.
   b. All input/output object listings and an alarm point summary listing.
   c. Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.
   d. Complete bill of materials, valve schedule and damper schedule.
   e. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
   f. Overall system operation and maintenance instructions—including preventive maintenance and troubleshooting instructions.
   g. For all system elements—operator’s workstation(s), building controller(s), application controllers, routers, and repeaters—provide BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2001.
   h. Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.
   i. A list of all functions available and a sample of function block programming that shall be part of delivered system.

C. Project Management
1. The vendor shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases. Schedule shall show all the target dates for transmission of project information and documents, and shall indicate timing and dates for system installation, debugging, and commissioning.

1.8 WARRANTY
A. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year. NOTE: (isn’t this a five year project – maybe supply a 5 year warranty) from completion of system acceptance.
B. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours, Monday through Friday and 48 hours on Saturday and Sunday.
C. This warranty shall apply equally to both hardware and software.

1.9 RELATED WORK IN OTHER SECTIONS
A. Refer to Division 0 and Division 1 for related contractual requirements.
B. Refer to Section 15 for General Mechanical Provisions.
C. Refer to Section 16 for General Electrical Provisions.

1.10 RECORD DOCUMENTS
A. Prior to submitting the specified number of record documents, submit 2 sets for review. One will be returned with review comments. Include review comments in the final specified number of copies.
B. Upon completion of Project, prior to acceptance of the system by the Owner, submit the following supplemental items:
1. Detailed report of check-out including calibration and programmed setpoints of the control system. List control set points, tuning constants, and calibrated ranges on shop drawings.
2. Furnish a shop drawing submittal prior to final acceptance showing all revisions incorporated during the Project. Comply with Article 1.4, G.1 and G.2. Furnish Final Record Documents in accordance with Division 1 with all delta symbols, clouds, and reference to same removed.
3. Include a set of reduced (11 inches by 17 inches) shop and schematic Drawings for field use at each local panel. In the event system changes occur during the warranty period, revise original record document Drawings to reflect the changes and replace Drawings accordingly.
4. Provide a spare parts list with part numbers and current prices.
5. Provide manufacturer’s installation and calibration instructions for each piece of equipment.
7. Prior to system acceptance, furnish the Owner with a "Letter of Certification" ensuring the system has been installed in compliance with governing fire codes. Include a listing of system specific software. Show all formulas, algorithms, and calculations specific to this Project. Include in the Operation and Maintenance Manual.
8. Furnish a trend log printout of 2 hours duration for each control system. Include every system point status, setpoints and analog value in engineering units at 5-minute
intervals. Submit trend log after systems have been air balanced, water balanced, and final control loop tuning constants entered.

9. Indicate field changes on a master set of Contract Drawings maintained solely for this purpose. Define relocation, addition or deletion of instruments, instrument schedule changes, wiring or piping changes, relative to the system, and wiring and raceway runs provided within the system furnished. Upon completion of the Project, reproducible copies of the Contract Drawings will be furnished to the I&C contractor for revision. Indicate changes in a format identical to Contract Drawings. Return completed record document reproducibles to the Owner within 30 days of receipt.

10. Furnish 1 compact disk containing design, fabrication, and installation drawings developed for the Project. Include all software/programs and files in .DXF format. Files may be compressed using PKZIP compression format. Include updating diskettes during the warranty period.

1.11 SINGLE SOURCE RESPONSIBILITY

A. Provide a fully integrated system.

B. Provide software, hardware, operator input/output devices, remote processing units, automation sensors and controls, wiring, piping, engineering, installation, supervision, labor, calibration, software programming and commissioning for a fully operational system.

1.12 INSTRUCTION FOR THE OWNER

A. Provide competent instructors to instruct designated personnel in adjustment, operation and maintenance of equipment. Furnish training manuals for each trainee and system manufacturer issued video taped instruction. Provide 8 hours of instruction.

1.13 ACCEPTANCE PROCEDURE

A. Test and adjust equipment to perform as specified. Coordinate the testing of components installed under this division with the testing requirements of Section 15190 and other Divisions.

PART 2 - PRODUCTS

2.1 ADVANCED WORKSTATION (AWS)

A. General structure of workstation interaction shall be a standard client/server relationship with web server embedded in the server for browser only access. Server shall be used to archive data and store system database. Clients shall access server for all archived data. Each AWS shall support operation in a virtualized server environment. Thick and web clients shall access server for all archived data.

1. A single server license shall:
   a. Allow a minimum of 50 thick client seats/installations.
   b. Allow a minimum of 200 web client users.
   c. Not restrict system size based on point count (BACnet or Integration).

B. BACnet Conformance

1. Operator Work Station shall be approved by the BTL as meeting the BACnet Advanced Work Station requirements.
2. Please refer to Section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

3. Standard BACnet object types accessed by the workstation shall include as a minimum: Analog Value, Analog Input, Analog Output, Binary Value, Binary Input, Binary Output, Calendar, Device, Event Enrollment, File, Notification Class, Program, and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

4. The operator’s workstation shall comply with Annex J of the BACnet specification for IP connections. Must support remote connection to server using a thick client application. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs). Workstation shall support Foreign Device Registration to allow temporary workstation connection to IP network.

C. Data Displays

1. Data displays shall render all data associated with project as called out on drawings and/or object type list supplied. Graphic files shall be created using digital, full color photographs of system installation, AutoCAD or Visio drawing files of field installation drawings, and wiring diagrams from as-built drawings.

2. Data displays shall render data using iconic graphic representations of all mechanical equipment. System shall be capable of displaying graphic file, text, trendlog, and dynamic object data together on each display and shall include animation. Information shall be labeled with descriptors and shall be shown with the appropriate engineering units. All information on any display shall be dynamically updated without any action by the user.

3. Data display frame shall allow user to change all field-resident AWS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc., from any screen, no matter if that screen shows all text or a complete graphic display. This shall be done without any reference to object addresses or other numeric/mnemonic indications.

4. Analog objects shall be displayed with operator modifiable units. Analog input objects may also be displayed as individual graphic items on the display screen as an overlay to the system graphic.

5. All displays and programming shall be generated and customized by the local use energy management and control system (EMCS) supplier and installer. Systems requiring factory development of graphics or programming of DDC logic are specifically prohibited.

6. AWS shall be supplied with a library of standard graphics, which may be used unaltered or modified by the operator. AWS shall include a library of equipment graphic components to assemble custom graphics. Systems that do not allow customization or creation of new graphic objects by the operator (or with third-party software) shall not be allowed.

7. A navigation tree for building, equipment and system diagnostic centric display organization shall be available from data display view. The tree navigation contents shall be customizable on a per-user and per-group basis.
8. Each display may be protected from viewing unless operator credentials have the appropriate access level. An access level may be assigned to each display and system object. The menu label shall not appear on the graphic if the operator does not have the appropriate security level.

9. Data displays shall have the ability to link to content outside of the EMCS system. Such content shall include, but is not limited to launching external files in their native applications (for example, a Microsoft Word document).

10. A single system software license can support a minimum of 200 user accounts and web access.

11. Data displays shall support:
   a. Graphic items with custom geometry that offer both color gradient shading and variable opacity in scale to system variables, both analog and digital, and color range settings. For example, rooms on a floor plan graphic can be made to indicate the space temperature by varying the color of that room.
   b. Clear and custom geometry navigation buttons to provide intuitive navigation to system display or external URLs.
   c. Graphic files in JPG, PNG, and GIF file types.
   d. Viewing of up to 1,024 system data points (Analog, Binary, and/or Multi-state) in a single screen.
   e. Customizable mouse-over tooltip information of graphic items or data points can be displayed. The tooltips can be turned on and off. The default setting is off.
   f. Right click capability to directly access system functionality, such as Schedule, Trendlogs, and Alarms associated with a display object selected.
   g. Automatic zooming to the screen size detected to maximize the size of the display to match screen display area available. The zoom capability can be enabled or disabled, default is enabled. The background color, if solid, will be used to flood fill the remaining screen background.
   h. Supports user configurable embedded Data Viewer for a persistent trend log data view to accompany system data and graphic information on a single display.

D. Displays

1. Operator’s workstation shall display all data associated with project as called out on drawings and/or object type list supplied. Graphic files shall be created using digital, full color photographs of system installation, AutoCAD or Visio drawing files of field installation drawings and wiring diagrams from as-built drawings. Operator’s workstation shall display all data using three-dimensional graphic representations of all mechanical equipment. System shall be capable of displaying graphic file, text, and dynamic object data together on each display and shall include animation. Information shall be labeled with descriptors and shall be shown with the appropriate engineering units. All information on any display shall be dynamically updated without any action by the user. Workstation shall allow user to change all field-resident EMCS functions associated with the project, such as setpoints, weekly schedules, exception schedules, etc., from any screen, no matter if that screen shows all text or a complete graphic display. This shall be done without any reference to object addresses or other numeric/mnemonic indications.

2. All displays and programming shall be generated and customized by the local EMCS supplier and installer. Systems requiring factory development of graphics or programming of DDC logic are specifically prohibited.

3. Binary objects shall be displayed as ACTIVE/INACTIVE/NULL or with customized text such as Hand-Off-Auto. Text shall be justified left, right or center as selected by
the user. Also, allow binary objects to be displayed as individual change-of-state graphic objects on the display screen such that they overlay the system graphic. Each binary object displayed in this manner shall be assigned up to three graphic files for display when the point is ON, OFF or in alarm. For binary outputs, toggle the object’s commanded status when the graphic item is selected with the system mouse. Similarly, allow the workstation operator to toggle the binary object’s status by selecting with the mouse, for example, a graphic of a switch or light, which then displays a different graphic (such as an “ON” switch or lighted lamp. Additionally, allow binary objects to be displayed as an animated graphic. Animated graphic objects shall be displayed as a sequence of multiple graphics to simulate motion. For example, when a pump is in the OFF condition, display a stationary graphic of the pump. When the operator selects the pump graphic with the mouse, the represented object’s status is toggled and the graphic of the pump’s impeller rotates in a time-based animation. The operator shall be able to click an animated graphical object or switch it from the OFF position to ON, or ON to OFF. Allow operator to change graphic file assignment and also create new and original graphics online. System shall be supplied with a library of standard graphics, which may be used unaltered or modified by the operator. Systems that do not allow customization or creation of new graphic objects by the operator (or with third-party software) shall not be allowed.

4. Analog objects shall be displayed with operator modifiable units. Analog input objects may also be displayed as individual graphic items on the display screen as an overlay to the system graphic. Each analog input object may be assigned a minimum of five graphic files, each with high/low limits for automatic selection and display of these graphics. As an example, a graphic representation of a thermometer would rise and fall in response to either the room temperature or its deviation from the controlling setpoint. Analog output objects, when selected with the mouse, shall be displayed as a prompted dialog (text only) box. Selection for display type shall be individual for each object. Analog object values may be changed by selecting either the “increase” or “decrease” arrow in the analog object spinner box without using the keypad. Pressing the button on the right side of the analog object spinner box allows direct entry of an analog value and accesses various menus where the analog value may be used, such as trendlogs.

5. Analog objects may also be assigned to a system graphic, where the color of the defined object changes based on the analog object’s value. For example, graphical thermostat device served by a single control zone would change color with respect to the temperature of the zone or its deviation from setpoint. All editing and area assignment shall be created or modified online using simple icon tools.

6. A customized menu label (push-button) shall be used for display selection. Menu items on a display shall allow penetration to lower level displays or additional menus. Dynamic point information and menu label pushbuttons may be mixed on the same display to allow sub-displays to exist for each item. Each display may be protected from viewing unless operator has appropriate security level. A security level may be assigned to each display and system object. The menu label shall not appear on the graphic if the operator does not have the appropriate security level.

7. The BAS displays shall have the ability to link to content outside of the BAS system. Such content shall include but is not limited to: Launching external files in their native applications (for example, a Microsoft Word document) and launching a Web browser resolving to a specified Web address.

8. The BAS system shall have the ability to run multiple, concurrent displays windows showing continuously updated data.
E. Password Protection
   1. Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator’s assigned functions when user is logged on. This includes displays as outlined above.
   2. Each AWS shall provide security for a minimum of 200 users. Each user shall have an individual User ID, User Name, and Password. Entries are alphanumeric characters only and are case sensitive (except for User ID). User ID, User Name, and Password shall support a minimum of 40 characters. All user information and passwords shall be stored in an encrypted form. Each system user shall be allowed individual assignment of only those control functions, menu items, and user specific system start display, as well restricted access to discrete BACnet devices to which that user requires access. All passwords, user names, and access assignments shall be adjustable via Server and Thick client. Password shall be adjustable via the web client. Users should have the capability to be assigned to specific user type “groups” that can share the same access levels to speed setup. Users who are members of multiple “groups” shall have the ability to activate/deactivate membership to those groups while using the BAS (without logout). Users shall also have a set security level, which defines access to displays and individual objects the user may control. System shall include 10 separate and distinct security levels for assignment to users.
   3. System shall include an Auto Logout Feature that shall automatically logout user when there has been no keyboard or mouse activity for a set period of time. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.
   4. The system shall permit the assignment of an effective date range, as well as an effective time of day, that the User IDs are permitted to authenticate.

F. Operator Activity Log
   1. Operator Activity Log that tracks all operator changes and activities shall be included with system. System shall track what is changed in the system, who performed this change, date and time of system activity, and value of the change before and after operator activity. Operator shall be able to display all activity, sort the changes by user and also by operation. Operator shall be able to print the Operator Activity log display.
   2. Log shall be gathered and archived to hard drive on operator’s workstation as needed. Operator shall be able to export data for display and sorting in a spreadsheet.
   3. Any displayed data that is changeable by the operator may be selected using the right mouse button and the operator activity log shall then be selectable on the screen. Selection of the operator activity log using this method shall show all operator changes of just that displayed data.

G. Scheduling
   1. Operator’s workstation shall show all information in easy-to-read daily format including calendar of this month and next. All schedules shall show actual ON/OFF times for day based on scheduling priority. Priority for scheduling shall be events, holidays and daily, with events being the highest.
   2. Holiday and special event schedules shall display data in calendar format. Operator shall be able to schedule holidays and special events directly from these calendars.
   3. Operator shall be able to change all information for a given weekly or exception schedule if logged on with the appropriate security access.
4. System shall include a Schedule Wizard for set up of schedules. Wizard shall walk user through all steps necessary for schedule generation. Wizard shall have its own pull-down selection for startup or may be started by right-clicking on value displayed on graphic and then selecting Schedule.

5. Scheduling shall include optimum start based on outside air temperature, current heating/cooling setpoints, indoor temperature and history of previous starts. Each and every individual zone shall have optimum start time independently calculated based on all parameters listed. User shall input schedules to set time that occupied setpoint is to be attained. Optimum start feature shall calculate the startup time needed to match zone temperature to setpoint. User shall be able to set a limit for the maximum startup time allowed.

6. Any displayed data that is changeable by the operator may be selected using the right mouse button and the schedule shall then be selectable on the screen. Selection of the schedule using this method shall allow the viewing of the assigned schedule or launch the Schedule Wizard to allow the point to be scheduled.

H. Alarm Indication and Handling.
1. AWS shall provide visual, printed, and email means of alarm indication. Printout of alarms shall be sent to the assigned terminal and port. Alarm notification can be filtered based on the User ID’s authorization level.

2. Web client shall display a persistent alarm state for the system regardless of the data view including points in alarm but not acknowledged, and points that have gone into alarm and returned to normal without being acknowledged.

3. Alarm History shall provide log of alarm messages. Alarm log shall be archived to the hard disk of the AWS. Each entry shall include a description of the event-initiating object generating the alarm. Description shall be an alarm message of at least 256 characters in length. Entry shall include time and date of alarm occurrence, time and date of object state return to normal, time and date of alarm acknowledgment, and identification of operator acknowledging alarm.

4. Alarm messages shall be in user-definable text (English or other specified language) and shall be delivered either to the operator’s terminal, client or through remote communication using email (Authenticated SMTP supported).

5. AWS, Thick Client, and Web Client shall allow for set up of alarms. UI shall walk user through all steps necessary for alarm generation. Alarm creation may be started by right-clicking on value displayed on graphic and then selecting Alarm setup.

6. Web client shall support color-coded indication of current alarms as follows:
   a. Red indicator shows number of active alarms that have not been acknowledged.
   b. Yellow indicator shows number of alarms that are still active but have been acknowledged.
   c. Blue indicator shows number of alarms that have returned to normal but have not been acknowledged.
   d. Color-coded indicators, when selected by the user, navigate to a pre-filtered view of alarm history.
   e. Alarm history can be filtered by color-coded indicator states.

7. Alarm annunciation includes navigation link to a user-selected display or URL.

8. Any displayed data that is changeable by the operator may be selected using the right mouse button and the alarm shall then be selectable on the screen. Selection of the alarm using this method shall allow the viewing of the alarm history or allow the creation of a new alarm.
I. Trendlog Information
1. System server shall periodically gather historically recorded data stored in the building controllers and store the information in the system database. Stored records shall be appended with new sample data, allowing records to be accumulated. Systems that write over stored records shall not be allowed unless limited file size is specified. System database shall be capable of storing up to 50 million records before needing to archive data. Samples may be viewed at the operator’s workstation. Operator shall be able to view all trended records, both stored and archived. All trendlog records shall be displayed in standard engineering units.

2. Software that is capable of graphing the trend logged object data shall be included. Software shall be capable of creating two-axis (X, Y) graphs that display up to 10 object types at the same time in different colors. Graphs shall show object values relative to time. Each trendlog shall support a custom scale setting for the graph view that is to be stored continuously. System shall be capable of trending on an interval determined by a polling rate, or change-of-value.

3. Operator shall be able to change Trendlog setup information. This includes the information to be logged as well as the interval at which it is to be logged. All input, output, and value object types in the system may be logged. All operations shall be password protected. Setup and viewing may be accessed directly from any and all graphics on which object is displayed.

4. System shall include a Trend Wizard for setup of logs. Wizard shall walk user through all necessary steps. Wizard shall have its own pull-down selection for startup, or may be started by right-clicking on value displayed on graphic, and then selecting Trendlogs from the displayed menu.

5. System shall be capable of using Microsoft SQL as the system database.

6. Any displayed data that is changeable by the operator may be selected using the right mouse button and the trendlog shall then be selectable on the screen. Selection of the trendlog using this method shall allow the viewing of the trendlog view or launch the Trendlog wizard to allow the creation of a new trend.

J. Energy Log Information
1. System server shall be capable of periodically gathering energy log data stored in the field equipment and archive the information. Archive files shall be appended with new data, allowing data to be accumulated. Systems that write over archived data shall not be allowed unless limited file size is specified. Display all energy log information in standard engineering units.

2. All data shall be stored in database file format for direct use by third-party programs. Operation of system shall stay completely online during all graphing operations.

3. Operator shall be able to change the energy log setup information as well. This includes the meters to be logged, meter pulse value, and the type of energy units to be logged. All meters monitored by the system may be logged. System shall support using flow and temperature sensors for BTU monitoring.

4. System shall display archived data in tabular format form for both consumption and peak values. Data shall be shown in hourly, daily, weekly, monthly and yearly formats. In each format, the user shall be able to select a specific period of data to view.

K. Demand Limiting
1. System shall include demand limiting program that includes two types of load shedding. One type of load shedding shall shed/restore equipment in binary fashion based on energy usage when compared to shed and restore settings. The other type of shedding
shall adjust operator selected control setpoints in an analog fashion based on energy usage when compared to shed and restore settings. Shedding may be implemented independently on each and every zone or piece of equipment connected to system.

2. Binary shedding shall include minimum of five (5) priority levels of equipment shedding. All loads in a given priority level shall be shed before any loads in a higher priority level are shed. Load shedding within a given priority level shall include two methods. In one, the loads shall be shed/restored in a “first off-first on” mode, and in the other the loads are just shed/restored in a “first off-last on” (linear) fashion.

3. Analog shed program shall generate a ramp that is independently used by each individual zone or individual control algorithm to raise the appropriate cooling setting and lower appropriate heating setting to reduce energy usage.

4. Status of each and every load shed program shall be capable of being displayed on every operator terminal connected to system. Status of each load assigned to an individual shed program shall be displayed along with English description of each load.

L. Field Engineering Tools
1. Operator’s workstation software shall include field engineering tools for programming all controllers supplied. All controllers shall be programmed using graphical tools that allow the user to connect function blocks on screen that provide sequencing of all control logic. Function blocks shall be represented by graphical displays that are easily identified and distinct from other types of blocks. Graphical programming that uses simple rectangles and squares is not acceptable.

2. User shall be able to select a graphical function block from menu and place on screen. Provide zoom in and zoom out capabilities. Function blocks shall be downloaded to controller without any reentry of data.

3. Programming tools shall include a real-time operation mode. Function blocks shall display real-time data and be animated to show status of data inputs and outputs when in real-time operation. Animation shall show change of status on logic devices and countdown of timer devices in graphical format.

4. Field engineering tools shall also include a database manager of applications that include logic files for controllers and associated graphics. Operator shall be able to select unit type, input/output configuration and other items that define unit to be controlled. Supply minimum of 250 applications as part of workstation software.

5. Field engineering tool shall include Device Manager for detection of devices connected anywhere on the BACnet network by scanning of the entire network. This function shall display device instance, network identification, model number, and description of connected devices. It shall record and display software file loaded into each controller. A copy of each file shall be stored on the computer’s hard drive. If needed, this file shall be downloaded to the appropriate controller using the mouse.

6. System shall automatically notify the user when a device that is not in the database is added to the network.

7. System shall include backup/restore function that will back up entire system to selected medium and then restore system from that media. The system shall be capable of creating a backup for the purpose of instantiating a new client PC.

8. The system shall provide a means to scan, detect, interrogate, and edit 3rd party BACnet devices and BACnet objects within those devices.

M. Workstation Hardware
1. 1. Provide operator’s workstation(s) at location(s) noted on the plans.

2. 2. AWS Server Minimum Requirements
a. 64-bit OS
c. 2 GHz (or better), dual-core or quad-core processors
d. 4 GB RAM or higher
e. 3 GB of hard drive space required for base installation without application data
f. Network interface card (10/100/1000 Mbps)

N. Software
   1. At the conclusion of project, contractor shall leave with owner a CD ROM that includes the complete software operation system and project graphics, setpoints, system parameters, etc. This backup shall allow the owner how to completely restore the system in the case of a computer malfunction.

2.2 Web Interface
   1. EMCS supplier shall provide an HTML5-based browser access to the AWS as part of standard installation. User must be able to access all displays of real-time data that are part of the AWS using a standard web browser. Web browser shall tie into the network through owner-supplied Ethernet network connection. The web client shall support a minimum of 200 users with a single license.
   2. Browser shall be standard version of Microsoft Internet Explorer v10.0 or later, Firefox v19.0 or later, Chrome v24.0 or later, and Safari v7.1.1 or later. No special vendor-supplied software shall be needed on computers running browser. Data shall be displayed in real-time and update automatically without user interaction.
   3. Web pages shall be automatically generated using HTML5 from the data display files that reside on the AWS. Any system that requires use of an HTML editor for generation of web pages shall not be considered.
   4. Access through web client or thick client shall utilize the same hierarchical security scheme as the AWS. User shall be asked to log on once the client makes connection to the AWS. Once the user logs on, any and all changes that are made shall be tracked by the AWS. The user shall be able to change only those items he or she has authority to change. A user activity report shall show any and all activity of the users who have logged on to the system, regardless of whether those changes were made using a web client, thick client or through the AWS.
   5. Shall provide User Session Management including the ability to view all connected user sessions to the web client, see how long they have been active/inactive for each unique session, and force log-out for any or all sessions.
   6. Shall provide menu-style navigation access to primary features, i.e. alarm history, DataView, Search scheduled points and Zones, System Activity, User Session Management, and Top Display.
   7. Web client shall, at a minimum, support the following tablets:
      a. Android platform:
         1) Google Nexus
         2) Samsung Galaxy Note
      b. Apple platform
         1) Ipad
         2) Apple Ipad Mini

2.3 BUILDING CONTROLLER
   A. General Requirements
1. BACnet Conformance  
   a. Building Controller shall be approved by the BTL as meeting the BACnet Building Controller requirements.  
   b. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

2. Building controller shall be of scalable design such that the number of trunks and protocols may be selected to fit the specific requirements of a given project.

3. The controller shall be capable of panel-mounted on DIN rail and/or mounting screws.

4. The controller shall be capable of running up to six (6) independent control strategies simultaneously. The modification of one control strategy does not interrupt the function or runtime others.

5. The controller shall be capable of providing global control strategies for the system based on information from any objects in the system, regardless if the object is directly monitored by the building controller module or by another controller.

6. Programming shall be object-oriented using control function blocks, and support DDC functions, 6000 Analog Values and 6000 Binary Values. All flowcharts shall be generated and automatically downloaded to controller. Programming tool shall be supplied and be resident on workstation. The same tool shall be used for all controllers.

7. Controller IP configuration can be done via a direct USB connect with an operator’s workstation or field computer.

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

9. Controller shall have sufficient memory to ensure high performance and data reliability. Battery shall provide power for orderly shutdown of controller and storage of data in nonvolatile flash memory. Battery backup shall maintain real-time clock functions for a minimum of 20 days.

10. Controller shall have at a minimum a Quad Core 996Ghz processor to ensure fast processing speeds.

11. Global control algorithms and automated control functions shall execute using a 64-bit processor.

12. Controller shall support two (2) on-board EIA-485 ports capable of supporting various EIA-485 protocols including, but not limited to BACnet MS/TP and Modbus.  
   a. Ports are capable of supporting various EIA-485 protocols including, but not limited to BACnet MS/TP and Modbus.

13. Controller shall support two (2) ports—each of gigabit speed—Ethernet (10/100/1000) ports.  
   a. Ports are capable of supporting various Ethernet protocols including, but not limited to BACnet IP, FOX, and Modbus.

14. All ports shall be capable of having protocol(s) assigned to utilize the port’s physical connection.

15. The controller shall have at a minimum four (4) onboard inputs, two (2) universal inputs and two (2) binary inputs.

16. Schedules

17. Each building controller module shall support a minimum of 380 BACnet Schedule Objects and 380 BACnet Calendar Objects.
18. Building controller modules shall provide normal seven-day scheduling, holiday scheduling and event scheduling.

19. Logging Capabilities
   a. Each building controller shall log as minimum 2000 Objects at 15 minute intervals. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator’s workstation.
   b. Logs may be viewed both on-site or off-site using WAN or remote communication.
   c. Building controller shall periodically upload trended data to networked operator’s workstation for long-term archiving if desired.
   d. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.

20. Alarm Generation
   a. Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
   b. Each alarm may be dialed out as noted elsewhere.
   c. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator’s terminal or off-site using remote communications.
   d. Controller must be able to handle up to 2000 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.

21. Demand Limiting
   a. Demand limiting of energy shall be a built-in, user-configurable function. Each controller module shall support shedding of up to 1200 loads using a minimum of two types of shed programs.
   b. Load shedding programs in building controller modules shall operate as defined in section 2.1.J of this specification.

B. Ethernet – MS/TP Module
   1. Ethernet – MS/TP Module shall support every function as listed under paragraph A, General Requirements, of this section and the following.
   2. All communication with operator’s workstation and all application controllers shall be through BACnet. Building controller Ethernet – MS/TP module shall incorporate as a minimum, the functions of a 2-way BACnet router. Controller shall route BACnet messages between the high-speed LAN (Ethernet 10/100MHz) and MS/TP LAN. Ethernet – MS/TP module shall also route messages from all other building controller modules onto the BACnet Ethernet network.
      a. MS/TP LAN must be software-configurable from 9.6 to 76.8Kbps.
      b. The RJ-45 Ethernet connection must accept either 10 Base-T or 100Base-TX BACnet over twisted pair cable (UTP).
   3. BACnet Conformance
      a. Ethernet – MS/TP module shall, as a minimum, support MS/TP and Ethernet BACnet LAN types. It shall communicate directly using these BACnet LANs as a native BACnet device and shall support simultaneous routing functions between all supported LAN types. Global controller shall be approved by the BACnet Testing Laboratory (BTL) as meeting the BACnet Building Controller requirements.
b. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

c. The building controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN. Must support interoperability on WANs and CANs and function as a BACnet Broadcast Management Device (BBMD).

C. MS/TP Module
1. MS/TP Module shall support every function as listed under paragraph A, General Requirements, of this section and the following.
2. Building controller MS/TP module communications shall be through BACnet MS/TP LAN to all advanced application and application-specific controllers. MS/TP module shall also route messages to Ethernet - MS/TP module for communication over WAN.
   a. MS/TP LAN must be software configurable from 9.6 to 76.8Kbps
   b. Configuration shall be through RS-232 connection.
3. BACnet Conformance
   a. MS/TP module shall be approved by the BTL (BACnet Testing Laboratory) as meeting the BACnet Building Controller requirements. MS/TP module shall as a minimum support MS/TP BACnet LAN type. It shall communicate directly using this BACnet LAN as a native BACnet device and shall support simultaneous routing functions between all supported LAN types.
   b. Standard BACnet object types supported shall include, as a minimum, Analog Value, Binary Value, Calendar, Device, File, Group, Notification Class, Program, and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

D. Power Supply Module
1. Power supply module shall power up to seven building controller modules. Input for power shall accept between 17–30VAC, 47–65Hz.
2. Power supply module shall include rechargeable battery for orderly shutdown of controller modules including storage of all data in flash memory and for continuous operation of real-time clocks for minimum of 20 days.

2.4 CENTRAL PLANT AND AIR HANDLER APPLICATION CONTROLLERS
A. Provide one or more native BACnet application controllers for each air handler and provide native BACnet application controllers as needed for central plant control that adequately cover all objects listed in object list. All controllers shall interface to building controller through either MS/TP LAN using BACnet protocol, or Ethernet LAN using BACnet over Ethernet or BACnet TCP/IP. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable using graphical programming blocks. Programming tool shall be resident on operator workstation and be the same tool as used for the building controller. No auxiliary or non-BACnet controllers shall be used.

B. BACnet Conformance
1. Application controllers shall be approved by the BTL as meeting the BACnet Advanced Application Controller requirements.
2. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Multi-state Values, Device, File, and Program object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. Application controllers shall include universal inputs with 12-bit resolution that accept 3K and 10K thermistors, 0–10VDC, Platinum 1000 ohm RTD, 0–5VDC, 4–20mA and dry contact signals. Any input on a controller may be either analog or digital with a minimum of three inputs that accept pulses. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall include binary and analog outputs on board. Analog outputs with 12-bit resolution shall support either 0–10VDC or 0–20mA. Binary outputs shall have LED indication of status. Software shall include scaling features for analog outputs. Application controller shall include 20VDC voltage supply for use as power supply to external sensors.

1. All outputs must have onboard Hand-Off-Auto (HOA) switches and a status indicator light. HOA switch position shall be monitored. Each analog output shall include a potentiometer for manually adjusting the output when the HOA switch is in the Hand position. The position of each and every HOA switch shall be available system wide as a BACnet object property.

D. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller up to 20 times per second (minimum of 10 times per second) and capable of multiple PID loops for control of multiple devices. All calculations shall be completed using floating-point math and system shall support display of all information in floating-point nomenclature at operator’s terminal.

1. The following control blocks shall be supported:
   a. Natural Log
   b. Exponential
   c. Log base 10
   d. X to the power of Y
   e. Nth square root of X
   f. 5th Order Polynomial Equations
   g. Astronomical Clock (sunrise/sunset calculation)
   h. Time based schedules

E. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely using modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using programming tools as described in operator’s terminal section.

F. Application controller shall include support for intelligent room sensor (see Section 2.9.B.) Display on intelligent room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode, based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

G. Schedules
   1. The controller shall support a minimum of 3 BACnet Schedule Objects and have a real time clock on board with battery backup to maintain time through a power loss.

H. Logging Capabilities
1. Controller shall support a minimum of 50 trendlogs. Any object in the controller (real or calculated) may be logged. Sample time interval shall be adjustable at the operator’s workstation.
2. Controller shall periodically upload trended data to system server for long-term archiving if desired. Archived data stored in (MS Jet Database or SQL) database form and shall be available for use in third-party spreadsheet or database programs.

I. Alarm Generation
1. Alarms may be generated within the controller for any object change of value or state (either real or calculated). This includes things such as analog object value changes, and binary object state changes.
2. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator’s terminal or off-site using remote communications.
3. Controller must be able to handle up to 25 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.

J. The controller processor shall be a 32-bit processor.

K. The packaging of the controller shall provide operable doors to cover the terminals once installation is complete. The housing of the controller shall provide for DIN rail mounting and also fully enclose circuit board.

2.5 TERMINAL UNIT APPLICATION CONTROLLERS (Heat Pumps, AC Units, Fan-Coils)

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

B. BACnet Conformance
1. Application controllers shall, as a minimum, support MS/TP BACnet LAN types. They shall communicate directly using this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be approved by the BTL as meeting the BACnet Application Specific Controller requirements and support all BACnet services necessary to provide the following BACnet functional groups:
   a. Files Functional Group
   b. Reinitialize Functional Group
   c. Device Communications Functional Group

2. Please refer to Section 22.2, BACnet Functional Groups in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5VDC, 4–20mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.
D. All program sequences shall be stored on board controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely through modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.

E. Application controller shall include support for intelligent room sensor (see Section 2.9.B.) Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

2.6 AUXILIARY CONTROL DEVICES

A. Temperature Sensors
1. All temperature sensors to be solid-state electronic, interchangeable with housing appropriate for application. Wall sensors to be installed as indicated on drawings. Mount 48 inches above finished floor. Duct sensors to be installed such that the sensing element is in the main air stream. Immersion sensors to be installed in wells provided by control contractor, but installed by mechanical contractor. Immersion wells shall be filled with thermal compound before installation of immersion sensors. Outside air sensors shall be installed away from exhaust or relief vents, not in an outside air intake, and in a location that is in the shade most of the day.

B. Intelligent Room Sensor with Touchscreen
1. Hardware
   a. Room sensor shall include:
      1) Backlit touchscreen LCD digital display
      2) Temperature sensor
      3) Humidity sensor
      4) Programmable Status Light indicator
      5) OPTIONAL - CO2 sensor or BACnet MS/TP communication up to 115.2kbps
   b. Temperature sensor shall be a Uni-Curve Type II thermistor with an accuracy of +/- 0.36 °F (0.3 °C) at calibration point over the range of 32 to 158 °F or better.
   c. Humidity sensor shall have an accuracy of +/-3% from 10 to 90% relative humidity (RH) or better, non-condensing.
   d. The intelligent room sensor’s Status Light indicator shall have a minimum of four (4) colors (blue, red, amber and green) that will cast a glow onto the wall below the sensor to be used as visual indicator to the occupants of the condition of the system. The color and on/off state of the Status Light indicator shall be fully programmable.
   e. Option for CO2 sensor shall have an accuracy of +/- 30 ppm over the range of 0–5000 ppm or better.
   f. Option for CO2 sensor shall utilize Automatic Baseline Correction to maintain sensor calibration without the need for manual calibration.
   g. The user shall interact with the smart sensor using a touchscreen, with no buttons allowed.
   h. The intelligent room sensor shall have provisions for a tamper proof installation requiring tools to be removed from the wall.
   i. The touchscreen shall have a surface hardness of Mohs 7 or greater to prevent being easily scratched.
Controller shall function as room control unit, and allow occupant to raise and lower setpoint, and activate terminal unit for override use—all within limits as programmed by building operator.

C. Wall Sensor
1. Standard wall sensor shall use solid-state sensor identical to intelligent room sensor and shall be packaged in aesthetically pleasing enclosure. Sensor shall provide override function, warmer/cooler lever for set point adjustment and port for plug-in of Field Service Tool for field adjustments. Override time shall be stored in controller and be adjustable on a zone-by-zone basis. Adjustment range for warmer/cooler lever shall also be stored in EEPROM on controller. All programmable variables shall be available to field service tool through wall sensor port.

2.7 Electronic Actuators and Valves
A. Quality Assurance for Actuators and Valves
1. UL Listed Standard 873 and C.S.A. Class 4813 02 certified.
2. NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.
3. Five-year manufacturer’s warranty. Two-year unconditional and three-year product defect from date of installation.

B. Execution Details for Actuators and Valves
1. Furnish a Freeze-stat and install “Hard Wire” interlock to disconnect the mechanical spring return actuator power circuit for fail-safe operation. Use of the control signal to drive the actuators closed is not acceptable.
2. 2. control signal, wired and terminated in the control panel for true position information and troubleshooting. Or the actuator feedback signal may be wired to the DDC as an analog input for true actuator position status.
3. VAV box damper actuation shall be floating type or analog (2–10VDC, 4–20mA).
4. Booster-heat valve actuation shall be floating type or analog (2-10vdc, 4-20ma).
5. Primary valve control shall be analog (2–10VDC, 4–20mA).

C. Actuators for damper and control valves 0.5–6 inches shall be electric unless otherwise specified, provide actuators as follows:
1. UL Listed Standard 873 and Canadian Standards association Class 481302 shall certify actuators.
2. NEMA 2 rated actuator enclosures for inside mounting. Use additional weather shield to protect actuator when mounted outside.
3. Five-year manufacturer’s warranty. Two-year unconditional and three-year product defect from date of installation.
4. Mechanical spring shall be provided when specified. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
5. Position indicator device shall be installed and made visible to the exposed side of the actuator. For damper short shaft mounting, a separate indicator shall be provided to the exposed side of the actuator.
6. Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for butterfly valve actuators.
7. A Pushbutton gearbox release shall be provided for all non-spring actuators.
8. Modulating actuators shall be 24VAC and consume 10VA power or less.
9. Conduit connectors are required when specified and when code requires it.

D. Damper Actuators:
1. Outside air and exhaust air damper actuators shall be mechanical spring return. Capacitors or other non-mechanical forms of fail-safe are not acceptable. The actuator
mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.

2. Economizer actuators shall utilize analog control 2–10VDC, floating control is not acceptable.

3. Electric damper actuators (including VAV box actuators) shall be direct shaft-mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or set-screw type fasteners are not acceptable.

4. One electronic actuator shall be direct shaft-mounted per damper section. No connecting rods or jackshafts shall be needed. Small outside air and return air economizer dampers may be mechanically linked together if one actuator has sufficient torque to drive both and damper drive shafts are both horizontal installed.

5. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft-mounted per damper section. (See below execution section for more installation details.)

E. Control Valves 0.5–6" inches

1. The BAS contractor shall furnish all specified motorized control valves and actuators. BAS contractor shall furnish all control wiring to actuators. The plumbing contractor shall install all valves. Equal percentage control characteristic shall be provided for all water coil control valves. Linear valve characteristic is acceptable for 3-way valves that are 2.5 inches and above.

2. Characterized control valves shall be used for hydronic heating or cooling applications and small to medium AHU water-coil applications to 100GPM. Actuators are non-spring return for terminal unit coil control unless otherwise noted. If the coil is exposed to the outside air stream, see plans for spring return requirement.
   a. Leakage is aero percent, close-off is 200psi, maximum differential is 30psi; rangeability is 500:1.
   b. Valves 0.5–2 inches shall be nickel-plated forged brass body, NPT screw type connections.
   c. Valves 0.5–1.25 inches shall be rated for ANSI Class 600 working pressure. Valves 1.5 and 2 inches shall be rated for ANSI Class 400 working pressure.
   d. The operating temperature range shall be 0–250 degrees F.
   e. Stainless steel ball and stem shall be furnished on all modulating valves.
   f. Seats shall be fiberglass reinforced Teflon.
   g. Two-way and three-way valves shall have an equal percentage control port. Full stem rotation is required for maximum flow to insure stable BTU control of the coil.
   h. Three-way valve shall be applicable for both mixing and diverting.
   i. The characterizing disc is made of TEFZEL and shall be keyed and held secure by a retaining ring.
   j. The valves shall have a blow-out proof stem design.
   k. The stem packing shall consist of 2 lubricated O-rings designed for on-off or modulating service and require no maintenance.
   l. The valves shall have an ISO type, 4-bolt flange for mounting actuator in any orientation parallel or perpendicular to the pipe.
   m. A non-metallic thermal isolation adapter shall separate valve flange from actuator.
   n. One fastening screw shall secure the direct coupling of the thermal isolation adapter between the actuator and the valve. This will prevent all lateral or rotational forces from affecting the stem and its packing O-rings.

3. Performance Verification Test
   a. Control loops shall cause productive actuation with each movement of the actuator and actuators shall modulate at a rate that is stable and responsive. Actuator movement shall not occur before the effects of previous movement have affected the sensor.
   b. Actuator shall have capability of signaling a trouble alarm when the actuator Stop-Go Ratio exceeds 30%.
4. Actuator mounting for damper and valve arrangements shall comply to the following:
   a. Damper actuators: Shall not be installed in the air stream
   b. A weather shield shall be used if actuators are located outside. For damper actuators, use clear plastic enclosure.
   c. Damper or valve actuator ambient temperature shall not exceed 122 degrees F through any combination of medium temperature or surrounding air. Appropriate air gaps, thermal isolation washers or spacers, standoff legs, or insulation shall be provided as necessary.
   d. Actuator cords or conduit shall incorporate a drip leg if condensation is possible. Water shall not be allowed to contact actuator or internal parts. Location of conduits in temperatures dropping below dew point shall be avoided to prevent water from condensing in conduit and running into actuator.
   e. Damper mounting arrangements shall comply to the following:
      1) The ventilation subcontractor shall furnish and install damper channel supports and sheet metal collars.
      2) No jack shafting of damper sections shall be allowed.
      3) Multi-section dampers shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per section.
   f. Size damper sections based on actuator manufacturer’s specific recommendations for face velocity, differential pressure and damper type. In general:
      1) Damper section shall not exceed 24 ft-sq. with face velocity >1500 FPM.
      2) Damper section shall not exceed 18 ft-sq. with face velocity > 2500 FPM.
      3) Damper section shall not exceed 13 ft-sq. with face velocity > 3000 FPM.
   g. Multiple section dampers of two or more shall be arranged to allow actuators to be direct shaft mounted on the outside of the duct.
   h. Multiple section dampers of three or more sections wide shall be arranged with a 3-sided vertical channel (8 inches wide by 6 inches deep) within the duct or fan housing and between adjacent damper sections. Vertical channel shall be anchored at the top and bottom to the fan housing or building structure for support. The sides of each damper frame shall be connected to the channels. Holes in the channel shall allow damper drive blade shafts to pass through channel for direct shaft-mounting of actuators. Open side of channel shall be faced downstream of the airflow, except for exhaust air dampers.
   i. Multiple section dampers to be mounted flush within a wall or housing opening shall receive either vertical channel supports as described above or sheet metal standout collars. Sheet metal collars (12-inch minimum) shall bring each damper section out of the wall to allow direct shaft-mounting of the actuator on the side of the collar.

5. Valve Sizing for Water Coil
   a. On/Off control valves shall be line size.
   b. Modulating control valve body size may be reduced, at most, two pipe sizes from the line size or not less than half the pipe size. The BAS contractor shall size all water coil control valves for the application as follows:
      1) Booster-heat valves shall be sized not to exceed 4–9psi differential pressure. Size valve for 50% valve authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
      2) Primary valves shall be sized not to exceed 5–15psi differential pressure. Size valve for 50% valve authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
      3) Butterfly valves shall be sized for modulating service at 60–70 degree rotation. Design velocity shall be 12 feet per second or less when used with standard EPDM seats.
   c. Valve mounting arrangements shall comply to the following:
      1) Unions shall be provided on all ports of two-way and three-way valves.
2) Install three-way equal percentage characterized control valves in a mixing configuration with the “A” port piped to the coil.
3) Install 2.5 inches and above, three-way globe valves, as manufactured for mixing or diverting service to the coil.

2.8 ENCLOSURES
A. All controllers, power supplies and relays shall be mounted in enclosures.
B. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment. Indoor enclosures shall be NEMA 12 when installed in other than a clean environment.
C. Enclosures shall have hinged, locking doors.
D. Provide laminated plastic nameplates for all enclosures in any mechanical room or electrical room. Include location and unit served on nameplate. Laminated plastic shall be 0.125 inches thick and appropriately sized to make label easy to read.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.
B. Notify the owner’s representative in writing of conditions detrimental to the proper and timely completion of the work.
C. Do not begin work until all unsatisfactory conditions are resolved.

3.2 INSTALLATION (GENERAL)
A. Install in accordance with manufacturer’s instructions.
B. Provide all miscellaneous devices, hardware, software, interconnections, installation, and programming required to ensure a complete operating system in accordance with the sequences of operation and point schedules.

3.3 LOCATION AND INSTALLATION OF COMPONENTS
A. Locate and install components for easy accessibility; in general, mount 48 inches above floor with minimum 3 feet of clear access space in front of units. Obtain approval on locations from owner’s representative prior to installation.
B. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture, and high or low temperatures.
C. Identify all equipment and panels. Provide permanently mounted tags for all panels.
D. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections, and sized to suit pipe diameter without restricting flow.

3.4 INTERLOCKING AND CONTROL WIRING
A. Provide all interlock and control wiring. All wiring shall be installed neatly and professionally, in accordance with Specification Division 16 and all national, state and local electrical codes.
B. Provide wiring as required by functions as specified and as recommended by equipment manufacturers, to serve specified control functions. Provide shielded low capacitance wire for all communications trunks.
C. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the owner's representative prior to rough-in.

D. Provide auxiliary pilot duty relays on motor starters as required for control function.

E. Provide power for all control components from nearest electrical control panel or as indicated on the electrical drawings; coordinate with electrical contractor.

F. All control wiring in the mechanical, electrical, telephone and boiler rooms to be installed in raceways. All other wiring to be installed neatly and inconspicuously per local code requirements. If local code allows, control wiring above accessible ceiling spaces may be run with plenum-rated cable (without conduit).

3.5 DDC OBJECT TYPE SUMMARY
A. Provide all database generation.

B. Displays
   1. System displays shall show all analog and binary object types within the system. They shall be logically laid out for easy use by the owner. Provide outside air temperature indication on all system displays associated with economizer cycles.

C. Run Time Totalization
   1. At a minimum, run time totalization shall be incorporated for each monitored supply fan, return fan, exhaust fan, hot water and chilled water pumps. Warning limits for each point shall be entered for alarm and or maintenance purposes.

D. Trendlog
   1. All binary and analog object types (including zones) shall have the capability to be automatically trended.

E. Alarm
   1. All analog inputs (High/Low Limits) and selected binary input alarm points shall be prioritized and routed (locally or remotely) with alarm message per owner's requirements.

F. Database Save
   1. Provide backup database for all standalone application controllers on disk.

3.6 FIELD SERVICES
A. Prepare and start logic control system under provisions of this section.

B. Start up and commission systems. Allow sufficient time for startup and commissioning prior to placing control systems in permanent operation.

C. Provide the capability for off-site monitoring at control contractor's local or main office. At a minimum, off-site facility shall be capable of system diagnostics and software download. Owner shall provide phone line for this service for one year or as specified.

D. Provide owner's representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.

3.7 AS-BUILT DOCUMENTATION REQUIRED
A. At the completion of the project provide close out document that include:
   1. As built diagrams showing sequences, terminations and bills of material
   2. Cut sheet information of the products used in the control system
3. Maintenance and service information of the products provided.

3.8 TRAINING
A. Provide application engineer to instruct owner in operation of systems and equipment.

B. Provide system operator’s training to include (but not be limited to) such items as the following: modification of data displays, alarm and status descriptors, requesting data, execution of commands and request of logs. Provide this training to a minimum of three persons.

C. Provide on-site training above as required, up to 16 hours as part of this contract.

D. Provide tuition for at least one individual to attend for a one-week factory training class. If applicable, costs for travel, lodging and meals will be the responsibility of the owner.

3.9 DEMONSTRATION
A. Demonstrate complete operating system to owner’s representative.

B. Provide certificate stating that control system has been tested and adjusted for

END OF SECTION
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Raceways.
2. Building wire and connectors.
4. Electrical identification.
5. Electricity-metering components.
6. Electrical demolition.
7. Cutting and patching for electrical construction.
8. Touchup painting.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. FMC: Flexible metal conduit.

C. IMC: Intermediate metal conduit.

D. LFMC: Liquidtight flexible metal conduit.

E. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For electricity-metering equipment.

B. Shop Drawings: Dimensioned plans and sections or elevation layouts of electricity-metering equipment.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
1.5 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.

1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.

B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.

C. Coordinate electrical service connections to components furnished by utility companies.

1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.

2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.

D. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces. Access doors and panels are specified in Division 8 Section "Access Doors."

E. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.

F. Where electrical identification markings and devices will be concealed by acoustical ceilings and similar finishes, coordinate installation of these items before ceiling installation.

PART 2 - PRODUCTS

2.1 RACEWAYS

A. EMT: ANSI C80.3, zinc-coated steel, with set-screw or compression fittings.

B. FMC: Zinc-coated steel.

C. IMC: ANSI C80.6, zinc-coated steel, with threaded fittings.

D. LFMC: Zinc-coated steel with sunlight-resistant and mineral-oil-resistant plastic jacket.

E. RNC: NEMA TC 2, Schedule 40 PVC, with NEMA TC3 fittings.
F. Raceway Fittings: Specifically designed for the raceway type with which used.

2.2 CONDUCTORS

A. Conductors, No. 10 AWG and Smaller: Solid or stranded copper.

B. Conductors, Larger Than No. 10 AWG: Stranded copper.

C. Insulation: Thermoplastic, rated at 90 deg C minimum.

D. Wire Connectors and Splices: Units of size, ampacity rating, material, type, and class suitable for service indicated.

2.3 SUPPORTING DEVICES

A. Material: Cold-formed steel, with corrosion-resistant coating acceptable to authorities having jurisdiction.

B. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel.

C. Slotted-Steel Channel Supports: Flange edges turned toward web, and 9/16-inch- (14-mm-) diameter slotted holes at a maximum of 2 inches (50 mm) o.c., in webs.

D. Slotted-Steel Channel Supports: Comply with Division 5 Section "Metal Fabrications" for slotted channel framing.
   1. Channel Thickness: Selected to suit structural loading.
   2. Fittings and Accessories: Products of the same manufacturer as channel supports.

E. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring-steel clamps or click-type hangers.

F. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.

G. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Plugs have number and size of conductor gripping holes as required to suit individual risers. Body constructed of malleable-iron casting with hot-dip galvanized finish.

H. Expansion Anchors: Carbon-steel wedge or sleeve type.

I. Toggle Bolts: All-steel springhead type.


2.4 ELECTRICAL IDENTIFICATION
A. Identification Devices: A single type of identification product for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and these Specifications.

B. Raceway and Cable Labels: Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and minimum length of color field for each raceway and cable size.
   1. Type: Pretensioned, wraparound plastic sleeves. Flexible, preprinted, color-coded, acrylic band sized to suit the diameter of the item it identifies.
   2. Type: Preprinted, flexible, self-adhesive, vinyl. Legend is overlaminated with a clear, weather- and chemical-resistant coating.
   3. Color: Black letters on orange background.
   4. Legend: Indicates voltage.

C. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape, not less than 1 inch wide by 3 mils thick (25 mm wide by 0.08 mm thick).

D. Tape Markers for Wire: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.

E. Color-Coding Cable Ties: Type 6/6 nylon, self-locking type. Colors to suit coding scheme.

F. Engraved-Plastic Labels, Signs, and Instruction Plates: Engraving stock, melamine plastic laminate punched or drilled for mechanical fasteners 1/16-inch (1.6-mm) minimum thickness for signs up to 20 sq. in. (129 sq. cm) and 1/8-inch (3.2-mm) minimum thickness for larger sizes. Engraved legend in black letters on white background.

G. Interior Warning and Caution Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145. Preprinted, aluminum, baked-enamel-finish signs, punched or drilled for mechanical fasteners, with colors, legend, and size appropriate to the application.

H. Exterior Warning and Caution Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm), galvanized-steel backing, with colors, legend, and size appropriate to the application. 1/4-inch (6-mm) grommets in corners for mounting.

I. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers.

2.5 EQUIPMENT FOR ELECTRICITY METERING BY OWNER

A. Meter: Electronic kilowatt-hour measuring to record electricity used.

B. Meter: Electronic kilowatt-hour/demand measuring to record electricity used and highest peak demand over a time period according to electric utility. Meter is designed for use on the type and rating of circuit indicated for its application.
   2. Kilowatt-Demand Display: Digital, liquid-crystal type to register highest peak demand.
   3. Enclosure: NEMA 250, Type 1, minimum, with hasp for padlocking or sealing.
4. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.

5. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for the ratings of the circuits indicated for this application.
   a. Type: [Split] or [Solid] core.

6. Accuracy: Nationally recognized testing laboratory certified to meet [ANSI C12.1] [ANSI C12.16] specifications.

7. Demand Signal Communication Interface: Match signal to building automation system input that conveys data on instantaneous/integrated demand level measured by meter used for load switching to control demand.

C. Current-Transformer Cabinets: Listed or recommended by metering equipment manufacturer for use with sensors indicated.

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

2.6 TOUCHUP PAINT

A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.

B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 - EXECUTION

3.1 ELECTRICAL EQUIPMENT INSTALLATION

A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom.

B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.

C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.

D. Right of Way: Give to raceways and piping systems installed at a required slope.

3.2 RACEWAY APPLICATION

A. Use the following raceways for outdoor installations:
   1. Exposed: IMC.
   2. Concealed: IMC.
3. Underground, Single Run: RNC.
4. Underground, Grouped: RNC.
5. Connection to Vibrating Equipment: LFMC.
6. Boxes and Enclosures: NEMA 250, Type 3R or Type 4.

B. Use the following raceways for indoor installations:

1. Exposed: EMT.
2. Concealed: EMT.
3. Connection to Vibrating Equipment: FMC; except in wet or damp locations, use LFMC.
4. Damp or Wet Locations: IMC.
5. Boxes and Enclosures: NEMA 250, Type 1, unless otherwise indicated.

3.3 RACEWAY AND CABLE INSTALLATION

A. Conceal raceways and cables, unless otherwise indicated, within finished walls, ceilings, and floors.

B. Install raceways and cables at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Locate horizontal raceway runs above water and steam piping.

C. Use temporary raceway caps to prevent foreign matter from entering.

D. Make conduit bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.

E. Use raceway and cable fittings compatible with raceways and cables and suitable for use and location.

F. Install raceways embedded in slabs in middle third of slab thickness where practical, and leave at least 1-inch (25-mm) concrete cover.

1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
2. Space raceways laterally to prevent voids in concrete.
3. Install conduit larger than 1-inch trade size (DN27) parallel to or at right angles to main reinforcement. Where conduit is at right angles to reinforcement, place conduit close to slab support.
4. Make bends in exposed parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for exposed parallel raceways.

G. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of the pull wire.

H. Install telephone and signal system raceways, 2-inch trade size (DN53) and smaller, in maximum lengths of 150 feet (45 m) and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements, in addition to requirements above.
I. Connect motors and equipment subject to vibration, noise transmission, or movement with a maximum of 72-inch (1830-mm) flexible conduit. Install LFMC in wet or damp locations. Install separate ground conductor across flexible connections.

J. Set floor boxes level and trim after installation to fit flush to finished floor surface.

3.4 WIRING METHODS FOR POWER, LIGHTING, AND CONTROL CIRCUITS

A. Feeders: [Type THHN/THWN insulated conductors in raceway].

B. Branch Circuits: Type THHN/THWN insulated conductors in raceway.

C. Remote-Control Signaling and Power-Limited Circuits: Type THHN/THWN insulated conductors in raceway for Classes 1, 2, and 3, unless otherwise indicated.

3.5 WIRING INSTALLATION

A. Install splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

B. Install wiring at outlets with at least 12 inches (300 mm) of slack conductor at each outlet.

C. Connect outlet and component connections to wiring systems and to ground. 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.

3.6 ELECTRICAL SUPPORTING DEVICE APPLICATION

A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components.

B. Dry Locations: Steel materials.

C. Selection of Supports: Comply with manufacturer's written instructions.

D. Strength of Supports: Adequate to carry present and future loads, times a safety factor of at least four; minimum of 200-lb (90-kg) design load.

3.7 SUPPORT INSTALLATION

A. Install support devices to securely and permanently fasten and support electrical components.

B. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.
C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.

D. Size supports for multiple raceway installations so capacity can be increased by a 25 percent minimum in the future.

E. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

F. Install 1/4-inch-(6-mm-) diameter or larger threaded steel hanger rods, unless otherwise indicated.

G. Spring-steel fasteners specifically designed for supporting single conduits or tubing may be used instead of malleable-iron hangers for 1-1/2-inch (38-mm) and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to slotted channel and angle supports.

H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.

I. Simultaneously install vertical conductor supports with conductors.

J. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers. If bar hangers are used, attach bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 24 inches (610 mm) from the box.

K. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.

L. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.

M. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:

1. Wood: Fasten with wood screws or screw-type nails.
2. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.
3. New Concrete: Concrete inserts with machine screws and bolts.
4. Existing Concrete: Expansion bolts.
5. Instead of expansion bolts, threaded studs driven by a powder charge and provided with lock washers may be used in existing concrete.
6. Steel: Welded threaded studs or spring-tension clamps on steel.
   a. Field Welding: Comply with AWS D1.1.
7. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
8. Light Steel: Sheet-metal screws.
9. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load.

3.8 IDENTIFICATION MATERIALS AND DEVICES

A. Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated in the Contract Documents or required by codes and standards. Use consistent designations throughout Project.

C. Self-Adhesive Identification Products: Clean surfaces before applying.

D. Identify raceways and cables with color banding as follows:
   1. Bands: Pretensioned, snap-around, colored plastic sleeves or colored adhesive marking tape. Make each color band 2 inches (51 mm) wide, completely encircling conduit, and place adjacent bands of two-color markings in contact, side by side.
   2. Band Locations: At changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (8-m) maximum intervals in congested areas.
   3. Colors: As follows:
      c. Telecommunication System: Green and yellow.

E. Tag and label circuits designated to be extended in the future. Identify source and circuit numbers in each cabinet, pull and junction box, and outlet box. Color-coding may be used for voltage and phase identification.

F. Install continuous underground plastic markers during trench backfilling, for exterior underground power, control, signal, and communication lines located directly above power and communication lines. Locate 6 to 8 inches (150 to 200 mm) below finished grade. If width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches (400 mm), overall, use a single line marker.

G. Color-code 208/120-V system secondary service, feeder, and branch-circuit conductors throughout the secondary electrical system as follows:
   1. Phase A: Black.
   2. Phase B: Red.
   3. Phase C: Blue.
   5. Ground: Green.

H. Color-code 480/277-V system secondary service, feeder, and branch-circuit conductors throughout the secondary electrical system as follows:
   1. Phase A: Yellow.
2. Phase B: Brown.
3. Phase C: Orange.
4. Neutral: White with a colored stripe or gray.
5. Ground: Green.

I. Install warning, caution, and instruction signs where required to comply with 29 CFR, Chapter XVII, Part 1910.145, and where needed to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.

J. Install engraved-laminated emergency-operating signs with white letters on red background with minimum 3/8-inch- (9-mm-) high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

3.9 FIRESTOPPING

A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestopping."

3.10 DEMOLITION

A. Protect existing electrical equipment and installations indicated to remain. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.

B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.

C. Abandoned Work: Cut and remove buried raceway and wiring, indicated to be abandoned in place, 2 inches (50 mm) below the surface of adjacent construction. Cap raceways and patch surface to match existing finish.

D. Remove demolished material from Project site.

E. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.

3.11 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.

B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.
3.12 FIELD QUALITY CONTROL

A. Inspect installed components for damage and faulty work, including the following:
   1. Raceways.
   2. Building wire and connectors.
   4. Electrical identification.
   5. Electricity-metering components.
   6. Concrete bases.
   7. Electrical demolition.
   8. Cutting and patching for electrical construction.

B. Test Owner's electricity-metering installation for proper operation, accuracy, and usability of output data.
   1. Connect a load of known kW rating, 1.5 kW minimum, to a circuit supplied by the metered feeder.
   2. Turn off circuits supplied by the metered feeder and secure them in the "off" condition.
   3. Run the test load continuously for eight hours, minimum, or longer to obtain a measurable meter indication. Use a test load placement and setting that ensure continuous, safe operation.
   4. Check and record meter reading at end of test period and compare with actual electricity used based on test load rating, duration of test, and sample measurements of supply voltage at the test load connection. Record test results.
   5. Repair or replace malfunctioning metering equipment or correct test setup; then retest. Repeat for each meter in installation until proper operation of entire system is verified.

3.13 REFINISHING AND TOUCHUP PAINTING

A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 9 Section "Painting."
   1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
   2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
   3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
   4. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.14 CLEANING AND PROTECTION

A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
END OF SECTION 16050
SECTION 16060
GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Product Data: For the following:
   1. Ground rods.
   2. Ground Buses.
C. Qualification Data: For firms and persons specified in "Quality Assurance" Article.
D. Field Test Reports: Submit written test reports to include the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the InterNational Electrical Testing Association and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association to supervise on-site testing specified in Part 3.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

   1. Comply with UL 467.

C. Comply with NFPA 70; for overhead-line construction and medium-voltage underground construction, comply with IEEE C2.

D. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

   1. Grounding Conductors, Cables, Connectors, and Rods:
      
      a. Apache Grounding/Erico Inc.
      b. Boggs, Inc.
      c. Chance/Hubbell.
      d. Copperweld Corp.
      e. Dossert Corp.
      g. Framatome Connectors/Burndy Electrical.
      h. Galvan Industries, Inc.
      i. Harger Lightning Protection, Inc.
      j. Hastings Fiber Glass Products, Inc.
      k. Heary Brothers Lightning Protection Co.
      l. Ideal Industries, Inc.
      m. ILSCO.
      o. Korns: C. C. Korns Co.; Division of Robroy Industries.
      p. Lightning Master Corp.
      q. Lyncole XIT Grounding.
      r. O-Z/Gedney Co.; a business of the EGS Electrical Group.
      s. Raco, Inc.; Division of Hubbell.
      t. Robbins Lightning, Inc.
      v. Superior Grounding Systems, Inc.
      w. Thomas & Betts, Electrical.

2.2 GROUNDING CONDUCTORS
A. For insulated conductors, comply with Division 16 Section "Conductors and Cables."

B. Equipment Grounding Conductors: Insulated with green-colored insulation.

C. Grounding Electrode Conductors: Stranded cable.

D. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.

E. Bare Copper Conductors: Comply with the following:

F. Copper Bonding Conductors: As follows:
   1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inch (6.4 mm) in diameter.
   2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
   3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches (42 mm) wide and 1/16 inch (1.5 mm) thick.
   4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches (42 mm) wide and 1/16 inch (1.5 mm) thick.

G. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulators.

2.3 CONNECTOR PRODUCTS

A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Bolted Connectors: Bolted-pressure-type connectors, or compression type.

C. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

2.4 GROUNDING ELECTRODES

A. Ground Rods: [Copper-clad] steel.
   1. Size: [3/4 by 120 inches (19 by 3000 mm)] [5/8 by 96 inches (16 by 2400 mm)] in diameter.

PART 3 - EXECUTION

3.1 APPLICATION
A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. In raceways, use insulated equipment grounding conductors.

C. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells.

D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

E. Ground Rod Clamps at Test Wells: Use bolted pressure clamps with at least two bolts.

F. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Use insulated spacer; space 1 inch (25.4 mm) from wall and support from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.
   2. At doors, route the bus up to the top of the door frame, across the top of the doorway, and down to the specified height above the floor.

G. Underground Grounding Conductors: Use \textit{tinned} copper conductor, No. 2/0 AWG minimum. Bury at least 24 inches (600 mm) below grade or bury 12 inches (300 mm) above duct bank when installed as part of the duct bank.

3.2 EQUIPMENT GROUNDING CONDUCTORS

A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

B. Install equipment grounding conductors in all feeders and circuits.

C. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by NEC:
   1. Feeders and branch circuits.
   2. Lighting circuits.
   3. Receptacle circuits.
   5. Three-phase motor and appliance branch circuits.
   6. Flexible raceway runs.
   7. Armored and metal-clad cable runs.

D. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch-circuit runs from computer-area power panels or power-distribution units.

E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate equipment grounding conductor. Isolate equipment grounding conductor from raceway and from panelboard grounding terminals.
Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

F. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.

G. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and antifrost heating cable. Bond conductor to heater units, piping, connected equipment, and components.

H. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, 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.

3.3 INSTALLATION

A. Ground Rods: 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.
   1. Drive ground rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
   2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

C. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

D. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.

E. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.

F. Install one test well for each service at the ground rod electrically closest to the service entrance. Set top of well flush with finished grade or floor.

3.4 CONNECTIONS
A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

D. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

E. Connections at Test Wells: Use compression-type connectors on conductors and make bolted- and clamped-type connections between conductors and ground rods.

F. Tighten screws and bolts for grounding and bonding 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].

G. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

H. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.5 FIELD QUALITY CONTROL

A. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

B. Testing: Perform the following field quality-control testing:

1. After installing grounding system but before permanent electrical circuitry has 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. Measure ground resistance not less than two full days after the last trace of precipitation, and without the 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. Perform tests, by the fall-of-potential method according to IEEE 81.

3. Provide drawings locating each ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

   a. Equipment Rated 500 kVA and Less: 10 ohms.
   b. Equipment Rated 500 to 1000 kVA: 5 ohms.
   c. Equipment Rated More Than 1000 kVA: 3 ohms.
   e. Manhole Grounds: 10 ohms.

4. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

3.6 GRADING AND PLANTING

   A. Restore surface features, including vegetation, at areas disturbed by Work of this Section. Reestablish original grades, unless otherwise indicated. If sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include application of topsoil, fertilizer, lime, seed, sod, sprig, and mulch. Comply with Division 2 Section "Landscaping." Maintain restored surfaces. Restore disturbed paving as indicated.

END OF SECTION 16060
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes seismic restraints and other earthquake-damage-reduction measures for electrical components. It complements optional seismic construction requirements in the various electrical component Sections.

1.3 DEFINITIONS


B. Seismic Restraint: A fixed device (a seismic brace, an anchor bolt or stud, or a fastening assembly) used to prevent vertical or horizontal movement, or both vertical and horizontal movement, of an electrical system component during an earthquake.

C. Mobile Structural Element: A part of the building structure such as a slab, floor structure, roof structure, or wall that may move independent of other mobile structural elements during an earthquake.

1.4 SUBMITTALS

A. Product Data: Illustrate and indicate types, styles, materials, strength, fastening provisions, and finish for each type and size of seismic restraint component used.

1.  Anchor Bolts and Studs: Tabulate types and sizes, complete with report numbers and rated strength in tension and shear as evaluated by [an agency approved by authorities having jurisdiction].

1.5 PROJECT CONDITIONS

A. Project Seismic Zone and Zone Factor as Defined in UBC.

1.6 COORDINATION
A. Coordinate layout and installation of seismic bracing with building structural system and architectural features, and with mechanical, fire-protection, electrical, and other building features in the vicinity.

B. Coordinate concrete bases with building structural system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

1. Amber/Booth Company, Inc.
2. B-Line Systems, Inc.
3. Erico, Inc.
4. GS Metals Corp.
5. Loos & Company, Inc.
6. Mason Industries, Inc.
7. Powerstrut.
8. Thomas & Betts Corp.

2.2 MATERIALS

A. Use the following materials for restraints:

1. Indoor Dry Locations: Steel, zinc plated.
2. Outdoors and Damp Locations: Galvanized steel.

2.3 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

A. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

B. Concrete and Masonry Anchor Bolts and Studs: Steel-expansion wedge type.

C. Concrete Inserts: Steel-channel type.

D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.
E. Welding Lugs: Comply with MSS SP-69, Type 57.

F. Beam Clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

G. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

2.4 SEISMIC BRACING COMPONENTS

A. Slotted Steel Channel: 1-5/8-by-1-5/8-inch (41-by-41-mm) cross section, formed from 0.1046-inch- (2.7-mm-) thick steel, with 9/16-by-7/8-inch (14-by-22-mm) slots at a maximum of 2 inches (50 mm) o.c. in webs, and flange edges turned toward web.

1. Materials for Channel: ASTM A 570, GR 33.
3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.
4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.

B. Channel-Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.

C. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets, and bolts designed for cable service.

1. Arrange units for attachment to the braced component at one end and to the structure at the other end.
2. Wire Rope Cable: Comply with ASTM 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.

D. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

PART 3 - EXECUTION

3.1 APPLICATION

A. Generator Sets: Comply with Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."

3.2 INSTALLATION

A. Install seismic restraints according to applicable codes and regulations and as approved by authorities having jurisdiction, unless more stringent requirements are indicated.
3.3 STRUCTURAL ATTACHMENTS

A. Use bolted connections with steel brackets, slotted channel, and slotted-channel fittings to spread structural loads and reduce stresses.

B. Attachments to New Concrete: Bolt to channel-type concrete inserts or use expansion anchors.

C. Attachments to Existing Concrete: Use expansion anchors.

D. Holes for Expansion Anchors in Concrete: Drill at locations and to depths that avoid reinforcing bars.

E. Attachments to Solid Concrete Masonry Unit Walls: Use expansion anchors.

F. Attachments to Hollow Walls: Bolt to slotted steel channels fastened to wall with expansion anchors.

G. Attachments to Wood Structural Members: Install bolts through members.

H. Attachments to Steel: Bolt to clamps on flanges of beams or on upper truss chords of bar joists.

3.4 ELECTRICAL EQUIPMENT ANCHORAGE

A. Anchor rigidly to a single mobile structural element or to a concrete base that is structurally tied to a single mobile structural element.

B. Anchor panelboards, motor-control centers, motor controls, switchboards, switchgear, transformers, unit substations, fused power-circuit devices, transfer switches, busways, battery racks, static uninterruptible power units, power conditioners, capacitor units, communication system components, and electronic signal processing, control, and distribution units as follows:

1. Size concrete bases so expansion anchors will be a minimum of 10 bolt diameters from the edge of the concrete base.
2. Concrete Bases for Floor-Mounted Equipment: Use female expansion anchors and install studs and nuts after equipment is positioned.
3. Bushings for Floor-Mounted Equipment Anchors: Install to allow for resilient media between anchor bolt or stud and mounting hole in concrete.
4. Anchor Bolt Bushing Assemblies for Wall-Mounted Equipment: Install to allow for resilient media where equipment or equipment-mounting channels are attached to wall.
5. Torque bolts and nuts on studs to values recommended by equipment manufacturer.

3.5 SEISMIC BRACING INSTALLATION

A. Install bracing according to spacings and strengths indicated by approved analysis.

B. Expansion and Contraction: Install to allow for thermal movement of braced components.

C. Cable Braces: Install with maximum cable slack recommended by manufacturer.
D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to the structure at flanges of beams, upper truss chords of bar joists, or at concrete members.

3.6 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Make flexible connections in raceways, cables, wireways, cable trays, and busways where they cross expansion and seismic control joints, where adjacent sections or branches are supported by different structural elements, and where they terminate at electrical equipment anchored to a different mobile structural element from the one supporting them.

END OF SECTION 16071
SECTION 16139

CABLE TRAYS

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes cable trays and accessories.
   B. Related Sections include the following:
      1. Division 16 Section "Electrical General Provisions" for cable tray supports not specified in this Section.

1.3 SUBMITTALS
   A. Product Data: Include data indicating dimensions and finishes for each type of cable tray.
   B. Shop Drawings: Detail fabrication and installation of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
   C. Coordination Drawings: Include floor plans and sections drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural and mechanical elements.
   D. Factory-certified test reports of specified products, complying with NEMA VE 1.
   E. Maintenance Data: For cable trays to include in the maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE
   A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.
   B. Listing and Labeling: Provide cable trays and accessories specified in this Section that are listed and labeled.
C. Comply with NEMA VE 1, "Metal Cable Tray Systems," for materials, sizes, and configurations.

D. Comply with NFPA 70.

1.5 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated.

1. Notify Owner not less than 5 days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Owner’s written permission.

1.6 COORDINATION

A. Coordinate layout and installation of cable tray with other installations.

1. Revise locations and elevations from those indicated as required to suit field conditions and as approved by Architect.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

1. B-Line Systems, Inc.
2. Chalfant Cable Trays.
3. GS Metals Corp.
5. Mono-Systems, Inc.
6. P-W Industries, Inc.

2.2 MATERIALS AND FINISHES

A. Cable Trays, Fittings, and Accessories: Aluminum, open ladder type complying with Aluminum Association’s alloy 6063-T6 for rails, rungs, and cable trays, and alloy 5052-H32 or 6061-T6 for fabricated parts.

B. Cable Trays, Fittings, and Accessories: Stainless steel, Type 304.
C. Protect steel hardware against corrosion by galvanizing according to ASTM B 633 or cadmium plating according to ASTM B 766.

D. Fabricate cable tray products with rounded edges and smooth surfaces.

E. Sizes: Refer to Drawings for specific configurations.

2.3 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.4 WARNING SIGNS

A. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

B. Materials and fastening are specified in Division 16 Section "Electrical General Provisions."

2.5 SOURCE QUALITY CONTROL

A. Perform design and production tests according to NEMA VE 1.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates for compliance with requirements for installation tolerances and other conditions affecting performance of cable trays. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install cable tray level and plumb according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.

B. Remove burrs and sharp edges from cable trays.

C. Fasten cable tray supports securely to building structure as specified in Division 16 Section "Basic Electrical Materials and Methods," unless otherwise indicated.
1. Locate and install supports according to NEMA VE 1.
2. Design supports, including fastenings to the structure, to carry the greater of the calculated load multiplied by a safety factor of 4 or the calculated load plus 200 lb (90 kg).

D. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independently of fittings. Do not carry weight of cable tray on equipment enclosure.

E. Install expansion connectors where cable tray crosses a building expansion joint and in cable tray runs that exceed 90 feet (27 m). Space connectors and set gaps according to NEMA VE 1.

F. Make changes in direction and elevation using standard fittings.

G. Make cable tray connections using standard fittings.

H. Locate cable tray above piping, unless accessibility to cable tray is required or unless otherwise indicated.

I. Seal penetrations through fire and smoke barriers according to Division 16 Section "Electrical ageneral Provisions."

J. Sleeves for Future Cables: Install capped sleeves for future cables through firestopping-sealed cable tray penetrations of fire and smoke barriers.

K. Workspace: Install cable trays with sufficient space to permit access for installing cables.

3.3 CONNECTIONS

A. Ground cable trays according to manufacturer's instructions.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Grounding: Test cable trays to ensure electrical continuity of bonding and grounding connections.

3.5 CLEANING

A. On completion of cable tray installation, including fittings, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes, including chips, scratches, and abrasions.

3.6 PROTECTION

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure cable tray is without damage or deterioration at the time of Substantial Completion.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 16139
SECTION 16140
WIRING DEVICES

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes receptacles, connectors, switches, and finish plates.

1.3 DEFINITIONS
   A. GFCI:  Ground-fault circuit interrupter.

1.4 SUBMITTALS
   A. Product Data:  For each product specified.
   B. Shop Drawings:  Legends for receptacles and switch plates.
   C. Samples:  For devices and device plates for color selection and evaluation of technical features.
   D. Maintenance Data:  For materials and products to include in maintenance manuals specified in Division 1.

1.5 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories:  Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
   B. Comply with NEMA WD 1.
   C. Comply with NFPA 70.

1.6 COORDINATION
   A. Receptacles for Owner-Furnished Equipment:  Match plug configurations.
1. Cord and Plug Sets: Match equipment requirements.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Owner.

1. Telephone/Power Service Poles: One for each 10, but not less than one.
2. Floor Service-Outlet Assemblies: One for each 10, but not less than one.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: As specified on Drawings.

2.2 RECEPTACLES

A. Straight-Blade and Locking Receptacles: Heavy-Duty grade.

B. GFCI Receptacles: Feed-through type, with integral NEMA WD 6, Configuration 5-20R duplex receptacle arranged to protect connected downstream receptacles on same circuit. Design units for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter.

2.3 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded-copper conductors, with type SOW-A jacket. Green-insulated grounding conductor, and equipment-rating ampacity plus a minimum of 30 percent.

2.4 SWITCHES

A. Snap Switches: Heavy-duty, quiet type.

2.5 WALL PLATES

A. Single and combination types match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.04-inch- (1-mm-) thick, Type 302, satin-finished stainless steel.

2.6 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
B. Type: Modular, pop-up, dual-service units suitable for wiring method used.
C. Compartmentation: Barrier separates power and signal compartments.
D. Power Receptacle: NEMA WD 6, Configuration 5-20R, gray finish, unless otherwise indicated.

2.7 FINISHES

A. Color: Gray, unless otherwise indicated or required by Code.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install devices and assemblies plumb and secure.
B. Install wall plates when painting is complete.
C. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates. See Architectural Drawings for other orientations.
D. Protect devices and assemblies during painting.
E. Adjust locations at which floor service outlets to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 16 Section "Electrical General Provisions."
1. Switches: Where three or more switches are ganged, and elsewhere as indicated, identify each switch with approved legend engraved on wall plate.
2. Receptacles: Identify panelboard and circuit number from which served. Use machine-printed, pressure-sensitive, abrasion-resistant label tape on face of plate and durable wire markers or tags within outlet boxes.
3.3 CONNECTIONS

A. Connect wiring device grounding terminal to branch-circuit equipment grounding conductor.

B. Tighten electrical connectors and terminals according to manufacturers published torque-tightening values. If manufacturers torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.

B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.

C. Replace damaged or defective components.

3.5 CLEANING

A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 16140
SECTION 16410
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:

1. Service disconnecting means.
2. Feeder and branch-circuit protection.

1.3 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.
B. RMS: Root mean square.
C. SPDT: Single pole, double throw.

1.4 SUBMITTALS

A. Product Data: For each type of switch, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
B. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.
C. Field Test Reports: Submit written test reports and include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
D. Maintenance Data: For enclosed switches and circuit breakers and for components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:

1. Routine maintenance requirements for components.
2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
3. Time-current curves, including selectable ranges for each type of circuit breaker.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency that is a member company of the InterNational Electrical Testing Association and that is acceptable to authorities having jurisdiction.

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

C. Comply with NEMA AB 1 and NEMA KS 1.

D. Comply with NFPA 70.

E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.6 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Fusible Switches:
   b. General Electric Co.; Electrical Distribution & Control Division.
   c. Siemens Energy & Automation, Inc.
   d. Square D Co.

2. Molded-Case Circuit Breakers:
b. General Electric Co.; Electrical Distribution & Control Division.
c. Siemens Energy & Automation, Inc.
d. Square D Co.

3. Combination Circuit Breaker and Ground-Fault Trip:
   b. General Electric Co.; Electrical Distribution & Control Division.
   c. Siemens Energy & Automation, Inc.
   d. Square D Co.

2.2 ENCLOSED SWITCHES

A. Enclosed, Non-fusible Switch: NEMA KS 1, Type [GD] [HD], with lockable handle.

B. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, lockable handle with two padlocks, and interlocked with cover in closed position.

2.3 ENCLOSED CIRCUIT BREAKERS

A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
   3. Molded-Case Switch: Molded-case circuit breaker without trip units.

B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
   1. Lugs: [Mechanical] style suitable for number, size, trip ratings, and material of conductors.
   2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
   4. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at [55] [75] percent of rated voltage.

2.4 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
   1. Outdoor Locations: NEMA 250, Type 3R.
   3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
2.5 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosures before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.

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

3.2 INSTALLATION

A. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "[Electrical General Provisions]."

B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.4 CONNECTIONS

A. Install equipment grounding connections for switches and circuit breakers with ground continuity to main electrical ground bus.

B. Install power wiring. Install wiring between switches and circuit breakers, and control and indication devices.

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL
A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
2. Test continuity of each line- and load-side circuit.

B. Testing Agency: Engage a qualified independent testing agency to perform specified testing.

C. Testing: After installing enclosed switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.6 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16410
PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes load centers and panelboards, overcurrent protective devices, and associated auxiliary equipment rated 600 V and less for the following types:
   1. Lighting and appliance branch-circuit panelboards.
   2. Distribution panelboards.
B. Related Sections include the following:
   1. Division 16 Section "Seismic Controls for Electrical Work."

1.3 DEFINITIONS
A. EMI: Electromagnetic interference.
B. GFCI: Ground-fault circuit interrupter.
C. RFI: Radio-frequency interference.
D. RMS: Root mean square.
E. SPDT: Single pole, double throw.

1.4 SUBMITTALS
A. Product Data: For each type of panelboard, overcurrent protective device, TVSS device, accessory, and component indicated. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, and finishes.
B. Shop Drawings: For each panelboard and related equipment.
   1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
a. Enclosure types and details for types other than NEMA 250, Type 1.
b. Bus configuration, current, and voltage ratings.
c. Short-circuit current rating of panelboards and overcurrent protective devices.
d. UL listing for series rating of installed devices.
e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Seismic Controls for Electrical Work." Include the following:
   1. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Qualification Data: Submit data for testing agencies indicating that they comply with qualifications specified in "Quality Assurance" Article.

E. Field Test Reports: Submit written test reports and include the following:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

F. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

G. Maintenance Data: For panelboards and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Contract Closeout," include the following:
   1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency that is a member company of the InterNational Electrical Testing Association and that is acceptable to authorities having jurisdiction.

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

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.
1.6 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

1.7 EXTRA MATERIALS

A. Keys: [Six] spares of each type of panelboard cabinet lock.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
   c. Siemens Energy & Automation, Inc.
   d. Square D Co.

2. TVSS Panelboards:
   a. Current Technology, Inc.
   b. Liebert Corporation.

2.2 FABRICATION AND FEATURES

A. Enclosures: [Flush- and surface-] mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.

B. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.

C. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

D. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.

E. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.

F. Bus: [Hard-drawn copper, 98 percent conductivity]

G. Main and Neutral Lugs: [Compression] and [Mechanical] type suitable for use with conductor material.
H. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.

I. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.

J. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

K. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box.

L. Gutter Barrier: Arrange to isolate individual panel sections.

2.3 PANELBOARD SHORT-CIRCUIT RATING

A. Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: [Plug-in] or [Bolt-on] circuit breakers, replaceable without disturbing adjacent units.

B. Doors: Front mounted with concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.5 DISTRIBUTION PANELBOARDS

A. Doors: Front mounted, secured with vault-type latch with tumbler lock; keyed alike.

B. Main Overcurrent Protective Devices: [Circuit breaker] [Fused switch].

C. Branch overcurrent protective devices shall be one of the following:

2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
3. Fused switches.

2.6 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

B. Molded-Case Circuit-Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.

1. Lugs: [Mechanical] style, suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
4. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at [55] [75] percent of rated voltage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.
B. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."
C. Mounting Heights: Top of trim 74 inches (1880 mm) above finished floor, unless otherwise indicated.
D. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
E. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
F. Install filler plates in unused spaces.
G. Provision for Future Circuits at Flush Panelboards: Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
H. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "[Electrical General Provisions]."
B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.
3.3 CONNECTIONS

A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.

B. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Testing Agency: Engage a qualified independent testing agency to perform specified testing.

C. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Balancing Loads: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data-processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

E. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.6 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16442
SECTION 16491

FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes cartridge fuses, rated 600 V and less, for use in switches, panelboards, switchboards, controllers, and motor-control centers; and spare fuse cabinets.

1.3 SUBMITTALS

A. Product Data: Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings for each fuse type indicated.

B. Product Data: Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Let-through current curves for fuses with current-limiting characteristics.
3. Time-current curves, coordination charts and tables, and related data.
4. Fuse size for elevator feeders and elevator disconnect switches.

1.4 QUALITY ASSURANCE

A. Source Limitations: Provide fuses from a single manufacturer.

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

C. Comply with NEMA FU 1.

D. Comply with NFPA 70.

1.5 PROJECT CONDITIONS
A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (4.4 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION
A. Coordinate fuse ratings with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

1.7 EXTRA MATERIALS
A. Furnish extra materials described below that match products installed and that are packaged in original cartons or containers and identified with labels describing contents.

1. Fuses: Quantity equal to <3> of each type and size.

PART 2 - PRODUCTS

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

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

2. Eagle Electric Mfg. Co., Inc.
3. Ferraz Corp.
5. Gould Shawmut.

2.2 CARTRIDGE FUSES
A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

3.2 FUSE APPLICATIONS

A. Main Service: [Class L, time delay]

B. Main Feeders: [Class L, time delay].

C. Motor Branch Circuits: [Class RK1, time delay] or [Class RK5, time delay].

D. Other Branch Circuits: [Class RK1, time delay] or [Class RK5, time delay].

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

END OF SECTION 16491
SECTION 16511
INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes interior lighting fixtures, lighting fixtures mounted on exterior building surfaces, lamps, ballasts, emergency lighting units, and accessories.

1.3 SUBMITTALS

A. Product Data: For each type of lighting fixture indicated, arranged in order of fixture designation. Include data on features, accessories, and the following:

1. Dimensions of fixtures.
2. Certified results of independent laboratory tests for fixtures and lamps for electrical ratings and photometric data.
3. Certified results of laboratory tests for fixtures and lamps for photometric performance.
4. Emergency lighting unit battery and charger.
5. Fluorescent and high-intensity-discharge ballasts.
6. Air and Thermal Performance Data: For air-handling fixtures. Furnish data required in "Submittals" Article in Division 15 Section "Diffusers, Registers, and Grilles."
7. Sound Performance Data: For air-handling fixtures. Indicate sound power level and sound transmission class in test reports certified according to ADC.
8. Types of lamps.

B. Shop Drawings: Show details of nonstandard or custom fixtures. Indicate dimensions, weights, method of field assembly, components, features, and accessories.

1. Wiring Diagrams: Detail wiring for fixtures and differentiate between manufacturer-installed and field-installed wiring.

C. Coordination Drawings: Reflected ceiling plans and sections drawn to scale and coordinating fixture installation with ceiling grid, ceiling-mounted items, and other components in the vicinity. Include work of all trades that is to be installed near lighting equipment.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
E. Maintenance Data: For lighting fixtures to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

B. Comply with NFPA 70.

C. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

1.5 COORDINATION

A. Fixtures, Mounting Hardware, and Trim: Coordinate layout and installation of lighting fixtures with ceiling system and other construction.

1.6 WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Special Warranty for Batteries: Written warranty, executed by manufacturer agreeing to replace rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Special Warranty Period for Batteries: Manufacturer's standard, but not less than 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for last nine years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: As specified on Drawings...

2.2 FIXTURES AND FIXTURE COMPONENTS, GENERAL

A. Metal Parts: Free from burrs, sharp corners, and edges.

B. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses,
diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.

2.3 EXIT SIGNS

A. General Requirements: Comply with UL 924 and the following:
   1. Sign Colors and Lettering Size: Comply with authorities having jurisdiction.

2.4 FIXTURE SUPPORT COMPONENTS

A. Comply with Division 16 Section "Basic Electrical Materials and Methods," for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (12-mm) steel tubing with swivel ball fitting and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch (12-mm) steel tubes with single canopy arranged to mount a single fixture. Finish same as fixture.

D. Rod Hangers: 3/16-inch- (5-mm-) minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

F. Aircraft Cable Support: Use cable, anchorages, and intermediate supports recommended by fixture manufacturer.

2.5 FINISHES

A. Fixtures: Manufacturer's standard, unless otherwise indicated.
   1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials. Install lamps in each fixture.

B. Support for Fixtures in or on Grid-Type Suspended Ceilings: Use grid for support.
1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches (150 mm) from fixture corners.
2. Support Clips: Fasten to fixtures and to ceiling grid members at or near each fixture corner.
3. Fixtures of Sizes Less Than Ceiling Grid: Arrange as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.

C. Suspended Fixture Support: As follows:
   1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
   3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
   4. Continuous Rows: Suspend from cable installed according to fixture manufacturer's written instructions and details on Drawings.

D. Air-Handling Fixtures: Install with dampers closed.

3.2 CONNECTIONS

A. Ground equipment.
   1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
B. Provide instruments to make and record test results.
C. Tests: As follows:
   1. Verify normal operation of each fixture after installation.
   2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
   3. Verify normal transfer to battery source and retransfer to normal.
   4. Report results in writing.
D. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

3.4 CLEANING AND ADJUSTING

A. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer.
B. Adjust aimable fixtures to provide required light intensities.

END OF SECTION 16511