

PROJECT MANUAL

100% ISSUE FOR BID
BIA Project No. 140A1622F0214

Rosebud Agency Boiler and HVAC System(s) Design

at

Mission, South Dakota

September 25, 2024

for

Bureau of Indian Affairs Great Plains Region Division of Facilities



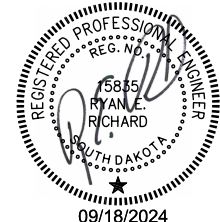
Joseph David Associates LLC
19970 Chloe Layne Rd.
Spiro, OK 74959

Architect of Record:
David M. Shelton
Joseph David Associates



Farris Engineering INC
Farris-usa.com

Mechanical Engineer of Record:
Ryan E. Richard
Farris Engineering



Electrical Engineer of Record:
Michael D. Wallace
Farris Engineering



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END OF SECTION

**SECTION 011000
SUMMARY****PART 1 GENERAL****1.01 PROJECT**

- A. Project Name: Rosebud Agency Boiler and HVAC System(s) Design
- B. Owner's Name and Address: Bureau of Indian Affairs, Great Plains Region, Division of Facilities 115 Fourth Ave SE, Suite 400 Aberdeen, South Dakota 57401.
 - 1. The Contracting Office (CO) and Contracting Officer Representative (COR) are synonymous with the Owner relative to all communications, submittals, and correspondence.
- C. Architect's Name: Joseph David Associates LLC.
 - 1. Under BIA Contract No.:140A1622F0214
- D. The Project consists of limited demolition and MEP improvements.

1.02 DESCRIPTION OF WORK

- A. Scope of work is defined in the Drawings and Specifications.

1.03 OWNER OCCUPANCY

- A. Owner intends to continue to occupy adjacent portions of the existing building during the entire construction period.
- B. Owner intends to occupy the Project upon Substantial Completion.
- C. Cooperate with Owner to minimize conflict and to facilitate Owner's operations.
- D. Schedule the Work to accommodate Owner occupancy.
- E. Project phasing to be approved by the Owner or Owner's Representative prior to commencement of work.

1.04 CONTRACTOR USE OF SITE AND PREMISES

- A. Construction Operations: Limited to areas noted on Drawings.
- B. Provide access to and from site as required by law and by Owner:
 - 1. Emergency Building Exits During Construction: Keep all exits required by code open during construction period; provide temporary exit signs if exit routes are temporarily altered.
 - 2. Do not obstruct roadways, sidewalks, or other public ways without permit.

END OF SECTION

SECTION 01 1100 SUMMARY OF WORK**PART 1 - GENERAL****1.01 DESCRIPTION OF WORK****A. Project Identification:**

1. Project Location: BUILDING 1004
MISSION, SOUTH DAKOTA
2. Owner's Name: Bureau of Indian Affairs, Great Plains Region, Division of Facilities
3. Asbestos Removal Designer:

Legend Technical Services, Inc., 88 Empire Drive, St Paul, MN 55103 – 651-221-4085 or 612-619-6547 (cell phone). Cheryl A Sykora, CIH,CSP,CHMM, SDRP – South Dakota certified asbestos designer #9566.

C. Work Scope –

Includes the removal of the following:

General Information

Building 1004 was historically utilized as a Boy's dormitory and converted to an administration building. The building is two levels with the lower, basement level predominantly mechanical crawlspaces. The drawings provided by Farris Engineering show the general layout of the building and the mechanical systems to be demolished as part of the planned mechanical changes in the building. A building survey performed in 1989 identified asbestos in mechanical system insulation. Any thermal system insulation that is not obviously fiberglass will be considered asbestos and will be removed in accordance with these asbestos remediation specifications. NOTE: the possibility exists that fiberglass was added later over the existing asbestos materials and the abatement contractor should investigate prior to assuming it is fiberglass.

Specific Scope

Ceiling Tile and associated glue pucks – ground/first floor hallways have a ceiling tile glued to gypsum wallboard. The remediation work includes removing all the vintage fluorescent light fixtures from the ceiling and removing the ceiling tile/glue pucks to the GWB substrate. Work needs to be coordinated with building occupants and all hallways may not be available for abatement at one time.

Crawlspace Piping – The intent of this renovation is to replace all of the piping in the crawlspaces located on either side of the basement central main area. The crawlspaces are dirt floored and may have pieces of insulation on the surface. Visible insulation pieces are to be removed first and then the objective is to wrap the pipe lengths and use glovebag techniques to remove sections of insulation to cut the piping into manageable lengths.

Boiler Room – The intent of the renovation is to remove all the existing mechanical systems and replace with new systems. The boiler(s) are still operating and will require investigation at the time of demolition to identify and remove any asbestos-containing material by the abatement contractor at the time of demolition. The piping and tanks have asbestos insulation that will require abatement prior to removing. The boiler flue has asbestos containing insulation and the intent is to re-use the opening for future exhaust. The opening needs to be open and free of any asbestos containing materials. When the abatement contractor is completed in the boiler room there will be no asbestos-containing materials

remaining.

Other thermal system insulation as needed – It is anticipated that the renovation may require small areas of asbestos removal to accomplish some of the work. This will require coordination with the trades involved to identify what is needed. It is the responsibility of the abatement contractor to bring this to the attention of the General Contractor to get addressed in the most cost-effective manner avoiding additional site visits to accommodate missed items.

D. Drawings –

The mechanical drawings produced by others show the extent of the piping in the crawlspace and the layout of the hallway ceilings. Consult those for information.

1.02 WORK SEQUENCING

1.03 CONDITIONS OF THE SITE

- A. The contractor shall accept the site in the condition that he/she finds it. It is anticipated the asbestos abatement contractor is a subcontractor to a general contractor and items required by the abatement contractor such as water source and power will be coordinated with a General Contractor. The work locations are traditionally free of moveable items but it is anticipated any items the occupants wish to save in these areas will be moved by them.

1.04 SCHEDULING

- A. The contractor shall schedule and sequence his/her work so as to minimize the interruption of services and interference with the Owner's use of the building and the site.

1.05 INTERRUPTIONS OF UTILITIES

- A. The contractor shall receive permission from the Owner before interrupting any utility service that will affect the community or the building. Such interruptions shall generally be kept to a practical minimum and in no case shall exceed 1 hour without prior approval by the Owner.
- B. Verify water and power to the buildings at the time of the work under this contract. Contractor is required to provide power and water if they are not otherwise available.

1.06 STORAGE OF MATERIALS

- A. The Owner will allow the temporary storage of materials and contractors equipment in designated areas.

1.07 BARRIERS

- A. Provide a barrier and/or locked dumpster for any waste ACM being stored on the site.

1.08 LIFE SAFETY

- A. Where necessary and/or required by the governing authority, this contractor shall provide any necessary temporary detectors, alarm systems, or perform fire watches in accordance with the requirements of the local governing authority. If required, these services shall be provided at no additional cost to the Owner.

1.09 VENTILATION

It will be the contractor's responsibility to provide any necessary local or general ventilation and any associated heating or cooling to protect workers from any harmful fumes or dust generated by his/her work.

1.10 EXAMINATION OF SITE OF WORK

- A. It shall be expected that each contractor, before submitting a proposal for work required under this specification, has visited the site, made a thorough examination of conditions, and familiarized himself/herself with all existing conditions and all the limitations pertaining to the work herein contemplated.

- B. No additional compensation or time will be allowed because of the contractor's misunderstanding as to the amount of work involved, the quantities of asbestos materials, or his/her lack of knowledge of any of the conditions pertaining to the work based on his/her neglect or failure to visit or make an examination of the site.
- C. It is also expected that in the event that any of this specification or the drawings relative to asbestos-containing materials removal and demolition work are not clear or in the event there are any discrepancies, these will be brought to the attention of the Design Professional/Owner/Owner's Representative during bidding so that a decision in writing can be rendered by the Design Professional before the bids are opened. Failure to clarify a discrepancy shall make the contractor responsible for bidding the largest quantity, best quality, or most stringent requirement stated or implied by any of the contract documents.

1.11 CONTRACTOR'S RESPONSIBILITY

- A. The whole of the work and everything pertaining thereto which is specified or reasonably implied in the contract documents shall be the sole cost and risk of the contractor from its commencement until its final acceptance by the Owner. The contractor shall personally, or, through an authorized representative, constantly supervise the work and be at the site of the work during working hours or be represented by them, and who shall have authority to act for the contractor. The contractor shall employ only competent mechanics and workers on the project. Asbestos workers must be licensed in the State of South Dakota.
- B. The contractor shall cause the least possible inconvenience to the public, to the neighboring residences, and others in the vicinity of this work. He/she shall not permit any materials, tools, equipment, waste excavation or rubbish to be stored, deposited or thrown upon any private or adjoining grounds, nor cause or permit to exist any unnecessary or unreasonable obstructions anywhere.

1.12 PROCEDURES AND PROTECTION

- A. Suitable precautions shall be taken to prevent injury to persons and property. The contractor shall protect the grounds, fences, walks, curbs, pavements, building, and all else from injury on account of this work.

1.13 CONTRACTOR USE OF PREMISES

- A. The contractor shall limit his/her use of the premises to the work areas indicated. Confine operations at the site to the areas permitted under the contract. Portions of the site beyond areas on which work is indicated are not to be disturbed.

Conform to site rules and regulations affecting the work while engaged in project construction. The contractor's employees are to park their vehicles in areas designated and follow existing parking rules and regulations.

- B. Keep existing driveways and entrances serving the premises clear and available to the Owner and his/her employees at all times. Do not use these areas for parking or storage of materials.
- C. Do not encumber the site with materials or equipment. Confine stockpiling of materials and location of storage sheds to the areas indicated. If additional storage is necessary, the contractor shall obtain such storage on-site with no additional payment by Owner.

1.14 WORK PLAN

- A. Submit a project plan of the procedures, materials, and methods proposed for use in complying with the requirements of this specification. Include in the plan the location and layout of decontamination areas, the sequencing of asbestos removal work, the interface of trades involved in the performance of work, methods to be used to assure the safety of occupants and visitors to the site, disposal plan including name and location of EPA approved disposal site, and a detailed description of the methods to be employed to control pollution. Identify the extent and location of each containment area. List specific removal methods proposed for each operation in every area of this building. The plan must be approved by the Owner or Owner's designated representative prior to commencement of work.

1.16 POTENTIAL ASBESTOS HAZARD

- A. If asbestos materials are disturbed outside of a containment enclosure, close off the area, stop work, and notify the Owner and Owner's representative.

1.17 STOP WORK

- A. If the Owner or Owner's designated representative presents a written stop work order, immediately and automatically stop all work. Do not commence work until authorized in writing by the Owner.

1.18 CODE COMPLIANCE

- A. The work to be performed and materials used shall conform in every respect to all requirements of Federal, State, and local codes, ordinances, laws, rules, and regulations pertaining to such work. It is the contractor's responsibility to check all requirements before bidding or performing the work.
- B. Where these specifications may deviate from the most current edition and recent interpretation of applicable codes or regulations, the contractor shall perform in accordance with the requirements of the governing authority.

1.19 ADMINISTRATION AND SUPERVISOR PERSONNEL – Asbestos

- A. Asbestos Work - Provide a full-time general superintendent who is experienced in administration and supervision of asbestos abatement projects including work practices, protective measures for building and personnel, disposal procedures, etc. This person is to be the competent person as required by OSHA, in 29 CFR 1926, for the Contractor and is the Contractor's representative responsible for compliance with all applicable federal, state and local regulations, particularly those relating to asbestos containing materials. This person must have completed a 40 hour course at an EPA training center or have an equivalent certified course in asbestos abatement procedures which complies with AHERA. He/she is also required to have a minimum of two (2) years on-the-job training and must meet any additional requirements set forth in 29 CFR for a competent person.
- B. Provide one foreperson for abatement crew. The foreperson must have completed a supervisory health and safety training course offered by an EPA or OSHA endorsed educational institute. The foreperson must also have a minimum of 12 months of on-the-job experience on asbestos abatement projects.

1.20 SPECIAL REPORTS

- A. Except as otherwise indicated, submit reports directly to Owner and or designated representative electronically one day of occurrence as required, with a copy to others affected by the occurrence.

1.21 CONTINGENCY PLAN

- A. Prepare a contingency plan for emergencies including fire, accident, power failure, differential pressure system failure, supplied air system failure or any other event that may require modification or abridgement of decontamination or work area isolation procedures. Include in the plan specific procedures for decontamination or work area isolation. Note that nothing in this specification should impede safe exiting or provision of adequate medical attention in the event of an emergency.
- B. Post on site, telephone numbers and locations of emergency services including, but not limited to, fire, ambulance, doctor, hospital, police, electrical power company, telephone company.

1.22 CONSTRUCTION SCHEDULE

- A. Construction schedule will be determined at the time of contract award.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION

SECTION 013000
ADMINISTRATIVE REQUIREMENTS**PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. General administrative requirements.
- B. Preconstruction meeting.
- C. Site mobilization meeting.
- D. Progress meetings.
- E. Construction progress schedule.
- F. Contractor's daily reports.
- G. Progress photographs.
- H. Submittals for review, information, and project closeout.
- I. Number of copies of submittals.
- J. Requests for Interpretation (RFI) procedures.
- K. Submittal procedures.

1.02 GENERAL ADMINISTRATIVE REQUIREMENTS

- A. Comply with requirements of Section 017000 - Execution and Closeout Requirements for coordination of execution of administrative tasks with timing of construction activities.
- B. Make the following types of submittals to Owner:
 - 1. Requests for Information (RFI).
 - 2. Requests for substitution.
 - 3. Shop drawings, product data, and samples.
 - 4. Test and inspection reports.
 - 5. Design data.
 - 6. Manufacturer's instructions and field reports.
 - 7. Applications for payment and change order requests.
 - 8. Progress schedules.
 - 9. Coordination drawings.
 - 10. Correction Punch List and Final Correction Punch List for Substantial Completion.
 - 11. Closeout submittals.

PART 2 PRODUCTS - NOT USED**PART 3 EXECUTION****3.01 PRECONSTRUCTION MEETING**

- A. Attendance Required:
 - 1. Owner: BIA's Contracting Officer (CO) and the Contracting Officer's Representative (COR) as defined in the Contract
 - 2. Architect/Engineer of Record: Joseph David Associates LLC, Farris Engineering Inc. (Architects & Engineers)
 - 3. Contractor. As referenced in the Contract
- B. Agenda:
 - 1. Execution of Contract
 - 2. Submission of executed bonds and insurance certificates.
 - 3. Distribution of Contract Documents.

4. Submission of list of subcontractors, list of products, schedule of values, and progress schedule.
 5. Designation of personnel representing the parties to the Contract.
 6. Procedures and processing of field decisions, submittals, substitutions, applications for payments, proposal request, Change Orders, and Contract closeout procedures.
 7. Project Scheduling and phasing.
- C. Record minutes and distribute copies within two days after meeting to participants, with two copies to Architect, Owner, participants, and those affected by decisions made.

3.02 SITE MOBILIZATION MEETING

- A. Attendance Required:
1. Contractor.
 2. Owner (represented by the Contracting Officer and Contracting Officer's Representative)
 3. Architect and Engineer of Record (represented by Joseph David Associates)
 4. Contractor's superintendent.
 5. Major subcontractors.
 6. Contractor's Professional Services representatives.
- B. Agenda:
1. Use of premises by Owner and Contractor.
 2. Owner's requirements.
 3. Temporary utilities provided by Owner.
 4. Survey and building layout.
 5. Security and housekeeping procedures.
 6. Schedules.
 7. Application for payment procedures.
 8. Procedures for testing.
 9. Procedures for maintaining record documents.
 10. Requirements for start-up of equipment.
 11. Inspection and acceptance of equipment put into service during construction period.
- C. Record minutes and distribute copies within two days after meeting to participants, with two copies to Architect, Owner, participants, and those affected by decisions made.

3.03 PROGRESS MEETINGS

- A. Schedule and administer meetings throughout progress of the work at maximum bi-monthly intervals.
- B. Attendance Required:
1. Contractor.
 2. Owner.
 3. Architect/Engineer.
 4. Contractor's superintendent.
 5. Major subcontractors.
 6. Contractor's Professional Services representatives.
- C. Agenda:
1. Review minutes of previous meetings.
 2. Review of work progress.
 3. Field observations, problems, and decisions.
 4. Identification of problems that impede, or will impede, planned progress.
 5. Review of submittals schedule and status of submittals.
 6. Review of RFIs log and status of responses.
 7. Maintenance of progress schedule.

8. Corrective measures to regain projected schedules.
 9. Planned progress during succeeding work period.
 10. Maintenance of quality and work standards.
 11. Effect of proposed changes on progress schedule and coordination.
 12. Other business relating to work.
- D. Record minutes and distribute copies within two days after meeting to participants, with two copies to Architect, Owner, participants, and those affected by decisions made.

3.04 CONSTRUCTION PROGRESS SCHEDULE

- A. Within 10 days after date established in Notice to Proceed, submit preliminary schedule.
- B. If preliminary schedule requires revision after review, submit revised schedule within 10 days.
- C. Within 20 days after review of preliminary schedule, submit draft of proposed complete schedule for review.
 1. Include written certification that major Subcontractors have reviewed and accepted proposed schedule.
- D. Within 10 days after joint review, submit complete schedule.
- E. Submit updated schedule with each Application for Payment.

3.05 DAILY CONSTRUCTION REPORTS

- A. Include only factual information. Do not include personal remarks or opinions regarding operations and/or personnel.
- B. In addition to transmitting electronically a copy to Owner (CO & COR) and Architect (JDA/FE) submit two printed copies at monthly intervals to the Owner.
 1. Submit in format acceptable to Owner.
- C. Prepare a daily construction report recording the following information concerning events at Project site and project progress:
 1. Date.
 2. High and low temperatures, and general weather conditions.
 3. List of subcontractors at Project site.
 4. Major equipment at Project site.
 5. Safety, environmental, or industrial relations incidents.
 6. Meetings and significant decisions.
 7. Stoppages, delays, shortages, and losses. Include comparison between scheduled work activities (in Contractor's most recently updated and published schedule) and actual activities. Explain differences, if any. Note days or periods when no work was in progress and explain the reasons why.
 8. Emergency procedures.
 9. Testing and/or inspections performed.
 10. Signature of Contractor's authorized representative.

3.06 PROGRESS PHOTOGRAPHS

- A. Submit photographs with each application for payment, taken not more than 3 days prior to submission of application for payment.
- B. Maintain one set of all photographs at project site for reference; same copies as submitted, identified as such.
- C. Photography Type: Digital; electronic files.
- D. Provide photographs of site and construction throughout progress of work produced by an experienced photographer.

- E. In addition to periodic, recurring views, take photographs of each of the following events:
 - 1. Installation of major equipment
 - 2. MEP in progress.
 - 3. Final completion, minimum of twenty (20) photos.
- F. Views:
 - 1. Consult with Architect for instructions on views required.
 - 2. Provide factual presentation.
 - 3. Provide correct exposure and focus, high resolution and sharpness, maximum depth of field, and minimum distortion.
- G. Digital Photographs: 24-bit color, minimum resolution of 1024 by 768, in JPG format; provide files unaltered by photo editing software.
 - 1. Delivery Medium: Via email with project record photo CD.
 - 2. File Naming: Include project identification, date and time of view, and view identification.
 - 3. PDF File: Assemble all photos into printable pages in PDF format, with 2 to 3 photos per page, each photo labeled with file name; one PDF file per submittal.
 - 4. Photo CD(s): Provide 1 copy including all photos cumulative to date and PDF file(s) with files organized in separate folders by submittal date.

3.07 SUBMITTALS

A. GENERAL: Irrespective of Submittal type, all submittals will be electronically sent to the Owner (CO and COR) and to the Architect/Engineer for information and actions as noted below.

3.08 SUBMITTALS FOR REVIEW

- A. When the following are specified in individual sections, submit them for review:
 - 1. Product data.
 - 2. Shop drawings.
- B. Submit to Architect for review for the limited purpose of checking for compliance with information given and the design concept required by the design in Contract Documents.
- C. After review, provide copies and distribute in accordance with SUBMITTAL PROCEDURES article below.

3.09 SUBMITTALS FOR INFORMATION

- A. When the following are specified in individual sections, submit them for information:
 - 1. Design data.
 - 2. Certificates.
 - 3. Test reports.
 - 4. Inspection reports.
 - 5. Manufacturer's instructions.
 - 6. Field engineering reports.
 - 7. Other types indicated.
- B. Submit for Architect's knowledge as contract administrator or for Owner.

3.10 NUMBER OF COPIES OF SUBMITTALS

- A. Documents for Review:
 - 1. Small Size Sheets, Not Larger Than 11x17 inches: Submit the number of copies that Contractor requires, plus two copies that will be retained by the Owner and Architect.
- B. Documents for Information: Submit two copies.

3.11 SUBMITTAL PROCEDURES

- A. General Requirements:
 - 1. Use a single transmittal for related items.
 - 2. Submit separate packages of submittals for review and submittals for information, when included in the same specification section.
 - 3. Transmit using approved form.
 - 4. Sequentially identify each item. For revised submittals use original number and a sequential numerical suffix.
 - 5. Identify: Project; Contractor; subcontractor or supplier; pertinent drawing and detail number; and specification section number and article/paragraph, as appropriate on each copy.
 - 6. Schedule submittals to expedite the Project, and coordinate submission of related items.
 - 7. Identify variations from Contract Documents and product or system limitations that may be detrimental to successful performance of the completed work.

3.12 SUBMITTALS FOR PROJECT CLOSEOUT

- A. Submit Correction Punch List for Substantial Completion.
- B. Submit Final Correction Punch List for Substantial Completion.
- C. When the following are specified in individual sections, submit them at project closeout in compliance with requirements of Section 017800 - Closeout Submittals:
 - 1. Project record documents.
 - 2. Operation and maintenance data.
 - 3. Warranties.
 - 4. Bonds.
 - 5. Other types as indicated.

3.13 SUBMITTAL REVIEW

- A. Submittals for Review: Architect will review each submittal, and recommend to the CO/ COR appropriate actions listed below.
- B. Submittals for Information: Architect will not acknowledge receipt, and take no other action.
- C. Architect's actions will be reflected by marking each submittal using actual stamp on hard copies of submittals.
- D. Architect's and consultants' actions on items submitted for review:
 - 1. Authorizing purchasing, fabrication, delivery, and installation:
 - a. "Recommend Approved", or language with same legal meaning.
 - b. "Recommend Approved as Noted, Resubmission not required", or language with same legal meaning.
 - 1) At Contractor's option, submit corrected item, with review notations acknowledged and incorporated.
 - c. "Recommend Approved as Noted, Resubmit for Record", or language with same legal meaning.
 - 2. Not Authorizing fabrication, delivery, and installation:
 - a. "Recommend Revise and Resubmit".
 - 1) Resubmit revised item, with review notations acknowledged and incorporated.
- E. Architect's and consultants' actions on items submitted for information:
 - 1. Items for which no action was taken:
 - a. "Received" - to notify the Contractor that the submittal has been received for record only.

2. Items for which action was taken:
 - a. "Reviewed" - no further action is required from Contractor.

3.14 FORMS

- A. The following forms shall be used by the contractor to administer the work under this contract:
 1. Application for Payment
 2. ASI
 3. Bid Schedule
 4. RFI
 5. Submittal

Application for Payment

TO OWNER:

PROJECT:

APPLICATION DATE:

APPLICATION NO.:

PERIOD TO:

CONTRACT DATE:

FROM CONTRACTOR:

CONTRACT FOR:

ARCHITECT/ENGINEER:

CONTRACTOR PROJECT NO.:

OWNER PROJECT NO.:

ARCHITECT PROJECT NO.:

APPLICATION FOR PAYMENT SUMMARY

1. Original Contract Value.....	\$0.00
2. Net Change by Change Orders.....	\$0.00
3. Contract Value to Date.....	\$0.00
4. Total Completed and Stored to Date.....	\$0.00
5. Retainage	
6. Completed Work Retainage.....	\$0.00
7. Stored Material Retainage.....	\$0.00
8. Total Retainage.....	\$0.00
10. Less Previous Certificates for Payment...	\$0.00
11. Current Payment Due.....	\$0.00
12. Balance to Finish, Including Retainage....	\$0.00

CONTRACTOR'S CERTIFICATION (29 CFR 52.232-5(C)(4))

I hereby certify, to the best of my knowledge and belief, that-

(1) The amounts requested are only for performance in accordance with the specifications, terms, and conditions of the contract;

(2) All payments due to subcontractors and suppliers from previous payments received under the contract have been made, and timely payments will be made from the proceeds of the payment covered by this certification, in accordance with subcontract agreements and the requirements of Chapter 39 of Title 31, United States Code;

(3) This request for progress payments does not include any amounts which prime contractor intends to withhold or retain from a subcontractor or supplier in accordance with the terms and conditions of the subcontract

By: Date:

Title:

CHANGE ORDER SUMMARY	ADDITIONS	DELETIONS
Total Changes in previous months	\$0.00	\$0.00
Total Approved this month	\$0.00	\$0.00
Totals	\$0.00	\$0.00
Net Changes by Change Order	\$0.00	

OWNER/GOVERNMENT REPRESENTATIVE'S CERTIFICATION

AMOUNT CERTIFIED: \$

By: Date:

ARCHITECTS SUPPLEMENTAL INSTRUCTIONS (ASI)

ASI NUMBER: 000
DATE: mm/dd/yyyy

PROJECT:
OWNER/AGENT:
CONTRACTOR:

DISTRIBUTION: ☒ File ☒ Owner/Agent (BIA) By BIA Contractor

1<<Replace _____ with the following:

End of Replace>>

2<<Add to existing _____ with the following:

End of Replace>>

ISSUED BY: _____ DATE: _____

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF INDIAN AFFAIRS
GREAT PLAINS REGION - DIVISION OF FACILITIES
115 4th Ave. S.E.
ABERDEEN, SOUTH DAKOTA 57401

Project Title & Location:

Contract No. :

Order No.:

BIA Project No.:

Contractor:

Address:

BID SCHEDULE

[illegible]

Prepared by:

APPROVED:

Authorized Signature/Contractor or Firm

CONTRACTING OFFICER
BUREAU OF INDIAN AFFAIRS

SUBMIT IN DUPLICATE

Contractor Title
Contractor Address
Contractor Phone:
Contractor Fax:

Project Title:
Project Address

RFI Title

TO:	FROM:
DATE INITIATED:	
LOCATION:	STATUS:
PROJECT STAGE:	DUE DATE:
SUB JOB:	COST CODE:
COST IMPACT:	SCHEDULE IMPACT:
DRAWING NUMBER:	SPEC SECTION:
LINKED DRAWINGS:	REFERENCE:
RECEIVED FROM:	
COPIES TO:	

Question from Contractor at hh:mm on mm/dd/yyyy

All Replies:

Submittal #000
Division #000000
Division Title

Contractor Title
Contractor Address
Contractor Phone:
Contractor Fax:

Project Title:
Project Address

Submittal Title

SPEC SECTION:

SUBMITTAL MANAGER:

STATUS:

DATE CREATED:

ISSUE DATE:

REVISION:

RESPONSIBLE CONTRACTOR:

RECEIVED FROM:

RECEIVED DATE:

SUBMIT BY:

FINAL DUE DATE:

LOCATION:

TYPE:

COST CODE:

APPROVERS:

BALL IN COURT:

DISTRIBUTION:

DESCRIPTION:

ATTACHMENTS:

SUBMITTAL WORKFLOW

#	NAME	SUBMITTER/ APPROVER	SENT DATE	DUE DATE	RETURNED DATE	RESPONSE	ATTACHMENTS	COMMENTS
1								
2								

NOT FOR CONSTRUCTION

Administrative Requirements
013000

END OF SECTION

**SECTION 01 35 29
PERSONAL PROTECTIVE EQUIPMENT (PPE)****PART 1 - GENERAL****1.1 GENERAL - DESCRIPTION OF WORK**

- 1.1.1 This section describes the equipment and procedures required for protecting workers against asbestos/lead/fungal/dust contamination and other workplace hazards including respiratory protection.

1.2 WORKER TRAINING

- 1.2.1 All workers are to be trained and licensed as required by the State of South Dakota.
- 1.2.2 Train in accordance with 29 CFR 1926, all workers in the dangers inherent in handling asbestos and breathing asbestos dust and in proper work procedures and personal and area protective measures for workers involved in asbestos related work. Workers involved in lead work should be properly trained in lead safe work practices per SD requirements.
- 1.2.3 OSHA Regulations:
- 1926.20 General safety and health provisions.
 - 1926.22 Recording and reporting injuries
 - 1926.28 Personal Protective Equipment
 - 1926.52 Occupational noise exposure
 - 1926.95 Criteria for personal protective equipment
 - 1926.103 Respiratory protection
 - 1926.102 Eye and face protection
 - 1926.101 Hearing protection
 - 1926.501 Duty to have fall protection
 - 1926.1101 Asbestos
 - 1926.62 Lead

1.3 MEDICAL EXAMINATIONS

- 1.3.1 Provide medical examinations for all workers who will enter the work area for any reason. Examination shall at a minimum, meet OSHA requirements as set forth in 29 CFR 1926. In addition, provide an evaluation of the individual's ability to work in environments capable of producing heat or cold stress in the worker.

1.4 SUBMITTALS PRIOR TO PROJECT START UP

- 1.4.1 Submit the following to the Owner/Designated Representative for review. Do not start work until the submittals are approved by Owner.
- 1.4.1.1 Submit a copy of the worker certifications as issued by the state of South Dakota.
 - 1.4.1.2 Submit the report from medical examination conducted within last 12 months as part of compliance with OSHA medical surveillance requirements for each worker who is to enter the work area that they are approved for respiratory protection.
 - 1.4.1.3 Submit a copy of the current respiratory protection program.

PART 2 - PRODUCTS**2.1 EQUIPMENT**

- 2.1.1 Protective Clothing – Asbestos Abatement
- 2.1.1.1 Coveralls: Provide disposable full-body coveralls and disposable head covers and require that they

be worn by all workers in the work area. Provide a sufficient number of coveralls for all required changes for all workers in the work area for asbestos abatement.

2.1.1.2 Respiratory Protection: Provide half-face or full-face type respirators. Provide at a minimum, HEPA type filters labeled with NIOSH and MSHA certification for "Radionuclides, Radon Daughters, Dusts and Mists", and color coded in accordance with ANSI Z228.2 (1980). In addition, a chemical cartridge section may be added if required, for solvents, etc., in use. In this case, provide cartridges that have each section of the combination canister labeled with the appropriate color code and NIOSH/MSHA certification.

Non-permitted Respirators: Do not use single use, disposable or quarter-face respirators.

2.1.1.3 Boots: Provide work boots with non-skid soles, and where required, OSHA foot protectives for all workers. Provide boots at no cost to the workers. Paint uppers of all boots red with waterproof enamel. **Do not allow boots to be removed from the work area for any reason after being contaminated with asbestos-containing material.** Dispose of boots as asbestos-contaminated waste at the end of work.

2.1.1.4 Hard Hats: Provide head protectives (hard hats) as required by OSHA for all workers, and provide 4 spares for use by Government's representative, and Government. Label hats with same warning labels as used on disposable bags. Require hard hats to be worn at all times that work is in progress that may potentially cause head injury. Provide hard hats of type with plastic strap type suspension. Require hats to remain in the work area throughout the work. Thoroughly clean, decontaminate and bag hats before removing them from the work area at the end of the project.

2.1.1.5 Goggles: Provide eye protectives (goggles) as required by OSHA for all workers in any activity which may potentially cause eye injury if not all ready wearing full-face respiratory protection. Thoroughly clean, decontaminate and bag goggles before removing them from the work area at the end of the work.

2.1.1.6 Gloves: Provide work gloves to all workers and require that they be worn at all times in the work area. Do not remove gloves from work area and dispose of as asbestos contaminated waste at the end of the work when working inside asbestos abatement enclosures.

2.1.1.7 Hearing protection: Wear hearing protection such as disposable ear plugs when operating noisy equipment.

2.1.1.8 Additional Protective Equipment: Respirators, disposable coveralls, hard covers, and footwear covers shall be provided by the contractor for the Owner, Owner's representative, and other authorized representatives who may visit the job site. Provide two (2) respirators of the specific type being used on the project during the activity in-progress, and six (6) complete coveralls and, where applicable, six (6) filter changes per day.

PART 3 - EXECUTION

3.1 GENERAL

3.1.1 Provide worker protection as required by the most stringent OSHA and/or EPA standards applicable to the work. The following procedures are minimums to be adhered to regardless of fiber count in the work area.

3.1.2 Each time work area is entered remove all street clothes in the changing room of the personnel decontamination unit and put on new disposable coveralls, new head cover, and a clean respirator. Proceed through shower room to equipment room and put on work boots.

3.2 DECONTAMINATION PROCEDURES – FULL ENCLOSURE

3.2.1 When exiting area, remove disposable coveralls, disposable head covers, and disposable footwear covers or boots in the equipment room. Still wearing respirators, proceed to showers. Showering is mandatory. Care must be taken to follow reasonable procedures in removing the respirator to avoid asbestos fibers while showering. The following procedure is required as minimum:

3.2.1.1 When exiting area, remove disposable coveralls, disposable head covers, and disposable footwear

covers or boots in the equipment room.

3.2.1.2 Still wearing respirators, proceed to showers. Showering is mandatory. Care must be taken to follow reasonable procedures in removing the respiratory to avoid asbestos fibers while showering. The following procedure is required as a minimum:

Thoroughly wet body including hair and face. If using a powered air-purifying respirator (PAPR) hold blower unit above head to keep canisters dry. With respirator still in place, thoroughly wash body, hair, respirator face piece and all parts of the respiratory except the blower unit and battery pack on PAPR. Pay particular attention to seal between face and respirator and under straps. Take a deep breath, hold it and/or exhale slowly, completely wet hair, face, and respirator. While still holding breath, remove respirator and hold it away from face before starting to breath. Carefully wash facepiece of respirator inside and out.

3.2.1.3. If using PAPR, shut down in the following sequence. First cap inlets to filter cartridges, then turn off blower unit (this sequence will help keep debris which as collected on the inlet side of filter from dislodging and contaminating the outside of the unit). Thoroughly wash blower unit and hoses. Carefully wash battery pack with wet rag. Be extremely cautious of getting water in battery pack as this will short out and destroy battery.

3.2.1.4 Shower completely with soap and water. Rinse thoroughly. Rinse shower room walls and floor prior to exit. Proceed from shower to changing room and change into street clothes or into new disposable work items.

3.3 DECONTAMINATION PROCEDURES – GLOVE BAG/WRAP AND CUT PIPE REMOVAL

3.3.1 Use of double suit with a remote decontamination available – Persons leaving the work area should remove the over suit, clean themselves by wet wiping or HEPA vacuuming, and proceed to the remote decontamination unit while still wearing their under suit and respirator. Shower as one would from a full enclosure.

3.4 PERSONAL HYGIENE

3.4.1 Workers shall NOT eat, drink, smoke, chew gum, tobacco in the work area. Follow established rules for this project concerning where breaks are taken and where smoking is allowed.

END OF SECTION 01 35 29

**SECTION 014000
QUALITY REQUIREMENTS****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Submittals.
- B. Quality assurance.
- C. References and standards.
- D. Testing and inspection agencies and services.
- E. Control of installation.
- F. Defect Assessment.

1.02 RELATED REQUIREMENTS

- A. Section 014216 - Definitions.
- B. Section 014523 – Remediation Quality Assurance.

1.03 REFERENCE STANDARDS

- A. ASTM C1077 - Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation 2017.
- B. ASTM D3740 - Standard Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction 2019.
- C. ASTM E329 - Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection 2020.
- D. ASTM E543 - Standard Specification for Agencies Performing Nondestructive Testing 2015.
- E. IAS AC89 - Accreditation Criteria for Testing Laboratories 2018.

1.04 DEFINITIONS

- A. Contractor's Quality Control Plan: Contractor's management plan for executing the Contract for Construction.
- B. Design Data: Design-related, signed and sealed drawings, calculations, specifications, certifications, shop drawings and other submittals provided by Contractor, and prepared directly by, or under direct supervision of, appropriately licensed design professional.

1.05 NOT USED**1.06 NOT USED****1.07 NOT USED****1.08 QUALITY ASSURANCE**

- A. Testing Agency Qualifications:
 - 1. Prior to start of work, submit agency name, address, and telephone number, and names of full-time registered Engineer and responsible officer.

2. Qualification Statement: Provide documentation showing testing laboratory is accredited under IAS AC89.
- B. Contractor's Quality Control (CQC) Plan:
 1. Prior to start of work, submit a comprehensive plan describing how contract deliverables will be produced. Tailor CQC plan to specific requirements of the project. Include the following information:
 - a. Management Structure: Identify personnel responsible for quality. Include a chart showing lines of authority.
 - b. Management Approach: Define, describe, and include in the plan specific methodologies used in executing the work.
 - 1) Management and control of documents and records relating to quality.
 - 2) Communications.
 - 3) Coordination procedures.
 - 4) Inspection and testing procedures and scheduling.
 - 5) Tracking deficiencies from identification, through acceptable corrective action, and verification.
 - c. Owner will not make a separate payment for providing and maintaining a Quality Control Plan. Include associated costs in Bid price.
 - d. Acceptance of the plan is required prior to start of construction activities not including mobilization work. Owner's acceptance of the plan will be conditional and predicated on continuing satisfactory adherence to the plan. Owner reserves the right to require Contractor to make changes to the plan and operations, including removal of personnel, as necessary, to obtain specified quality of work results.

1.09 TESTING AND INSPECTION AGENCIES AND SERVICES

- A. Contractor shall employ and pay for services of an independent testing agency to perform specified testing.
- B. Employment of agency in no way relieves Contractor of obligation to perform Work in accordance with requirements of Contract Documents.
- C. Contractor Employed Agency:
 1. Testing agency: Comply with requirements of ASTM E329, ASTM E543, ASTM C1077, and ASTM D3740.
 2. Inspection agency: Comply with requirements of ASTM D3740.

PART 2 NOT USED

PART 3 EXECUTION

3.01 CONTROL OF INSTALLATION

- A. Monitor quality control over suppliers, products, services, site conditions, and workmanship, to produce work of specified quality.
- B. Comply with manufacturers' instructions, including each step-in sequence.
- C. Should manufacturers' instructions conflict with Contract Documents, request clarification from Architect before proceeding.
- D. Comply with specified standards as minimum quality for the work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.
- E. Have work performed by persons qualified to produce required and specified quality.
- F. Verify that field measurements are as indicated on shop drawings or as instructed by the manufacturer.

- G. Secure work in place with processes and devices designed and sized to withstand stresses, vibration, physical distortion, and disfigurement.

3.02 TESTING AND INSPECTION

- A. Testing Agency Duties:
 - 1. Provide qualified personnel at site. Cooperate with A/E and Contractor in performance of services.
 - 2. Perform specified sampling and testing of products in accordance with specified standards.
 - 3. Ascertain compliance of materials and mixes with requirements of Contract Documents.
 - 4. Promptly notify A/E and Contractor of observed irregularities or non-compliance of Work or products.
 - 5. Perform additional tests and inspections required by the Contract Documents.
 - 6. Submit reports of all tests/inspections specified.
- B. Limits on Testing/Inspection Agency Authority:
 - 1. Agency may not release, revoke, alter, or enlarge on requirements of Contract Documents.
 - 2. Agency may not approve or accept any portion of the Work.
 - 3. Agency may not assume any duties of Contractor.
 - 4. Agency has no authority to stop the Work.
- C. Contractor Responsibilities:
 - 1. Cooperate with testing personnel and provide access to the Work.
 - 2. Provide incidental labor and facilities:
 - a. To provide access to Work to be tested/inspected.
 - b. To facilitate tests/inspections.
- D. Re-testing required because of non-compliance with specified requirements shall be performed by the same agency on instructions by Owner.
- E. Re-testing required because of non-compliance with specified requirements shall be paid for by Contractor.

3.03 DEFECT ASSESSMENT

- A. Replace Work or portions of the Work not complying with specified requirements.

END OF SECTION

**SECTION 014216
DEFINITIONS**

PART 1 GENERAL

1.01 SUMMARY

- A. This section supplements the definitions contained in the General Conditions.
- B. Other definitions are included in individual specification sections.

1.02 DEFINITIONS

- A. Furnish: To supply, deliver, unload, and inspect for damage.
- B. Install: To unpack, assemble, erect, apply, place, finish, cure, protect, clean, start up, and make ready for use.
- C. Demolish: To deconstruct/disassemble and remove from the project premises to a suitable and legally authorized waste facility.
- D. Product: Material, machinery, components, equipment, fixtures, and systems forming the work result. Not materials or equipment used for preparation, fabrication, conveying, or erection and not incorporated into the work result. Products may be new, never before used, or re-used materials or equipment.
- E. Project Manual: The book-sized volume that includes the procurement requirements (if any), the contracting requirements, and the specifications.
- F. Provide: To furnish and install.
- G. Supply: Same as Furnish.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION - NOT USED

END OF SECTION

SECTION 01 45 23
REMEDATION QUALITY CONTROL – TESTING AND INSPECTION

PART 1 – GENERAL**1.1 DESCRIPTION**

- 1.1.1 Work under this section includes the requirements for industrial hygiene services during remediation activities and for determination of final clearance after asbestos removal and lead control/remediation actions if applicable.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- 1.2.1 Section 02 82 33 – REMOVAL AND DISPOSAL OF ASBESTOS CONTAINING MATERIALS
- 1.2.2 Section 02 8100 – REGULATED MATERIAL REMEDIATION/REMOVAL

1.3 QUALIFICATIONS OF COMPETENT PERSON

- 1.3.1 A full-time competent person will be on-site during the remediation portion of the demolition to verify removal of regulated materials from the buildings prior to releasing them for re-entry and demolition. The Owner reserves the right to provide the competent person directly or require the Contractor to provide a third party to fulfill this role.
- 1.3.2 Competent person qualifications – minimum qualifications for competent person is certified SD asbestos inspector with competency in asbestos air monitoring procedures, an EPA tribal lead risk assessor or EPA lead supervisor (if lead stabilization/removal work is part of the Contract), and competency in evaluating in managing other regulated materials that will be encountered including chemical containers, PCB ballasts, electronics, etc. A resume of the chosen individual needs to be provided with the submittals to verify the proposed individual meets the definition of a competent person.

1.4 GENERAL CONTROL – ASBESTOS REMOVAL

- 1.4.1 This section sets forth airborne fiber levels both inside and outside the work area and general clean-up parameters for each phase of asbestos removal.
- 1.4.2 The competent individual will monitor work practices, methods, and procedures to assure compliance with these specifications, approved work plans, or other applicable standards. The competent individual will have the authority to require changes in work practices where he/she deems current practices are not appropriate.
- 1.4.3 The contractor is not allowed to conduct abatement activity without the competent individual on-site.

1.4 AIR MONITORING – ASBESTOS REMOVAL

- 1.4.1 The purpose of the air monitoring will be to detect faults in the work area isolation such as the following:
- 1.4.1.1 Contamination of the building outside of the work area with airborne fibers.
 - 1.4.1.2 Failure of filtration or rupture in the negative pressure system.
 - 1.4.1.3 Contamination of the exterior of the building with airborne fibers.
- 1.4.2 Should any of the above occur, the contractor shall immediately cease asbestos abatement

activities until the fault is corrected. Work shall not commence until authorized by owner's representative.

- 1.4.3 The purpose of this air monitoring will be to detect airborne fiber counts which may significantly challenge the ability of the work area isolation procedures to protect the balance of the building or outside of the building from contamination by airborne fibers.

Approval of the completion of initial and final cleaning stages will include acceptable airborne fiber levels.

1.5 AIRBORNE FIBER COUNT LEVELS INSIDE WORK AREA – ASBESTOS REMOVAL

- 1.5.1 Maintain an airborne count in the work area of less than levels specified in Item 1.10 of this section. If the fiber counts rise above these levels for any sample taken, revise work procedures to lower fiber counts. If two consecutive fiber counts for any two work shifts or 16 hour period exceed the specified levels, stop asbestos removal, use dust control measures to reduce airborne fiber levels, and check individual negative air systems for operating conditions. Do not recommence removal of asbestos until authorized in writing by owner's representative.

1.6 AIRBORNE FIBER COUNT LEVELS OUTSIDE THE WORK AREA INSIDE THE BUILDING OR OUTSIDE THE BUILDING AT HEPA EXHAUST

- 1.6.1 The contractor shall cease asbestos removal in the event that any two air samples, collected either simultaneously or consecutively inside the building outside the enclosure or at HEPA exhaust exceed: fiber levels of 0.01 f/cc, or average fiber levels determined by preliminary baseline sampling.
- 1.6.2 Elevated fiber levels in the vicinity of HEPA exhaust requires the contractor to individually shutdown and inspect the negative pressure filtration systems. The inspection includes verifying that all controls and alarms are functional and that the primary HEPA filter is in place. Written verification is required by the beginning of the proceeding work shift.
- 1.6.3 Appropriate respiratory protection shall be worn in affected area until area is cleared for re-occupancy.
- 1.6.4 Leave critical barriers in place until completion of work and ensure that the operation of the differential pressure system in the work area results in a flow of air from the balance of the building into the affected area.
- 1.6.5 If the exit from the clean room of the personnel decontamination unit enters the affected area, establish a temporary decontamination facility consisting of a shower room and changing room. After cleaning and decontamination of the affected area, remove the shower room and leave the changing room in place as an air lock.
- 1.6.6 After certification of visual inspection in the work area, remove critical barriers separating the work area from the affected area. Final air samples will be taken within the entire area for final work area clearance.

1.7 ANALYTICAL METHODS - ASBESTOS

- 1.7.1 ASBESTOS - Preliminary (baseline), general, and final clearance samples will be collected and analyzed in accordance to OSHA/NIOSH Method 7400 A using PCM. Analysis will be done in an AIHA accredited laboratory or by an AIHA asbestos registry participant. Air sampling is to be performed by a third party independent of the abatement contractor with qualifications of an asbestos inspector certified in the State of South Dakota as a minimum requirement.

1.8 SAMPLES - ASBESTOS

- 1.8.1 From start of work through completion, the owner may take as many samples as he/she deems necessary to assure compliance with these specifications. Generally, five to nine samples will be collected on a daily basis. Samples will be taken inside the work area outside the work area but inside the building and outside the building.

1.9 PERSONAL MONITORING - ASBESTOS

- 1.9.1 Perform air monitoring as required to meet OSHA requirements for maintenance of time-weighted average (TWA) fiber counts for types of respiratory protection provided. The owner will not be performing air monitoring to meet these OSHA requirements. Results of OSHA monitoring will be made available to the owner within 24 hours of receipt of the results.

1.10 CRITERIA - ASBESTOS

<u>ACTIVITY</u>	<u>MAXIMUM ALLOWABLE LEVEL</u>
Preliminary	Background
Inside removal area during preparation	0.05 f/cc
Inside full containment area during gross removal	0.5 f/cc
During glovebag removal without mini-enclosure	0.01 f/cc
During wrap and cut procedures for pipe fittings	0.01 f/cc
Inside removal area during final clean	0.02 f/cc
	Outdoor Work >0.01 f/cc

1.11 LABORATORY/ON-SITE IH QUALIFICATIONS**1.11.1 Asbestos Laboratory**

NIST NVLAP accredited laboratory for any bulk asbestos analysis.
AIHA IHLAP accredited laboratory or AIHA registered analyst for PCM asbestos air analysis.

1.11.2 On-Site IH

On-site IH shall be a certified SD certified inspector or contractor/supervisor having completed a NIOSH 582 class and enrolled in the AIHA asbestos registry (if on site analysis is being performed).

PART 2 - PRODUCTS (NOT APPLICABLE)**PART 3 - EXECUTION****3.1 ADDITIONAL TESTING**

- A. The contractor may conduct his/her own air monitoring and laboratory testing beyond the scope of this section. If he/she elected to do this, the cost of such air monitoring and laboratory testing shall be included in the contract sum. Results of such testing shall be made available to the owner.

3.2 PERSONAL MONITORING

- A. Perform air monitoring as required to meet OSHA requirements for maintenance of Time Weighted Average (TWA) fiber counts for types of respiratory protection provided in case of asbestos abatement.

END OF SECTION 014523

SECTION 015000
TEMPORARY FACILITIES AND CONTROLS**PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Temporary sanitary facilities.
- B. Temporary Controls: Barriers, enclosures, and fencing.
- C. Security requirements.
- D. Vehicular access and parking.
- E. Waste removal facilities and services.
- F. Field offices.

1.02 RELATED REQUIREMENTS

- A. Section 015216 – Remediation Temporary Facilities

1.03 NOT USED**1.04 TEMPORARY UTILITIES**

- A. The Owner will provide and pay for all electrical power used for construction.
- B. The Contractor shall provide all lighting, water, temporary heating and cooling, and ventilation required for construction purposes.
- C. Existing facilities may not be used without written permission of the Owner.

1.05 TEMPORARY SANITARY FACILITIES

- A. Provide and maintain required facilities and enclosures. Provide at time of project mobilization.
- B. Use of existing facilities is not permitted.
- C. Maintain daily in clean and sanitary condition.

1.06 NOT USED**1.07 NOT USED****1.08 SECURITY**

- A. Provide security and facilities to protect Work, existing facilities, and Owner's operations from unauthorized entry, vandalism, or theft.

1.06 VEHICULAR ACCESS AND PARKING

- A. Coordinate access and haul routes with governing authorities and Owner.
- B. Provide and maintain access to fire hydrants, free of obstructions.
- C. Existing on-site roads may be used for construction traffic.
- D. Existing parking areas may be used for construction parking.
- E. Provide one parking space for Owner use.
- F. Provide one parking space for Architect use.

1.07 WASTE REMOVAL

- A. See Sections 017419 - Construction Waste Management and Disposal, 028100 – Regulated Material Remediation/Removal, 028213 removal of Asbestos Containing and Asbestos Contaminated Materials, & 028233 Asbestos Waste Disposal and Transportation for additional requirements.
- B. Provide waste removal facilities and services as required to maintain the site in clean and orderly condition.
- C. Provide containers with lids. Remove trash from site periodically.
- D. If materials to be recycled or re-used on the project must be stored on-site, provide suitable non-combustible containers; locate containers holding flammable material outside the structure unless otherwise approved by the authorities having jurisdiction.
- E. Open free-fall chutes are not permitted. Terminate closed chutes into appropriate containers with lids.

1.08 NOT USED**1.09 FIELD OFFICES**

- A. Office: Weathertight, with lighting, electrical outlets, heating, cooling equipment, and equipped with sturdy furniture, drawing rack, and drawing display table.
- B. Provide space for Project meetings, with table and chairs to accommodate 6 persons.

1.10 REMOVAL OF UTILITIES, FACILITIES, AND CONTROLS

- A. Remove temporary utilities, equipment, facilities, materials, prior to Date of Substantial Completion inspection.
- B. Clean and repair damage caused by installation or use of temporary work.
- C. Restore existing facilities used during construction to original condition.

PART 2 PRODUCTS - NOT USED**PART 3 EXECUTION - NOT USED****END OF SECTION**

**SECTION 01 52 16
REMEDATION TEMPORARY FACILITIES****PART 1 - GENERAL****1.1 GENERAL FACILITIES**

- 1.1.1 Related Documents: Drawings and general provision of the contract applicable.
- 1.1.2 General: Provide temporary connection to existing building utilities or provide temporary facilities as required herein or as necessary to carry out the work. Temporary facilities include, but are not limited to:
1. Temporary water service
 2. Fire extinguishing equipment and supplies
 3. First aid
 4. Temporary electrical
 5. Temporary lighting
 6. Sanitation facilities
 7. Scaffolding/ladders
 8. Office and storage trailers
 9. Signs
 10. Parking and traffic control

1.2 WATER SERVICE

- 1.2.1 Temporary Water Service Connection: All connections to the owner's water system shall include backflow protection. Valves shall be temperature and pressure rated for operation of the temperatures and pressures encountered. After completion of use, connections and fittings shall be removed without damage or alteration to existing water piping and equipment. Leaking or dripping valves shall be piped to the nearest drain or located over an existing sink or grade where water will not damage existing finishes or equipment.
- 1.2.2 Water Hoses: Employ heavy duty, abrasion-resistant hoses with a pressure rating greater than the maximum pressure of the water distribution system to provide water into each work area and to each decontamination unit. Provide fittings as required to allow for connection to existing wall hydrants or spouts, as well as temporary heating equipment, branch piping, showers, shut-off nozzles, and equipment.
- 1.2.3 Hot Water Heater: Contractor to provide a UL rated 20 gallon minimum electric hot water heater per six workers to supply hot water for the decontamination unit shower. Activate from 30 amp circuit breaker located within the decontamination unit subpanel. Provide with relief valve compatible with water heater operation: fittings and hook-up locations to be approved by owner. Wiring of the hot water shall be in compliance with NEMA, NECA, and UL standards. GFCI required. Owner will provide hot water, if available, to project area.
- 1.2.4 Coordinate all water connections with the building residents.

1.3 FIRE EXTINGUISHERS

- 1.3.1 Comply with governing regulations and recognized recommendations within the construction industry.

1.4 FIRST AID

- 1.4.1 Comply with governing regulations and recognized recommendations within the construction industry.
- 1.4.2 A minimum of two first aid kits will be readily available (one within the clean room or dressing area, and one within enclosure).

1.5 ELECTRICAL SERVICE

- 1.5.1 Comply with applicable NEMA, NECA, and UL standards and governing regulations for materials and layout of temporary electric service. Provide service to decontamination unit subpanel with minimum 60 amp, 2 pole circuit breaker or fused disconnect connected to the building's main distribution panel. Subpanel and disconnect shall be sized and equipped to accommodate all electrical equipment required for completion of the work.

- 1.5.2 Provide a weatherproof, grounded temporary electric power service and distribution system of sufficient size, capacity, and power characteristics to accommodate performance of work during the construction period. Install temporary lighting adequate to provide sufficient illumination for safe work and traffic conditions in every area of work.
- 1.5.3 Provide circuits of adequate size and proper characteristics for each use. In general, run wiring overhead, and rise vertically where wiring will be least exposed to damage from construction operations.
- 1.5.4 Temporary wiring in the work area shall be type UF non-metallic sheathed cable located overhead and exposed for surveillance. Do not wire temporary lighting with plain, exposed (insulated) electrical conductors. Provide liquid tight enclosures or boxes for wiring devices. Provide overload protected disconnect switch for each temporary circuit located at the power distribution center.
- 1.5.5 For power hand tools and task lighting, provide a temporary 4-gang outlet with GFI protection at each decontamination unit, located in equipment room. Provide a separate 110-120 volt, 20 amp circuit for each 4-gang outlet (4 outlets per circuit).
- 1.5.6 Contractor is responsible for providing a temporary service and all electricity costs.

1.6 TEMPORARY LIGHTING

- 1.6.1 Provide the following only where natural lighting or existing building lighting does not meet the required light level:

Four 200-watt incandescent lamp per 1,000 square feet of floor area, uniformly distributed, for general construction lighting, or equivalent illumination of a similar nature. Provide sufficient temporary lighting to ensure proper workmanship everywhere; by combined use of daylight, general lighting, and portable plug-in task lighting.
- 1.6.2 Provide lighting in the decontamination unit to supply 50 foot candle minimum light level.

1.7 SANITARY FACILITIES

- 1.7.1 Contractor will provide sufficient sanitation facilities to accommodate his/her work force. The Owner will not be responsible for providing sanitation facilities. Properly and regularly clean, supply and maintain the portable toilets.
- 1.7.2 Shower Facilities – Contractor will provide a centrally located shower unit meeting the requirements for asbestos abatement for use by personnel during all aspects of hazardous materials removal. A trailer decon facility would be acceptable.

1.8 SCAFFOLDING/LADDERS

- 1.8.1
 - A. Comply with 29 CFR 1926.450 (Scaffolds).
 - B. Comply with 29 CFR 1926.1052 (Ladders).
- 1.8.2 Provide all scaffolding, ladders and/or staging, etc. as necessary to accomplish the work of this contract. Scaffolding may be of suspension type or standing such as metal tube and coupler, tubular welded frame, pole type, outrigger type, or cantilever type. The type, erection, and use of all scaffolding shall comply with all applicable OSHA provisions.
 - 1. Equipment rungs of all metal ladders, etc. with an abrasive non-slip surface.
 - 2. Provide a non-skid surface on all scaffold surfaces to foot traffic.
 - 3. Cap and seal all open ends of scaffold.

1.9 STORAGE OF MATERIALS

- 1.9.1 Contractor shall provide and maintain all necessary on-site facilities and structures required to protect materials. Temporary structures for material storage shall be weather tight, neatly constructed, well maintained, and subject to approval of the owner. Materials shall be stored and secured in the area so designated on the plans and as directed by the owner. The contractor is responsible for the security of all his/her materials, tools, and equipment and the owner will not be liable for any loss or damage to same.

1.10 SIGNS

- 1.10.1 No advertising signs shall appear on the site except for the sign that the contractor may have on his/her field office stating his/her name and address. Small signs for the purpose of direction traffic or deliveries may be erected as approved. No other signs will be permitted on the site.

1.11 PARKING AND TRAFFIC CONTROL

- 1.11.1 Comply with all posted regulations, signs, and directions regarding traffic, parking, loading, or unloading.
- 1.11.2 Arrange for loading/unloading operations in designated areas as shown on the drawings or as approved by the owner.
- 1.11.3 Provisions will be made for parking contractor's vehicles on the site. Personal vehicles of construction workers may be parked at the locations designated by the owner.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION

**SECTION 01 56 16
REMEDATION TEMPORARY ENCLOSURES****PART 1 - GENERAL****1.1 DESCRIPTION**

- 1.1.1 Work under this section shall include all labor, materials, and equipment necessary for the construction and maintenance of temporary enclosures and barriers to contain the hazardous materials abatement work area.
- 1.1.2 Refer to specific sections addressing the various regulated/hazardous materials being remediated as part of the work scope under this contract.
- 1.1.3 Applicable to:
1. Decontamination unit construction
 2. Waste transfer airlock construction
 3. Enclosure, critical barriers, floor and wall coverings
 4. Special protection of existing equipment
 5. Mini enclosure

1.2 SUBMITTALS PRIOR TO PROJECT START UP

Submittals required for work includes:

1.2.1 Materials

1. Polyethylene sheeting
2. Spray poly. Use at contractor's option
3. Duct tape
4. Spray adhesives
5. Signage
6. Shop drawings indicating methods proposed to secure wall covering
7. Owner's approval of any pre-cleaning operation requiring cover up

1.2.2 Drawing showing proposed enclosure for vac truck (if applicable and being used for vermiculite removal).

1.2.3 Contingency plans for safety evacuation of work area in case of fire or injury.

1.2.4 Contact local fire marshall to review egress procedures and receive approval prior to start of work. Review plan with all subcontractors and project workers.

1.3 PRE-ABATEMENT CONDITION OF THE WORK AREA

- 1.3.1 The buildings are slated for demolition. Condition of the work area is as is. The debris must be substantially removed and sorted prior to establishing an asbestos containment area for asbestos removal. The finishes are not important. Limited demolition can be performed to join areas for abatement.

PART 2 - PRODUCTS**2.1 PROTECTION MATERIALS**

- 2.1.1 Polyethylene Sheet - A single polyethylene film in the largest sheet size possible to minimize seams, 4.0 or 6.0-mil thick as indicated, clear, frosted, or black as indicated.
- 2.1.2 Reinforced Polyethylene Sheet - Where plastic sheet is the only separation between the work area and building exterior, provide translucent, nylon reinforced, laminated, flame resistant, polyethylene film that conforms to requirements set forth by the National Fire Protection Association Standard 701, 2019 Edition, Small Scale Fire Test for Flame-resistant Textiles and Films. Provide largest size possible to minimize seams, 4.0 or 6.0-mils thick as indicated, frosted, or black as indicated.

- 2.1.3 Duct Tape- Provide duct tape in 2" or 3" widths as indicated, with an adhesive which is formulated to aggressively stick to sheet polyethylene.
- 2.1.4 Spray Cement - Provide spray adhesive in aerosol cans which is specifically formulated to stick tenaciously to sheet polyethylene.
- 2.1.5 Spray polyethylene may be used in lieu of sheet poly in some areas subject to the Owner's approval.

PART 3 - EXECUTION

3.1 GENERAL - ASBESTOS

- 3.1.1 Work area is the location where asbestos abatement work occurs. It is a variable of the extent of work of the contract. It may be a portion of a room, a single room, or a complex of rooms. A "work area" is considered contaminated during the work and must be isolated from the balance of the building and decontaminated at the completion of the asbestos control work.
- 3.1.2 Completely isolate the work area from other parts of the building so as to prevent asbestos containing dust or debris from passing beyond the isolated area. Should the area beyond the work area(s) become contaminated with asbestos containing dust or debris as a consequence of the work, clean those areas in accordance with the same procedures indicated for project decontamination. Perform all such required cleaning or decontamination at no additional cost to owner.

Place all tools, scaffolding, staging, etc. necessary for the work in the area to be isolated prior to erection of plastic sheeting temporary enclosure.

3.1.3 Emergency Exits

- 1. At each existing exit door or hatch from the work area provide the following means for emergency exiting: Arrange exit door or hatch so that it is secure from outside the work area but permits exiting from the work area. Mark outline of door on primary and critical barriers with luminescent paint at least 3" wide. Hang a razor knife on a string beside outline. Arrange critical and primary barriers so that they can easily cut with one pass of razor knife. Paint words "**EMERGENCY EXIT**" inside outline with luminescent paint in letters at least one foot high and 2" thick. Directions to the exits will be clearly marked by painting arrows 2 feet off the floor pointing to the nearest emergency exit. Arrows will be a minimum of 3 feet long and spaced no more than 10 feet apart. Use luminescent orange or red paint for all markings.
- 2. Building to be secured using existing doors during non-work hours.

3.1.4 Work Area Security - Control Access

- 1. Permit access to the work area only through the decontamination unit. All other means of access shall be closed off and sealed and warning signs displayed on the clean side of the sealed access. Verify with local fire marshal that occupant life safety requirements are met.
- 2. Where the work area is immediately adjacent to or within view of occupied areas, provide a visual barrier of opaque polyethylene sheeting at least 4-mil in thickness so that the work procedures are not visible to building occupants. Where this visual barrier would block natural light, substitute frosted sheet plastic.
- 3. Where the area adjacent to the work area is accessible to the public, construct a solid barrier on the public side of the sheeting to protect the sheeting. Construct barrier with nominal 2" x 4" wood or metal studs 16" on center, securely anchored to prevent movement, covered with 1/2" plywood or sheetrock.
- 4. Warning signs at each visual or physical barrier that could be breached as follows:

LEGEND

KEEP OUT

NOTATION

3" Sans Serif Gothic or Block

BEYOND THIS POINT

1" Sans Serif Gothic or Block

ASBESTOS ABATEMENT WORK

IN PROGRESS

1" Sans Serif Gothic or Block

BREATHING ASBESTOS DUST MAY BE
HAZARDOUS TO YOUR HEALTH

14 Point Gothic

5. The occupied side of non-breachable barriers are to be labeled "Construction Zone - Keep Out". Immediately inside such barriers, but outside critical barriers post an asbestos hazard warning sign per 29 CFR 1926.
 6. Temporary construction door locks shall be provided by the contractor. Locksets should be key lockable for the outside and always unlocked and operable from the inside. Do not use deadbolts or padlocks.
- 3.1.5 Respiratory and worker protection: Before proceeding beyond this point in providing temporary enclosures, provide worker protection including respiratory protection per Section 013529.
- 3.1.6 Ventilation: During pre-cleaning and enclosure construction, all required HEPA filtration systems will be operating.
- 3.2 CRITICAL BARRIERS, WALL AND FLOOR COVERINGS - ASBESTOS**
- 3.2.1 Critical Barriers
1. Completely separate the work area from other portions of the building and the outside by sheet plastic barriers at least 6-mil in thickness or by sealing with duct tape.
 2. Mechanically support sheet plastic independently of duct tape or spray poly seals so that seals do not support the weight of the plastic. Prepare shop drawings showing methods of supporting sheet plastic barriers. Support methods shall be approved in writing by the owner.
 3. Window's critical barrier will consist of a minimum of one layer of 6-mil poly sheeting.
 4. Electric motors and electrical service boxes require framing, plywood sheathing and a minimum of 3 layers of poly. Each layer of poly must be secured in such a manner as to allow the top layer to be removed without disrupting the seals of remaining layers.
 5. Seal all ventilation openings (supply and exhaust), electrical conduit connectors, telephone wire, existing lighting fixtures, clocks, doorways, windows, connectors and speakers, and other openings into the work area with duct tape alone or with polyethylene sheeting at least 6-mil in thickness, taped securely in place with duct tape. Maintain seal until all work, including project decontamination, is completed. If during the removal of thermal insulation it is observed the thermal insulation penetrated the wall or deck, the contractor will attempt to seal hole with fiberglass insulation or other appropriate material from outside the enclosure and will perform any necessary clean up activity required to prevent asbestos exposure.
 6. Provide sheet plastic barriers at least 6-mil in thickness as required to seal openings completely from the work area into adjacent areas. Seal the perimeter of all sheet plastic barriers with duct tape or spray adhesives.
 7. Where applicable, remove and HEPA vacuum suspended ceiling tile to access the deck for enclosure construction.
- 3.2.2 Wall covering layer of poly sheeting is to be constructed in such a manner as to allow no seam joints extending horizontally. Use widths of sheeting minimizing the required number of vertical seams. Vertical seams require a minimum of a 12 inch overlap sealed with spray adhesives and duct tape.

- 3.2.3 In addition to the critical barrier, a primary barrier as described herein shall be installed and maintained throughout the work areas as required by Section 028213. Prior to installing the primary barrier, pre-clean by HEPA vacuuming and wet wiping all surfaces in contact with the barriers.
- 3.2.4 Cover floor of work area with two individual layers of clear polyethylene sheeting, each at least 6-mil in thickness, turned up walls at least 12 inches, or provide an equivalent continuous film of spray poly. Form a sharp right angle bend at junction of floor and wall so that there is no radius which could be stepped on causing the wall attachment to be pulled loose. Both spray glue and duct tape all seams in floor covering. Locate seams in top layer six feet (6') from, or at right angles to, seams in bottom layer. Install sheeting so that top layer can be removed independently of bottom layer.
- 3.2.5 Where applicable, cover carpeting to be saved with three layers of polyethylene sheeting at least 6-mil in thickness. Place corrugated cardboard sheets between the top and middle layers of polyethylene.
- 3.2.6 Remove all electrical and mechanical items such as lighting fixtures, clocks, diffusers, registers, escutcheon plates, etc., which cover or interfere with any part of the surface to be worked on.
- 3.2.7 Remove all general construction items such as cabinets, doors, casework, door and window trim, moldings, ceilings, trim, etc., which cover the surface of the work as required to prevent interference with the work.
- 3.2.8 Cover all walls in work area including "Critical Barrier" sheet plastic barriers with one layer of polyethylene sheeting, at least 6-mil in thickness, mechanically supported, and sealed with duct tape or spray glue in the same manner as "Critical Barrier" sheet plastic barriers. Tape all joints including the joining with the floor covering with duct tape. An equivalent film of spray poly is acceptable for block walls.
- 3.2.9 Whenever required, mechanically support sheet plastic independently of duct tape or spray cement seals so that seals do not support the weight of the plastic. The following are acceptable methods of supporting sheet plastic barriers. Alternative support methods may be used if approved in writing by the Contracting Officer. Use methods that minimize damage to existing finishes, which must be repaired by this contractor.
1. Plywood squares 6" x 6" x 3/8" held in place with one 6d smooth masonry nail or electro-galvanized common nail driven through center of the plywood and duct tape on plastic so that plywood clamps to the wall. Locate plywood squares at each end, corner, and at maximum, 4' on corners.
 2. Nylon or polypropylene rope minimum 1/4" in diameter suspended between supports securely fastened on either side of opening at maximum 1' below ceiling. Tighten rope so that it has 2" maximum dip. Drape plastic over rope from outside work area so that a 2' flap of plastic extends over rope into work area. Staple or wire plastic to itself 1" below rope at maximum 6" on centers to form a sheath over rope. Lift flap and seal to ceiling with duct tape or spray cement. Seal loop at bottom of flap with duct tape. Erect entire assembly so that it hangs vertically without a "shelf" upon which debris could collect.
- 3.2.10 Do not cover stairs or ramps with unsecured sheet plastic. Where stairs or ramps are covered with plastic, provide 3/4" exterior grade plywood treads securely held in place over plastic. Do not cover rungs or rails with any type of protective materials.
- 3.2.11 Immediately remove and replace plastic sheeting which has been damaged by removal operations or where seal has failed allowing water to seep between layers. Remove affected sheeting and wipe down entire area. Install new sheet plastic only when area is completely dry.

3.3 CONTAINMENT - ASBESTOS

- 3.3.1 Full containment enclosures shall consist of critical barriers and primary barriers as described in this section and consisting of 2 layers of 6-mil polyethylene plastic on floors and wood framed walls and ceiling. Full containment shall include an attached decontamination unit for personnel and material.
- 3.3.2 Mini enclosures shall consist of a temporary rigid wood or metal frame with two layers of 6-mil polyethylene on the walls, floor, and ceiling. The enclosure shall include a decontamination airlock where workers can HEPA vacuum their suits and/or don clean suits prior to proceeding to a remote shower unit. Air clearance in mini enclosures shall be aggressive after removal of the inner layer of poly.

- 3.3.3 Glovebag enclosures shall consist of commercially available glovebags made of 6-mil polyethylene plastic.

3.4 DECONTAMINATION UNIT - Refer to Section 01 52 16.

3.5 EXTENSION OF WORK AREA

- 3.5.1 If the enclosure barrier is breached in any manner that could allow the passage of asbestos debris or airborne fibers, then add affected area to the work area, enclose it as required by this section of the specification and decontaminate in accordance with the project decontamination procedures specified elsewhere.

3.6 REPAIR OF DAMAGED POLYETHYLENE SHEETING

- 3.6.1 Remove and replace plastic sheeting which has been damaged by removal operations or where seal has failed allowing water to seep between layers. Remove affected sheeting and wipe down entire area. Install new sheet plastic only when area is completely dry.

3.7 ISOLATION AREAS

- 3.7.1 Establish and maintain isolation area between the work area and adjacent building areas as shown on the plans.
- 3.7.2 Form isolation area by controlling access to the space in the same manner as a work area. Physically isolate the space from the work area and adjacent areas. Accomplish physical isolation by installing critical barriers in unoccupied space or erecting a second critical barrier a minimum of 3' 0" away from the work area as appropriate. Plywood barrier to be installed where identified on the plans.

3.8 STOP WORK

- 3.8.1 If the critical or primary barrier falls or is breached in any manner, stop work immediately.

3.9 SECONDARY BARRIERS

- 3.9.1 The secondary layer of plastic is a drop cloth to protect the primary layer from debris generated by the asbestos abatement work and is specified in the appropriate work sections.

END OF SECTION

**SECTION 01 57 19
PRESSURE DIFFERENTIAL SYSTEMS - ASBESTOS****PART 1 - GENERAL****1.1 DESCRIPTION**

- 1.1.1 General provisions apply to work of this section.
- 1.1.2 Work under this section includes the provision of a complete system of HEPA filter units, make-up air openings, electrical power supply, alarm, and monitoring as specified and as necessary to maintain the work areas under a constant differential pressure from beginning to end of asbestos abatement activities.
- 1.1.3 Differential pressure systems are required for all work areas of this project that are inside the buildings. Exterior work does not require the use of differential pressure systems.
- 1.1.4 Supply required number of HEPA filtration units to provide a minimum of four air exchanges per hour in each enclosure. Continuously monitor and record the pressure differential between the work area and the building outside of the work area with a monitoring device incorporating a continuous recorder (e.g., strip chart) or electronic memory accessible for viewing during the project.

1.2 SUBMITTALS PRIOR TO PROJECT START-UP

- 1.2.1 Submit design of pressure differential system to the owner for review. Do not begin work until submittal is returned approved by the owner indicating that the submittal is returned for unrestricted use.

Prepare shop drawing to include the following:

- 1. Method of supplying adequate power to filtration systems.
- 2. Number of filtration systems and calculation necessary to determine quantity of machines.
- 3. Location of filtration systems in work area and exhaust ports to building's exterior.

- 1.2.2 Provide manufacturer's literature for each model of equipment including:

- 1. HEPA filtration systems.
- 2. Negative pressure monitoring sensor.

PART 2 - PRODUCTS**2.1 HEPA FILTRATION SYSTEMS**

- 2.1.1 General: Supply the required number of HEPA filtered fan units to the site in accordance with these specifications. Use units that meet the following requirements.
 - 1. Cabinet: Constructed of durable materials able to withstand damage from rough handling and transportation. Provide units whose cabinets are:
 - a. Factory sealed to prevent asbestos containing dust from being released during use, transport, or maintenance.
 - b. Arranged to provide access to and replacement of all air filters from intake end.
 - c. Mounted on casters or wheels.
 - 2. Fans: Rate capacity of fan according to usable air-moving capacity under actual operating conditions.

2.2 INSTRUMENTATION

Instrumentation and safety devices must include:

- 2.2.1 Magnehelic gauge or manometer to measure the pressure drop across filters and indicate when filters have

become loaded and need to be changed.

- 2.2.2 Electrical (or mechanical) lockout to prevent fan from operating without a HEPA filter, filter rupture, or filter blockage.
- 2.2.3 Audible alarm if unit shuts down due to operation of safety systems if pressure differential drops below 0.02 inches of water.
- 2.2.4 Warning lights to indicate normal operation (green), too high a pressure drop across the filters (i.e., filter overloading), (yellow), and too low of a pressure drop (i.e., rupture in HEPA filter or obstructed discharge), (red).
- 2.2.5 Elapsed time meter to show the total accumulated hours of operation.

2.3 FILTERS

2.3.1 HEPA

- 1. Provide units whose final filter is the HEPA type with the filter media (folded into closely pleated panels) completely sealed on all edges with a structurally rigid frame.
- 2. Provide units with a continuous rubber gasket located between the filter and the filter housing to form a tight seal.
- 3. Provide HEPA filters that are individually tested and certified by the manufacturer to have an efficiency of not less than 99.97 percent.
- 4. Subject to compliance with requirements, provide units manufactured by companies known to provide negative pressure units meeting the requirements of asbestos abatement including appropriate filtration and safety devices.
- 5. Supply the required number of asbestos air filtration units to the site in accordance with these specifications. Each unit shall include the following.
 - a. Cabinet - Constructed of steel or other durable materials able to withstand damage from rough handling and transportation. Cabinet shall be factory sealed to prevent asbestos containing dust from being released during use, transport, or maintenance. Access to and replacement of all air filters shall be from intake end. Unit shall be mounted on casters or wheels.
 - b. Fans - Rate capacity of fan according to useable air moving capacity under actual operating conditions. Use centrifugal-type fan.
 - c. HEPA Filters - The final filter shall be the HEPA type with the filter media (folded into closely pleated panels) completely sealed on all edges with a structurally rigid frame.
- 6. A continuous rubber gasket shall be located between the filter and the filter housing to form a tight seal.
- 7. Each HEPA filter shall be individually tested and certified by the manufacturer to have an efficiency of not less than 99.97 percent when challenged with a 0.3 cm dioctylphthalate (DOP) particles. Testing shall be in accordance with Military Standard Number 282 and shall bear UL 586 label.
- 8. Provide filters that are marked with the name of manufacturer and serial number.

2.3.2 Prefilters: Which protect the final filter by removing the larger particles, are required to prolong the operating life of the HEPA filter. Two stages of prefiltration are required. Provide units with the following prefilters:

- 1. First Stage Prefilter: Low efficiency type (e.g., for particles 100 um and larger).

2. Second Stage (or Intermediate) Filter: Medium efficiency (e.g., effective for particles down to 5 um).

Provide units with prefilters and intermediate filters installed either on or in the intake grid of the unit and held in place with special housings or clamps.

- 2.3.3 Safety and Warning Devices - The unit shall have an electrical (or mechanical) lockout to prevent fan from operating without a HEPA filter. Units shall be equipped with automatic shutdown system to stop fan in the event of a major rupture in the HEPA filter or blocked air discharge. Warning lights are required to indicate normal operation, too high of a pressure drop across the filters (i.e., filter overloading), and too low of a pressure drop (i.e., major rupture in HEPA filter or obstructed discharge).

- 2.3.4 Electrical components shall be approved by the National Electrical Manufacturers Association (NEMA) and Underwriter's Laboratories (UL). Each unit shall be equipped with overload protection sized for the equipment. The motor, fan, fan housing, and cabinet shall be grounded.

2.4 CONTINUOUS MONITORING EQUIPMENT

- 2.4.1 Provide all required submittals including:

1. Manufacturer's literature.
2. Manufacturer's recommended calibration method for calibration against standard.
3. Original daily chart strip from pressure differential monitoring equipment. Mark printout with date and start of time for each day. Use printout paper that indicates elapsed time in intervals no greater than hours. Indicate on each day's record times of starting and stopping work by including the following information three times during each work shift (prior to starting shift, mid-shift, end of shift):
 - a. Name of person check calibration.
 - b. Date and time.
 - c. Pressure sensor instrument reading.
 - d. Mark chart strip with arrow indicating precise time read.

- 2.4.2 Negative pressure of 0.02 inches pressure differential or greater is required for this project.

2.5 DUCTWORK FOR HEPA EXHAUST

- 2.5.1 Vent HEPA filtered fan units to outside of building unless authorized in writing by owner. Ventilation exhaust locations and construction subject to owner's approval.

2.5.2 Ducts

1. Use only new ductwork except for sheet metal connections and elbows.
2. Use ductwork and fittings of same diameter or larger than discharge connection on fan unit.
3. Use inflatable, disposable plastic ductwork in lengths not greater than 100 feet.
4. Use spiral wire reinforced flex duct in lengths not greater than 50 feet.
5. Arrange exhaust as required to inflate duct to a rigidity sufficient to prevent flapping.
6. If direction of discharge from fan unit is not aligned with duct, use sheet metal elbow to change direction. Use six feet of spiral wire reinforced flex duct after direction change.

2.6 BUILDING EXTERIOR HEPA EXHAUST PORTS

- 2.6.1 Fabricate 1/2" plywood sheathing to fit required opening. Opening may require added framing support to secure sheathing. Plywood is to be secured by appropriate fasteners. Temporarily caulk cracks between sheathing and frame. Secure exhaust tube to sheathing.

PART 3 - EXECUTION**3.1 AIR CIRCULATION IN THE WORK AREA**

3.1.1 Minimum number of air exchanges for work, provided continuous negative pressure monitor is operational, is four.

3.1.2 Determine number of units needed to achieve required air circulation according to the following procedure:

1. Determine the volume in cubic feet of the work area by multiplying floor area by ceiling height. Determine total air circulation requirements in cubic feet per minute (CFM) for the work area by dividing this volume by the air change rate and multiplying by 60.

Air Circulation Required in CFM =

$$\frac{\text{Volume of work area (cu. ft.)} \times \text{Number of air changes per hour}}{60 \text{ (minutes per hour)}}$$

2. Divide the air circulation requirement (CFM) above by capacity of HEPA filtered fan unit(s) used. Capacity of a unit for purposes of this section is the capacity in cubic feet per minute with fully loaded filters (pressure differential which causes loaded filter warning light to come on) in the machine's labeled operating characteristics. The maximum CFM handling capacity for any single filtration system will be calculated at 75 percent of the manufacturer's optimum rating capacity or manufacturer's stated capacity for fully loaded filters, whichever is less.

Number of Units Needed =

$$\frac{\text{Air Circulation Requirement (CFM)}}{\text{Capacity of unit with loaded filters (CFM) or 75 percent of manufacturer's optimum rating capacity}}$$

3.1.3 Add one (1) additional unit as a backup in case of equipment failure or machine shutdown for filter changing.

3.2 MAKE-UP AIR

3.2.1 Decontamination Units: Arrange work area and decontamination units so that the majority of make-up air comes through the decontamination units. Use either personnel or equipment decontamination unit at any one time and seal the other so that make-up air passes through unit in use.

3.3 RECIRCULATING AIR

3.3.1 Contractor may need additional HEPA filtration systems inside containment, in addition to those required to maintain a minimum of four air exchanges per hour, located in the work area to reduce airborne fiber concentrations.

3.4 USE OF SYSTEM DURING ABATEMENT OPERATIONS

3.4.1 Start exhaust units before beginning work (before any asbestos containing material is disturbed). After abatement work has begun, run units continuously to maintain a constant differential pressure and air circulation until decontamination of the work area is complete. Do not turn off units at the end of the work shift or when abatement operations temporarily stop.

3.4.2 Do not shut down differential air system during encapsulating procedures.

3.4.3 Start abatement work at a location farthest from the fan units and proceed toward them. If an electric power failure occurs, immediately stop all abatement work, seal all inlets to containment and do not resume until power is restored and fan units are operating again.

- 3.4.4 At completion of abatement work allow fan units to run as specified for project decontamination, to remove airborne fibers that may have been generated during abatement work and clean-up; and, to purge the work area with clean make-up air. The units may be required to run for a longer time after decontamination, if dry or only partially wetted asbestos material was encountered during any abatement work.

3.5 DISMANTLING THE SYSTEM

- 3.5.1 When a final visual inspection and the results of final air test indicate that the area has been decontaminated, fan units may be removed from the work area. Before removal from the work area, remove and properly dispose of filters, and seal intake to the machine with a 6-mil polyethylene to prevent environmental contamination from the filters.

END OF SECTION

SECTION 017000
EXECUTION AND CLOSEOUT REQUIREMENTS**PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. Examination, preparation, and general installation procedures.
- B. Cleaning and protection.
- C. Closeout procedures, including Contractor's Correction Punch List, except payment procedures.

1.02 RELATED REQUIREMENTS

- A. Section 011000 - Summary: Limitations on working in existing building; continued occupancy; work sequence; identification of salvaged and relocated materials.
- B. Section 011100 – Asbestos Remediation Summary of Work: Limitations on working in existing building; continued occupancy; work sequence; identification of salvaged and relocated materials.
- C. Section 014000 - Quality Requirements: Testing and inspection procedures.
- D. Section 015000 - Temporary Facilities and Controls: Temporary exterior enclosures.
- E. Section 017419 - Construction Waste Management and Disposal: Additional procedures for trash/waste removal, recycling, salvage, and reuse.
- F. Section 017800 - Closeout Submittals: Project record documents, operation and maintenance data, warranties, and bonds.
- G. Section 028233 – Asbestos Waste Disposal and Transportation: Additional procedures for disposal of asbestos-containing materials.
- H. Section 028234 – Project Decontamination and Work Area Clearance – Asbestos: Decontamination and cleaning requirements prior to work area clearance.

1.03 REFERENCE STANDARDS

- A. NFPA 241 - Standard for Safeguarding Construction, Alteration, and Demolition Operations 2019

1.06 PROJECT CONDITIONS

- A. Ventilate enclosed areas to prevent accumulation of dust, fumes, vapors, or gases.
- B. Dust Control: Execute work by methods to minimize raising dust from construction operations. Provide positive means to prevent air-borne dust from dispersing into atmosphere and over adjacent property. Cover all adjacent areas during drilling and cutting operations to prevent dust from settling into carpets and onto furniture.
- C. Noise Control: Provide methods, means, and facilities to minimize noise produced by construction operations.
 - 1. Outdoors: Limit conduct of especially noisy exterior work to the hours of 8 am to 5 pm.
- D. 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. Comply with federal, state, and local regulations.

1.07 COORDINATION

- A. Coordinate scheduling, submittals, and work of the various sections of the Project Manual to ensure efficient and orderly sequence of demolition of interdependent construction elements.
- B. Submit Mule-Hide's "Warranted Project Alteration Form" in order to obtain approval for the roof patches before beginning work.

- C. Notify affected utility companies and comply with their requirements.
 - 1. Coordinate all work with the site.
- D. Coordinate completion and clean-up of work of separate sections.
- E. After Owner occupancy of premises, coordinate access to site for correction of defective work and work not in accordance with Contract Documents, to minimize disruption of Owner's activities.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine and verify specific conditions described in individual specification sections.
- B. Verify that utility services are available, of the correct characteristics, and in the correct locations.
- C. Prior to Cutting: Examine existing conditions prior to commencing work, including elements subject to damage or movement during cutting and patching. After uncovering existing work, assess conditions affecting performance of work. Beginning of cutting or patching means acceptance of existing conditions.

3.02 LAYING OUT THE WORK

- A. Verify locations of survey control points prior to starting work.
- B. Promptly notify Owner of any discrepancies discovered.
- C. Protect survey control points prior to starting site work; preserve permanent reference points during construction.
- D. Promptly report to Owner the loss or destruction of any reference point or relocation required because of changes in grades or other reasons.
- E. Replace dislocated survey control points based on original survey control. Make no changes without prior written notice to Owner.
- F. Utilize recognized engineering survey practices.
- G. Establish elevations, lines and levels. Locate and lay out by instrumentation and similar appropriate means:
 - 1. Site improvements including stakes for grading, fill and topsoil placement; utility locations, slopes, and invert elevations.
 - 2. Grid or axis for structures.
- H. Periodically verify layouts by same means.
- I. Maintain a complete and accurate log of control and survey work as it progresses.

3.03 PROGRESS CLEANING

- A. Maintain areas free of waste materials, debris, and rubbish. Maintain site in a clean and orderly condition.
- B. Collect and remove waste materials, debris, and trash/rubbish from site periodically and dispose off-site; do not burn or bury.

3.04 FINAL CLEANING

- A. Clean site; sweep paved areas, rake clean landscaped surfaces.
- B. Remove waste, surplus materials, trash/rubbish, and construction facilities from the site; dispose of in legal manner; do not burn or bury.
- C. Additional cleaning and decontamination as required in other sections.

3.05 CLOSEOUT PROCEDURES

- A. Make submittals that are required by governing or other authorities.
 - 1. Provide copies to Architect and Owner.
- B. Accompany Project Coordinator on preliminary inspection to determine items to be listed for completion or correction in the Contractor's Correction Punch List for Contractor's Notice of Substantial Completion.
- C. Notify Owner when work is considered ready for Owner's Substantial Completion inspection.
- D. Submit written certification containing Contractor's Correction Punch List, that Contract Documents have been reviewed, work has been inspected, and that work is complete in accordance with Contract Documents and ready for Owner's Substantial Completion inspection.
- E. Conduct Substantial Completion inspection and create Final Correction Punch List containing Owner's and Contractor's comprehensive list of items identified to be completed or corrected and submit to Owner.
- F. Correct items of work listed in Final Correction Punch List and comply with requirements for access to Owner-occupied areas.
- G. Notify Owner when work is considered finally complete and ready for Owner's Substantial Completion final inspection.
- H. Complete items of work determined by Owner listed in executed Certificate of Substantial Completion.

3.06 FORMS

- A. Warranted Project Alteration Form

END OF SECTION



Warranted Project Alteration Form

Date: _____ Project #: _____ Exp. Date: _____

Building Identification/Name: _____ Building Address: _____

Owner: _____

Type of Post Warranty Alteration:

☐

General Roof Alterations

☐

Garden Roof System

☐

Photovoltaic (PV) Installation

General Alterations or Garden Roof projects only:

Thank you for your notice of alterations to the warranted Mule-Hide roof system on the above referenced building. A reasonable attempt should be made to involve the original installing contractor to make the necessary roof system repairs regarding these alterations. Only roofing contractors who are currently warranty eligible with Mule-Hide are permitted to perform alterations and repairs to a warranted roof system.

Mule-Hide reserves the right to require a post-alteration inspection upon review of the submitted documents. The purpose of the post-alteration inspection is to verify new membrane flashings or other membrane-related alterations comply with Mule-Hide's written technical specifications and details. The charge for a required inspection is \$350.00, payable to Mule-Hide Products. **No payments will be accepted prior to the issuance of a Mule-Hide invoice.** The invoice will be directed to the owner listed on the warranty unless a third party is responsible for payment and separate billing information has been provided.

Mule-Hide requires the following information in order to update the existing warranted project file and to ensure the existing warranty remains in full force:

Mule-Hide Warranty Eligible Applicator Name: _____

Mule-Hide Warranty Eligible Applicator Contractor #: _____

☐
☐
☐
☐

Mule-Hide warranty eligible applicator number

Before and after photos clearly showing scope of work performed

Description of work performed including all flashing and/or other details used

Roof Drawing indicating location of Alterations or Additions

Alterations over \$10,000

☐

YES

☐

NO

Photovoltaic (PV) projects only:

This form and all requested information should be submitted **after** the PV installation has been completed. An inspection by a Mule-Hide representative **may** be required upon review of the submitted documents and photos. The purpose of the inspection is to verify new membrane flashings or other membrane-related alterations comply with Mule-Hide's written technical specifications and details. **Mule-Hide does not perform pre-installation inspections for PV projects.**

I certify the following information is attached to this document: (all boxes must be checked)

☐
☐
☐
☐
☐

Name of PV Manufacturer

PV Install completion date

Drawing to include proposed PV layout and Roof Plan

Proposed protection/slip sheet materials Overburden waiver completed and signed by the Building Owner ONLY

PV rack manufacturer's detail drawing for the installed PV system.

Name of Submitter _____

Date _____

Representative of
(Company) _____

E-mail _____

Upon review and approval of the completed work and receipt of the required items outlined in this form, the existing warranty will remain in full force. Failure to follow the procedures outlined in this document, including failure to notify Mule-Hide of any post-warranty alteration to the Mule-Hide roofing system, may disrupt the Mule-Hide warranty coverage provided by the warranty on this project. Mule-Hide has the right to rely on the information provided with this form and submittal of this form is authorization for Mule-Hide to review the submitted material. Mule-Hide requires the person submitting this form to have the requisite power and authority to submit the information and make the request(s) accompanying it.

** Please submit this form and all required documentation and photos to mulehidewarranties@mulehide.com

FAILURE TO FOLLOW THE PROCEDURES OUTLINED ABOVE, INCLUDING FAILURE TO NOTIFY MULE-HIDE, MAY DISRUPT WARRANTY COVERAGE

SECTION 017419
CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL**PART 1 GENERAL****1.01 WASTE MANAGEMENT REQUIREMENTS**

- A. Owner requires that this project generate the least amount of trash and waste possible.
- B. Employ processes that ensure the generation of as little waste as possible due to error, poor planning, breakage, mishandling, contamination, or other factors.
- C. Minimize trash/waste disposal in landfills; reuse, salvage, or recycle as much waste as economically feasible.
- D. Contractor shall submit periodic Waste Disposal Reports; all landfill disposal, incineration, recycling, salvage, and reuse must be reported regardless of to whom the cost or savings accrues; use the same units of measure on all reports.
- E. Methods of trash/waste disposal that are not acceptable are:
 - 1. Burning on the project site.
 - 2. Burying on the project site.
 - 3. Dumping or burying on other property, public or private.
 - 4. Other illegal dumping or burying.
- F. Regulatory Requirements: Contractor is responsible for knowing and complying with regulatory requirements, including but not limited to Federal, state and local requirements, pertaining to legal disposal of all construction and demolition waste materials.

1.02 DEFINITIONS

- A. Clean: Untreated and unpainted; not contaminated with oils, solvents, caulk, or the like.
- B. Construction and Demolition Waste: Solid wastes typically including building materials, packaging, trash, debris, and rubble resulting from construction, remodeling, repair and demolition operations.
- C. Hazardous: Exhibiting the characteristics of hazardous substances, i.e., ignitibility, corrosivity, toxicity or reactivity.
- D. Nonhazardous: Exhibiting none of the characteristics of hazardous substances, i.e., ignitibility, corrosivity, toxicity, or reactivity.
- E. Nontoxic: Neither immediately poisonous to humans nor poisonous after a long period of exposure.
- F. Recyclable: The ability of a product or material to be recovered at the end of its life cycle and remanufactured into a new product for reuse by others.
- G. Recycle: To remove a waste material from the project site to another site for remanufacture into a new product for reuse by others.
- H. Recycling: The process of sorting, cleansing, treating and reconstituting solid waste and other discarded materials for the purpose of using the altered form. Recycling does not include burning, incinerating, or thermally destroying waste.
- I. Return: To give back reusable items or unused products to vendors for credit.
- J. Reuse: To reuse a construction waste material in some manner on the project site.
- K. Salvage: To remove a waste material from the project site to another site for resale or reuse by others.
- L. Sediment: Soil and other debris that has been eroded and transported by storm or well production run-off water.
- M. Source Separation: The act of keeping different types of waste materials separate beginning from the first time they become waste.

- N. Toxic: Poisonous to humans either immediately or after a long period of exposure.
- O. Trash: Any product or material unable to be reused, returned, recycled, or salvaged.
- P. Waste: Extra material or material that has reached the end of its useful life in its intended use. Waste includes salvageable, returnable, recyclable, and reusable material.

PART 2 PRODUCTS - NOT USED**PART 3 EXECUTION****3.01 WASTE MANAGEMENT PROCEDURES**

- A. See Section 013000 for additional requirements for project meetings, reports, submittal procedures, and project documentation.
- B. See Sections 015000 & 015216 for additional requirements related to trash/waste collection and removal facilities and services.
- C. See Sections 017000, 028100, 028213, & 028233 for trash/waste prevention procedures related to demolition, cutting and patching, installation, protection, and cleaning.

END OF SECTION

**SECTION 017800
CLOSEOUT SUBMITTALS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Project Record Documents.

1.02 RELATED REQUIREMENTS

- A. Section 013000 - Administrative Requirements: Submittals procedures, shop drawings, product data, and samples.

1.03 SUBMITTALS

- A. Project Record Documents: Submit documents to Owner (copy to Architect) with claim for final Application for Payment.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 PROJECT RECORD DOCUMENTS

- A. Maintain on site one set of the following record documents; record actual revisions to the Work:
 - 1. Drawings.
 - 2. Addenda.
 - 3. Change Orders and other modifications to the Contract.
- B. Ensure entries are complete and accurate, enabling future reference by Owner.
- C. Store record documents separate from documents used for construction.
- D. Record information concurrent with construction progress.
- E. Record Drawings: Legibly mark each item to record actual construction including:
 - 1. Field changes of dimension and detail.
 - 2. Details not on original Contract drawings.

END OF SECTION

**SECTION 02 81 00
REGULATED MATERIAL REMEDIATION/REMOVAL****PART 1 – GENERAL****1.1 DESCRIPTION**

- 1.1.1 Work under this section includes the handling of regulated materials including but not limited to: refrigerant containing HVAC and refrigeration equipment, mercury containing devices, mercury light bulbs, PCB containing electrical equipment, oil filled door closers, stored paints, solvents, cleansers, appliances, electronic items including PCs, printers, keyboards, etc. and general trash that meets the EPA definition of hazardous and or are considered “white goods” and are to be removed prior to demolition.

1.2 SCOPE OF WORK

- 1.2.1 The light fixtures in the first-floor hallways are to be removed and disposed of in building 1004 as part of the asbestos abatement contractor’s work scope. This work will be done first by the abatement contractor before the ceiling tile/glue pucks are removed. Removal will include separating the fluorescent tubes from the fixtures and disposing of them with a fluorescent bulb recycler. Bulbs should be containerized for disposal in a manner that minimizes breakage. The ballasts may or may not contain PCBs in this building. Disassemble each fixture to access the ballast. If the ballast is not labeled “non-PCB” then dispose of the ballast as PCB-containing material. If the ballast is labeled “non-PCB” containerize them separately and dispose of as a hydrocarbon containing material. It is expected that no more than two 55-gallon steel drums will be sufficient to containerize the ballasts.

1.3 RELATED WORK SPECIFIED ELSEWHERE

- 1.3.1 01 35 29 PERSONAL PROTECTIVE EQUIPMENT (PPE)
- 1.3.2 01 45 23 REMEDIATION QUALITY ASSURANCE
- 1.3.3 01 52 16 REMEDIATION TEMPORARY FACILITIES
- 1.3.4 02 82 13 REMOVAL OF ASBESTOS-CONTAINING AND CONTAMINATED MATERIALS

1.4 APPLICABLE PUBLICATIONS

- 1.4.1 The publications listed below form a part of this section to the extent referenced. The publications are referred to in this text by basic designation only.
- 1.4.2 TITLE 29, CODE OF FEDERAL REGULATIONS, U.S. DEPARTMENT OF LABOR, OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) STANDARDS.
- Part 1910.20 Access to Employee Exposure and Medical Records
- Part 1910.134 Respiratory Protection
- Part 1920.1200 Hazard Communication
- Part 1910.62 Lead Exposure in Construction
- 1.4.3 TITLE 40, CODE OF FEDERAL REGULATIONS, U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA) STANDARDS.

Part 261

Part 761 – Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in
Commerce and Use Prohibitions

1.4.4 ALL APPLICABLE STATE REGULATIONS

1.5 PERMITS AND NOTIFICATIONS

- 1.5.1 The contractor shall be responsible to obtain all necessary permits and certifications of personnel in conjunction with this work including hauling, and disposition and provide timely notification of such actions as may be required by Federal, State, Regional, and local authorities. Handling of refrigerants requires specially trained individuals with specialized equipment. Fees and/or charges for these permits shall be included in the contractor's bid price. The contractor shall submit copies of the required permits, notifications, and certifications to the Contracting Officer as indicated in this specification.

1.6 SUBMITTALS

- 1.6.1 In accordance with these specifications, the contractor shall submit the following:

- Copies of permits, notifications, and certifications.
- Proof of license and/or registration.
- Proof of employee training and medical examinations.
- Waste disposal – Description of planned waste disposal or recycling including written criteria for landfill, disposal, or recycling firm acceptance.

- 1.6.2 For Information

- OSHA compliance sample results.
- Copies of waste shipment records and manifests as proof of disposal or recycling. Note: if TCLP analysis is part of the waste disposal criteria, submit TCLP report information with waste shipment record. A copy of the waste shipment record shall be provided to the Contracting Officer and on-IH before the wastes are removed from the site. Additionally, a copy of the waste shipment records or manifests, signed by the landfill operator/disposal agency or recycling agency shall be submitted to the owner within 25 days of removal of the wastes from the project site.

- 1.6.3 Regulated Material Abatement Plan

- License of contractor performing the regulated material removal.
- Name and license of disposal landfill where regulated materials will be disposed of (for wastes that can be disposed of).
- Name and license of recycling facility where regulated materials will be recycled.
- Employee and supervisor training records and certifications.

- 1.6.4 Proof of Disposal/Recycling

- The contractor shall determine a course of disposal or recycling based on RCRA regulations for disposal of the various hazardous and non-hazardous wastes generated by his/her removal process and South Dakota regulatory requirements. Within 35 days of removal of waste from the site, the contractor shall submit a waste shipment record (WSR) to the Contracting Officer and designated representative as proof of disposal or recycling attesting that the waste has been disposed of or recycled in accordance with regulatory requirements. The WSR document shall include as a minimum the following:
 - The name and location of the disposal or recycling site(s).
 - Proof of regulatory approval.

- The name, address, and telephone number of the waste generator.
- The name, address, and telephone number of the transporter(s).
- The quantities of regulated wastes disposed of.
- The date of the receipt.

1.7 DEFINITIONS

- 1.7.1 **BIOLOGICAL MONITORING:** The analysis of a person's blood to determine the level of lead or other heavy metal in the body. Biological monitoring for lead hazard reduction work includes blood sampling and analysis for lead and zinc protoporphyrin levels.
- 1.7.2 **CHANGE ROOM:** The area of a worker decontamination facility used for removing protective equipment prior to entering the clean room.
- 1.7.3 **CLEAN ROOM:** The area of a worker decontamination facility used for donning protective equipment and storing street clothes.
- 1.7.4 **COMMON AREA:** A room or area that is accessible to more than one tenant in a building (i.e. common hallways, stairwells, laundry rooms, etc.).
- 1.7.5 **CONSULTANT:** The environmental consultant and its designated representative.
- 1.7.6 **CONTAINMENT:** The process of protecting other workers, residents, and the environment by isolating areas from exposure to lead dust and debris created during abatement in a work area.
- 1.7.7 **DECONTAMINATION OF PERSONNEL:** Shall include, at a minimum, HEPA vacuuming of disposable protective clothing according to provisions in 29 CFR 1926.62.
- 1.7.8 **ELEVATED LEAD LEVEL:** In adult workers – a blood lead concentration equal to or greater than ten micrograms per deciliter.
- 1.7.9 **ENCLOSURE:** Covering surfaces and sealing or caulking with durable materials to prevent or control chalking, peeling, or flaking substances containing toxic levels of lead from becoming part of house dust or accessible to children.
- 1.7.10 **HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTER:** A type of filtering system capable of filtering out particles of 0.3 microns or greater in diameter from a body of air at 99.97% efficiency or greater.
- 1.7.11 **HIGH PHOSPHATE DETERGENT:** Detergent which contains at least five percent tri-sodium phosphate (TSP) or other equally effective cleaning agent.
- 1.7.12 **LAMPS:** Is defined as the bulb or tube portion of an electric lighting device. A lamp is specifically designed to produce radiant energy, most often in the ultraviolet, visible, and infrared regions of the electromagnetic spectrum. Examples of common universal waste electric lamps include, but are not limited to, fluorescent, high intensity discharge, neon, mercury vapor, high pressure sodium, and metal halide lamps.
- 1.7.13 **LEAD-BASED:** Paints, glazes, and other surface coverings containing 0.5% by weight lead by laboratory analysis or 1.0 mg/cm² by XRF.
- 1.7.14 **LEAK:** Leak or leaking means any instance in which a PCB article, PCB container, PCB equipment, Oil containing equipment or container or other liquid regulated material has regulated material on it's outside surface.

1.7.15POLYCHLORINATED BIPHENYLS (PCBS): PCBs as used in this specification shall mean the same as PCBs, PCB containing lighting ballast, and PCB container, as defined in 40 CFR 761, Section 3 Definitions.

1.7.16SPILL: Spill means both intentional and unintentional spills, leaks, and other uncontrolled discharges when the release results in any quantity of PCBs or other liquid regulated materials running off or about to run off the external surface of the equipment.

1.7.17TOXICITY CHARACTERISTIC LEACHATE PROCEDURE (TCLP): The EPA required sample preparation for determining the hazard characteristic of a waste generated at a lead abatement site.

1.7.18UNIVERSAL WASTE/OIL WASTE: Means any of the following hazardous wastes that are managed under the universal waste requirements 40 CFR 273:

- (1) Batteries as described in 273.2 of this chapter
- (2) Pesticides as described in 273.3 of this chapter
- (3) Thermostats as described in 273.4 of this chapter
- (4) Lamps as described in 273.5 of this chapter
- (5) Oil filled door closures (40 CFR 279)

1.7.19 WHITE GOODS – Major household appliances like refrigerators, stoves, washer and dryer that are typically finished in white enamel.

1.8 WORKER SAFETY AND PROTECTION

1.8.1 WORKER TRAINING: The contractor shall ensure that all employees who perform hazardous waste removal and disposal have received training per OSHA requirements.

1.8.2 WORKER MEDICAL EXAMINATIONS: The contractor shall provide medical examinations for all employees engaged in hazardous waste removal and disposal in accordance with OSHA requirements.

1.8.3 WORKER PROTECTION AND DECONTAMINATION: The contractor shall take all safety measures and precautions necessary to protect employees and building occupants in accordance with OSHA Standard 29 CFR 1910 and 1926.

1.8.4 WORKSITE SAFETY: The contractor shall take all safety measures and precautions necessary to protect his/her employees and building occupants in accordance with OSHA Standard 29 CFR 1910 and 1926.

1.8.5 POSTING REQUIREMENTS: The contractor shall post copies of OSHA Standard 29 CFR 1926.62 in the worker decontamination enclosure system.

1.8.6 FIRST AID AND EMERGENCY RESPONSE REQUIREMENTS: The contractor shall provide for appropriate first aid equipment including an industrial-type first aid kit and a 20-pound ABC rated fire extinguisher.

1.9 BUILDING/PROPERTY PROTECTION

1.9.1 The contractor shall restrict work area access to only trained, qualified, and properly protected personnel during activities that disturb hazardous wastes and white goods.

1.9.2 The contractor shall protect buildings, sidewalks, lawns, trees, shrubbery, and other surfaces from the effects of the work.

- 1.9.3 Polyethylene (poly) sheeting with a minimum thickness of 6-mils is to be draped beneath the work areas where there is potential for spillage.

2.0 PRODUCTS

Furnished under this section shall be standard products of manufacturer regulatory engaged in the production of such items and the most current design which conforms to the requirements specified.

- 2.1 **POWER EQUIPMENT:** All powered equipment shall conform to OSHA Standard 29 CFR 1910.95 and 29 CFR 1926.62. Employees and building occupants shall not be exposed to equipment noise levels higher than 84 db without being provided approved hearing protection.

- 2.2 **VACUUM AND EXHAUST EQUIPMENT:** All vacuum and exhaust equipment shall have HEPA filters which conform to ANSI Z9.2. HEPA filters shall be capable of effectively capturing 99.97 percent of lead dust greater than 0.3 microns in size. No bypass devices will be permitted.

2.3 WORKER PROTECTIVE CLOTHING – REGULATED MATERIALS

Provide protective gloves, eye and splash protection, and protective suits as needed for removal and disposal of regulated materials. Respiratory protection is not expected to be needed. Protective equipment generally consists of impermeable gloves, eye protection, and a disposable coverall preferentially saran coated.

3.0 EXECUTION

- 3.1 Verify there is first aid equipment available including a shower and eye wash station.
- 3.2 Remove all materials from the sites that are not allowed in demolition landfills per South Dakota Department (SDDNR) requirements. NOTE: None of the materials are to be disposed of on Indian lands.
- 3.3 Items such as mercury containing devices, fluorescent light bulbs, etc. are to be recycled whenever possible.
- 3.4 All items that cannot be recycled are to be classified as either hazardous wastes or non-hazardous wastes and disposed of appropriately.
- 3.5 Fragile items such as fluorescent light bulbs, mercury containing devices, etc. are to be carefully removed from the site to avoid breakage. These items are to be packaged in secure packages for transportation. NOTE: Where broken fluorescent tubes are present, carefully clean this material up prior to performing other activities in the building.
- 3.6 Consolidate materials into waste streams identified in your Owner approved regulated materials disposal plan. If items are encountered outside the criteria for each waste stream, label the material as best able.
- 3.7 Items containing refrigerant gases need to have the refrigerant removed prior to ultimate disposal of the hard item. Choose a method that most efficiently works for this whether off site or on site.
- 3.8 Containerize small items in accordance with waste stream identification in DOT approved containers labeled and consolidated in accordance with the criteria of the waste accepting party and for transport.

- 3.9 If there is any possibility of liquid spillage, protect surfaces with an appropriate secondary container to collect any spills that might occur.

3.10 PROJECT CLOSEOUT – REGULATED MATERIALS

- 3.10.1 Following removal of all regulated materials, all areas will be visually examined by the Designer/Project Manager or designated representative to verify all materials have been removed from the building prior to beginning demolition.
- 3.10.2 Provide waste manifests, certifications, and other proof of recycling, disposal, etc. at project closeout.

END OF SECTION

SECTION 02 82 13
REMOVAL OF ASBESTOS CONTAINING AND ASBESTOS CONTAMINATED MATERIALS**PART 1 - GENERAL****1.1 DESCRIPTION**

Work to be performed under this section includes the removal, handling, movement through the building, loading, transport, and disposal of asbestos containing and asbestos contaminated materials. Removal and cleaning must be sufficient to achieve a visual clearance and meet the 0.01 fiber/cc air clearance criteria. Containment will be sufficient to allow the building occupants to work in the building in non-regulated/construction areas during normal work hours without fear of exposure to airborne asbestos fiber.

1.2 SCOPE OF WORK

1.2.1 The construction demolition drawings show the work locations and piping runs. The asbestos abatement work is as follows:

- Ceiling tile and glue pucks on GWB substrate in the first-floor hallways
- Dirt floored crawlspace and piping. Clean dirt surface of debris before removing thermal system insulation. Piping is to be demolished. Wrap and cut is acceptable as a removal technique.
- Boiler room – all insulations not obviously fiberglass including the boiler flue itself and the boiler after final shutdown. The boiler will require investigation after shutdown to identify the asbestos work scope.
- Small sections of thermal system insulation as necessary to complete the mechanical renovation. These are anticipated to be identified in some manner by the General Contractor. A bright colored spray paint is usually used. This work scope is driven by the renovation and will not be identified prior to initiation of the Work.

1.3 SUMMARY OF WORK

1.3.1 Construction drawings show the extent of piping in the crawlspaces and the hallway configuration for reference purposes. There are no special drawings for the abatement.

1.3.2 All asbestos waste materials must be cleaned up, bagged, and moved to an acceptable storage area or to a receiving dumpster each day. No loose asbestos material is to be left uncontained at the end of any work shift. The dumpster is to be secured against vandalism.

1.4 RELATED WORK SPECIFIED ELSEWHERE

1.4.1 Installation of critical and primary barriers, and work area isolation procedures are set forth in Section 01 56 16.

1.4.2 Project decontamination and clean-up procedures after removal of barriers are specified in Section 02 82 34.

1.4.3 Waste disposal is specified in Section 02 82 33.

1.5 NOTICES

Send written notification as required by USEPA National Emission Standards for Hazardous Air Pollutants (NESHAPS) Asbestos Regulations (40 CFR 61, Sub-part M) to the regional asbestos NESHAPS contact at least ten days prior to beginning any work on asbestos containing materials.

Region 8

EPA Region VIII Office
999 18th Street
Denver Place, Suite 500
Denver, CO 802202-2405
Attn: Regional Asbestos Coordinator
303-293-1730

Send completed original notification as required by the State of South Dakota on NOTIFICATION OF DEMOLITION AND RENOVATION FORM:

ASBESTOS COORDINATOR
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
WASTE MANAGEMENT PROGRAM
523 EAST CAPITOL AVENUE
PIERRE, SOUTH DAKOTA 57501-3182

Revisions to the original notification and courtesy notification can be sent by email:
Attention: Asbestos Coordinator, Waste Management Program
Email: Anthony.Wagner@state.sd.us

The ten weekdays required for processing of the notification begin when a completed notification form is received. Incomplete or inaccurate notifications will be returned to sender and a new 10 weekday period will begin when a completed notification is received.

B. Include the following information in the notification sent to the NESHAP's contact:

- Name and address of Owner or operator.
- Description of the facility being demolished or renovated, including the size, age, and prior use of the facility.
- Estimate of the approximate amount of friable asbestos material present in the facility in terms of linear feet of pipe, and surface area on other facility components. For facilities in which the amount of friable asbestos materials is less than 80 linear meters (260 linear feet) on pipes and less than 15 square meters (160 square feet) on other facility components, explain techniques of estimation.
- Location of the facility being demolished or renovated.
- Scheduled starting and completion dates of demolition or renovation.
- Nature of planned demolition or renovation and method(s) to be used.
- Procedures to be used to comply with the requirements of USEPA National Emission Standards for Hazardous Air Pollutants (NESHAPS) Asbestos Regulations (40 CFR, 61 Sub-part M).
- Name and location of the waste disposal site where the friable asbestos waste material will be deposited.

Submit evidence of notification to Contracting Officer and Designated Owner Representatives.

1.6 SUBMITTALS NOT OTHERWISE IDENTIFIED IN SEPARATE SECTIONS

- 1.6.1 Surfactant: Submit product data, use instructions and recommendations from manufacturer of surfactant intended for use. Include data substantiating that material complies with requirements.

- 1.6.2 Floor Tile Mastic Remover: Submit product data, use instructions and recommendations from manufacturer of surfactant intended for use. Include data substantiating that material complies with requirements.
- 1.6.3 Encapsulants: Submit product data, use instructions and recommendations from manufacturers of encapsulants intended for use. Include data substantiating that material complies with requirements and is compatible with paints, fireproofing or adhesives specified in other sections of these specifications or intended to be used by remodeling contractors. Use encapsulants rated for the temperature of affected piping services.
- 1.6.4 Certifications: Submit certification from manufacturer of surfactant or removal encapsulant that, to the extent required by this specification, the material, if used in accordance with manufacturer's instructions, will wet asbestos containing materials to which it is applied as required by the National Emission Standard for Hazardous Pollutants (NESHAPS) Asbestos Regulations (40 CFR 61, Subpart M).
- 1.6.5 Material Safety Data Sheet: Submit the Material Safety Data Sheet, or equivalent, in accordance with the OSHA Hazard Communication Standard (29 CFR 1910.1200) for each surfactant and encapsulating material proposed for use on the work. Include a separate attachment for each sheet indicating the specific worker protective equipment proposed for use with the material indicated.
- 1.6.6 Manifests and Disposal Certificates: Number sequentially each waste tracking form and keep copies at the job site. Submit tracking forms with attached landfill receipts as they are received (all receipts must be filed within 45 days of shipment). Identify landfill and waste hauler (contact persons, and telephone numbers) and submit state and federal permit of identification numbers to the Owner 30 days prior to disposal. Friable asbestos containing waste material and debris which is packaged in accordance with the provisions of this specification may be disposed of at designated EPA approved sanitary landfills. Vermiculite does not meet the definition of a Class 9 asbestos-containing material for disposal therefore alternative landfills can be used for disposal of this material with understanding by the landfill of the presence of vermiculite. DISPOSAL ON INDIAN LANDS IS NOT ALLOWED FOR THIS PROJECT.

PART 2 - PRODUCTS

2.1 WETTING AGENTS

- 2.1.1 For wetting prior to disturbance of asbestos containing materials, use either amended water or a removal encapsulant.
- 2.1.2 For amended water, provide water to which a surfactant has been added. Use a mixture of surfactant and water which results in wetting of the asbestos containing material and retardation of fiber release during disturbance of the material equal to or greater than that provided by the use of one ounce of a surfactant consisting of 50% polyoxyethylene ether mixed with five gallons of water.
- 2.1.3 For removal encapsulant designed specifically for removal of asbestos containing material. Use a material which results in wetting of the asbestos containing material and retardation of fiber release during disturbance of the material equal to or greater than that provided by water amended with a surfactant consisting of 50% polyoxyethylene ester and 50%polyoxyethylene ether mixed with five gallons of water.

2.2 PROTECTION MATERIALS

- 2.2.1 Polyethylene sheet shall be a single polyethylene film in the largest sheet size possible to minimize seams, 4.0 or 6.0 mils thick as indicated, clear, frosted, or black as indicated.
- 2.2.2 Duct tape shall be in 2" or 3" widths as indicated, with an adhesive which is formulated to aggressively stick to sheet polyethylene.

- 2.2.3 Spray cement shall be spray adhesive in aerosol cans which is specifically formulated to stick tenaciously to sheet polyethylene.
- 2.2.4 Disposal bags shall be 6-mil thick leak tight polyethylene bags labeled with three labels with text as follows:

First Label:

CAUTION
CONTAINS ASBESTOS FIBERS
AVOID OPENING OR BREAKING CONTAINER
BREATHING ASBESTOS IS HAZARDOUS TO YOUR HEALTH

Second Label: Provide in accordance with 29 CFR 1910.1200(f) of OSHA's Hazard Communication standard:

DANGER
CONTAINS ASBESTOS FIBERS
AVOID CREATING DUST
CANCER AND LUNG DISEASE HAZARD
BREATHING AIRBORNE ASBESTOS, TREMOLITE,
ANTHOPHYLLITE, OR ACTINOLITE FIBERS
IS HAZARDOUS TO YOUR HEALTH

Third Label: Provide in accordance with U.S. Department of Transportation regulation on hazardous waste marking, 49 CFR Parts 171 and 172. Hazardous Substances: Final Rule. Published November 21, 1986 and revised February 17, 1987:

RQ HAZARDOUS
SUBSTANCE,
SOLID, NOS,
ORM-E, NA 9188
(ASBESTOS)

- 2.2.5 Fiberboard drums shall be heavy duty leak tight fiberboard drums with tight sealing locking metal tops.
- 2.2.6 Paper board boxes shall be heavy duty corrugated paper board boxes coated with plastic or wax to retard deterioration from moisture. All boxes must be lined with two layers of 6-mil poly and appropriately labeled for disposal.

PART 3 - EXECUTION

3.1 PROTECTION - GENERAL REQUIREMENTS

- 3.1.1 Where required by this Section, install secondary barriers consisting of drop cloths of clear 6-mil sheet plastic installed over the primary barriers. Secondary barriers are required for removal of acoustical plaster, fireproofing, pipe insulation, and under glove-bags unless noted otherwise on the contract drawings or in these specifications.
- 3.1.2 Before beginning work with any material for which a Material Safety Data Sheet has been submitted, provide workers with the required protective equipment. Require that appropriate protective equipment be used at all times.
- 3.1.3 Use work procedures that result in airborne fiber counts less than that indicated in this Section of the specification. If airborne fiber counts exceed this level, immediately mist the area with amended water to lower fiber counts, increase level of respiratory protection if necessary and revise work procedures to

maintain airborne fiber levels within the required limits. Refer to Section 01 52 16 for additional requirements.

3.2 PRE-CLEANING

- 3.2.1 Containment for pre-cleaning shall be critical barriers and differential pressure. Respiratory protection shall be half-face APR. Pre-cleaning for this project consists of removing debris from the area(s) requiring asbestos abatement to access the asbestos for removal without obstruction and minimize final cleaning of ACM debris.

3.3 SECONDARY BARRIERS

- 3.3.1 Over the primary barrier, install as a drop cloth a clear 6-mil sheet plastic in all areas where asbestos removal work is to be carried out. Completely cover floor with sheet plastic. Where the work is within 10'0" of a wall, extend the secondary barrier up wall to ceiling. Support sheet plastic on wall with duct tape so that debris is unable to get behind it. Provide cross strips of duct tape at wall support as necessary to support sheet plastic prevent its falling during removal operations.
- 3.3.2 Install Secondary Barrier at the beginning of each shift and install only sufficient plastic for work of that shift or maintain barrier daily.
- 3.3.3 Remove secondary barrier at end of each work shift or as work in an area is completed. Fold plastic toward center of sheet and pack in disposal bags. Keep material on sheet continuously wet until bagged.

3.4 PROTECTION FOR GLOVEBAGGING AND FOR WRAP AND CUT OF ACM INSULATED PIPING

- 3.4.1 The pipe insulation shall be removed using glovebags made of transparent 6-mil polyethylene. Glovebags may be used only once. Sliding or moving a glovebag after asbestos removal work has begun is strictly prohibited.
- 3.4.2 Install critical barriers over all openings in the area and drop cloth in location of glovebag removal. Crawlspace are to have negative air pressure systems installed meeting the requirements of this specification. Ideally install a decontamination unit to the crawlspace area. If that is not feasible use the double suit method and a remote shower located on the basement level.
- 3.4.3 For the crawlspaces, it is expected the soil surface contains pieces of loose asbestos insulation. Install critical barriers and negative air for the area first, then remove the surface debris so that the surface is visually clean of thermal system insulation. Obvious metal or wood can be left in place. Any paper products, fiberglass insulation pieces, and other insulation materials shall be removed from the soil surface, containerized, and disposed of as asbestos waste material. After this work is completed, wrap piping in two layers of 6 mil polyethylene sheeting leaving locations where insulation will be removed by glovebag to facilitate cutting of the pipes into sections that can be removed from the crawlspace. Verify the method utilized to cut the pipe does not create excessive noise or any air contaminants/odors to occupied spaces of the building.

3.5 GENERAL REMOVAL PROCEDURES

- 3.5.1 After the contractor has demonstrated that he/she has complied with all of the on-site specific pre-abatement conditions contained in these specifications, then he/she shall begin actual asbestos removal work.
- 3.5.2 Thoroughly wet asbestos containing materials to be removed prior to stripping and/or tooling to reduce fiber dispersal into the air. Accomplish wetting by a fine spray (mist) of amended water or removal encapsulant. Saturate material sufficiently to wet to the substrate without causing excess dripping. Allow time for water or removal encapsulant to penetrate material thoroughly.

- If amended water is used, spray material repeatedly during the work process to maintain a continuously wet condition. If a removal encapsulant is used, apply in strict accordance with manufacturer's written instructions. Perforate outer covering or any installation which has been painted and/or jacketed in order to allow penetration of amended water or removal encapsulant, or where necessary, carefully strip away while simultaneously spraying amended water or removal encapsulant on the installation in order to minimize dispersal of asbestos fibers into the air.
- 3.5.3 Mist work area continuously with amended water whenever necessary to reduce airborne fiber levels. Use wet vacuums to control water buildup. Do not allow standing water to puddle on floors.
 - 3.5.4 Remove saturated asbestos containing material in small sections from all areas. Do not allow material to dry out. As it is removed, simultaneously pack material while still wet into disposal bags. Twist neck of bags, bend over and seal with minimum three wraps of duct tape. Clean outside and move to wash down station adjacent to material decontamination unit.
 - 3.5.5 Large components shall be wrapped in 2 layers of 6-mil polyethylene sheeting sealed with duct tape. Sharp corners shall be taped before covering with poly. Follow this procedure for the wrap and cut method of handling the piping to be removed as part of the mechanical work.
 - 3.5.6 Small sharp edged materials shall be placed in burlap bags prior to double bagging with 6-mil polyethylene or they shall be placed in drums.
 - 3.5.7 Saturated asbestos containing material shall be removed and containerized before moving to a new location for continuance of work. Surrounding areas shall be periodically sprayed and maintained in a wet condition until visible material is cleaned up. At the end of each work day, all visible asbestos containing materials shall be removed and containerized.
 - 3.5.8 Material removed from building structures or components shall not be dropped or thrown to the floor. Material shall be removed as intact sections or components whenever possible and carefully lowered to the floor. If this cannot be done for materials greater than 50 feet above the floor, a chute which does not allow dust to escape shall be constructed to transport the material to containers on the floor or the materials shall be containerized at elevated levels (e.g. on scaffolds) and carefully lowered to the ground by mechanical means. Materials between 15 and 20 feet above the ground may be containerized at elevated levels or dropped onto inclined chutes for subsequent collection and containerization.
 - 3.5.9 Containers (6-mil polyethylene bags or drums) shall be sealed when full. Asbestos containing material shall be double bagged when polyethylene bags are used for disposal. Bags shall not be overfilled. The bags shall be sealed to prevent accidental opening and leakage by tying the tops in an overhand knot or by taping in gooseneck fashion. Bags shall not be sealed with wire or cord. Bags may be placed in drums for staging and transportation to the landfill. Bags shall be decontaminated on exterior surfaces by wet cleaning before being removed from the enclosure.
 - 3.5.10 Metal or fiber drums with locking ring tops must be sealed for disposal of asbestos containing waste material that contains sharp edges, unless the sharp edges can be covered or blunted.
 - 3.5.11 After completion of all stripping work, surfaces from which asbestos containing materials have been removed shall be cleaned (e.g. wet brushed and sponged) to remove all visible residue.
 - 3.5.12 Clean-up shall proceed in accordance with Section 028234.
 - 3.5.13 For all surfaces stripped of asbestos containing materials, a coating of encapsulating agent must be applied after the area has passed the visual inspection, to securely seal any residual fibers. The encapsulating agent must be compatible with subsequent coverings.

3.5.14 Encapsulation operations must meet the following requirements:

- 3.5.14.1 Any loose or hanging asbestos containing material must be removed.
- 3.5.14.2 Filler material applied to gaps in existing material must contain no asbestos, adhere well to the substrate, and provide an adequate base for the encapsulating agent.
- 3.5.14.3 Encapsulants must be applied using only airless spray equipment with air pressure and nozzle orifice as recommended by the encapsulant manufacturer.
- 3.5.14.4 Encapsulant must not be solvent-based or use a vehicle consisting of hydrocarbons.
- 3.5.14.5 Encapsulated asbestos containing materials must be specifically designated according to the Code of Federal Regulations, Title 29, Section 1926.58 (K) (2), to warn individuals who may disturb the material.

3.5.15 After the work area has been rendered free of visible residues, a thin coat of an encapsulating agent shall be applied to all surfaces in the work area, including structural members, building components and plastic sheeting on walls and floors to seal in non-visible residue.

3.6 REMOVAL OF PIPE INSULATION - GENERAL

- 3.6.1 Containment for pipe insulation removal shall be full containment, mini enclosures, or glovebags as specified in Sections 015616, 015216, and as shown on the drawings. Respiratory protection will be as specified in Section 13529 and airborne fiber count limit will be 0.5 f/cc as specified in Section 014523 for full enclosures, 0.05 f/cc for mini enclosures, and 0.01 f/cc for glovebagging.
- 3.6.2 Establish specified level of containment. Spray insulation with a mist of amended water or removal encapsulant. Allow amended water or removal encapsulant to saturate material to substrate. If a removal encapsulant is used, use in strict accordance with manufacturer's instructions.
- 3.6.3 Cut all pipe insulation into chunks and carefully remove from pipes. Place all insulation by hand into disposal bags. Do not let insulation drop to floor or let insulation lay on the floor. Where asbestos insulation contacts fiberglass or other non-asbestos insulation that is to remain, cut back 6' into non-asbestos insulation.
- 3.6.4 Remove any residue on pipes or fittings with stiff bristle nylon hand brush and wet sponging.
- 3.6.5 Remove all pipe insulation passing through walls, floors, etc. Perform minor demolition as necessary to access insulation through floors and walls.

3.7 REMOVAL OF CEILING TILE/GLUE PUCKS

- 3.7.1 Containment for ceiling tile will be critical barriers and negative air as specified in text sections. Remove the tile and glue pucks completely from the gypsum wallboard substrate.

3.8 REMOVAL OF PIPE FITTINGS ABOVE A NONASBESTOS-CONTAINING PLASTER CEILING

- 3.8.1 Install critical barriers and negative air in rooms where plaster ceilings require cutting to access pipe fittings for removal. Cut the access for pipe insulation removal and clean all dust/debris from the area prior to accessing ceiling for pipe fitting insulation removal using glovebag. Remove any debris from the top side of the ceiling. Verify with general construction in the case of renovation as the plaster may be slated for demolition and/or have lead based paint.

3.9 REMOVAL OF FIRE DOORS

- 3.9.1 Remove fire doors with ACM core maintaining the door outer shell intact. Wrap door in two layers of 6 mil poly. Provide the appropriate warning labels on the outer layer of poly.

3.10 REMOVAL OF SMALL AREAS OF FRIABLE ACM WHERE GLOVEBAG CANNOT BE USED

- 3.10.1 Install critical barriers, decon and engineering controls.
- 3.10.2 Wet the material to be removed and carefully remove the material. Bag the debris.
- 3.10.3 Thoroughly clean the removal location of all visible asbestos debris. Encapsulate the location after the on-site IH has determined the removal is complete.
- 3.10.4 Final air samples in the area must be at or below 0.01 fibers per cubic centimeter.

3.11 REMOVAL OF GYPSUM WALLBOARD WITH ASBESTOS CONTAINING TAPING COMPOUND

- 3.11.1 Install critical barrier, mini-enclosure, and engineering controls. If work requires GWB removal on both sides of the wall, remove one side then the other.
- 3.11.2 Install remote shower.
- 3.11.3 Carefully remove section of GWB misting the front surface to minimize dust. Bag the debris.
- 3.11.4 Thoroughly clean the area of all visible dust including any cavities that were exposed during the work. If thermal system insulations are encountered, assume they are asbestos containing and remove them also in accordance with these procedures.
- 3.11.5 Final air samples in the area must be at or below 0.01 fibers per cubic centimeter by PCM.

3.12 DISPOSAL

- 3.12.1 Asbestos containing materials shall be placed in two 6-mil poly bags with the appropriate labeling as specified elsewhere. Sharp objects shall be bagged and drummed rather than double bagged. Drums may be fiber or metal construction at the contractor's option. Do not use labeled bags for general, non-asbestos waste.
- 3.12.2 Properly contained and labeled asbestos materials shall be moved through the building in carts or on dollies as appropriate. Drop chutes will not be allowed.
- 3.12.3 Do not store disposal bagged or drummed material outside of the work area. Take bags from the work area directly to a sealed truck or sealed dumpster each day. Store waste on site so that it cannot be accessed by the public.
- 3.12.4 Carefully load containerized waste in enclosed dumpsters or sealed trucks with poly lined beds for transport. Exercise care before and during transport. Exercise care before and during transport to ensure that no unauthorized persons have access to the material.
- 3.12.5 Do not transport bagged or drummed materials on open trucks. Label drums with same warning labels as bags. Uncontaminated drums may be reused. Treat drums that have been contaminated with asbestos containing waste and dispose of in accordance with this specification.
- 3.12.6 Advise the sanitary landfill operator, at least 10 days in advance of transport, of the quantity of material to be delivered. Provide bag counts or volume data by material type to Owner on a weekly basis.

- 3.12.7 At the disposal site, sealed plastic bags may be carefully unloaded from the truck. If bags are broken or damaged, return to work site for re-bagging and clean entire truck and contents using procedures set forth in Section 028234, Project Decontamination and work area clearance.
- 3.12.8 Retain receipts from landfill for materials disposed and submit along with waste manifests and chain of custody forms to the Owner on a weekly basis.

3.13 INITIAL CLEAN

The following applies to full containment enclosures.

- 3.13.1 Initial cleaning begins after all asbestos debris and bulk removal of asbestos bearing material is complete.
- 3.13.2 Remove secondary barrier (drop cloth plastic), roll up and pack for disposal in plastic bags or drums. Clean exposed surfaces and the primary barrier plastic by HEPA vacuuming and wet methods. This cleaning must remove any remaining bulk material and visible film or dust on all affected surfaces.
- 3.13.3 Where appropriate, use cloth cleaning rags and soap and water to get surfaces clean without leaving films and towel residues.

3.14 ENCAPSULATION

- 3.14.1 After the work area has been rendered free of all visible residues, a thin coat of satisfactory encapsulating agent shall be applied to all surfaces in the containment enclosure including structural members, exposed building components and any remaining plastic sheeting on walls, floors and covering over non-removable items.
- 3.14.2 Piping is to be encapsulated wherever asbestos bearing insulation has been removed.
- 3.14.3 Where primary barrier plastic is used, it shall be encapsulated before removal.

END OF SECTION 02 82 13

**SECTION 02 82 33
ASBESTOS WASTE DISPOSAL AND TRANSPORTATION****PART 1 - GENERAL****1.1 DESCRIPTION OF WORK**

- 1.1.1 This section describes the disposal of asbestos-containing materials. Disposal includes packaging of asbestos-containing waste materials and transporting them to a landfill accepting asbestos waste materials.

1.2 SUBMITTALS

- 1.2.1 Before start of work: Submit the following to the Owner/Owner's designated representative for review. Do not start work until these submittals are returned with Owner/Owner's designated representative action stamp indicating that the submittal is returned for unrestricted use.
1. Copy of state or local license for waste hauler.
 2. Name and address of landfill where asbestos-containing materials are to be buried. Include contact person and telephone number.
- 1.2.2 On a weekly basis submit copies of all manifests and disposal site receipts to owner's representative.
- 1.2.3 Submit original copy of Waste Transfer for each load leaving premises, within 24 hours of vehicle leaving premises.

PART 2 - PRODUCTS**2.1 MATERIALS**

- 2.1.1 Disposal Bags: Provide 6-mil thick, leak-tight polyethylene bags labeled with three labels with text as follows:
1. First label as required by NESHAPS

**CAUTION
CONTAINS ASBESTOS FIBERS
AVOID OPENING OR BREAKING CONTAINER
BREATHING ASBESTOS IS HAZARDOUS TO YOUR HEALTH**

2. Second label: Provide in accordance with 29 CFR 1910.1200(f) of OSHA's Hazard Communication Standard.

**DANGER
CONTAINS ASBESTOS FIBERS
AVOID CREATING DUST
CANCER AND LUNG DISEASE HAZARD
BREATHING AIRBORNE ASBESTOS, TREMOLITE, ANTHOPHYLLITE OR
ACTINOLITE FIBERS IS HAZARDOUS TO YOUR HEALTH**

3. Third Label: Provide in accordance with U.S. Department of Transportation regulation on hazardous waste marking, 49 CFR parts 171 and 172, Hazardous Substances: Final Rule. Published November 21, 1986 and revised February 17, 1987.

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(ASBESTOS)**

- 2.1.2 Any asbestos-containing material or material contaminated by asbestos that is not suitable to be contained in doubled 6-mil polyethylene bags, shall be contained in a minimum of one 6-mil bag and placed into metal

drums or fiber drum and sealed with appropriate lid.

1. Impermeable Containers: Suitable to receive and retain any asbestos-containing or contaminated materials until disposal at an approved site. The containers shall be labeled in accordance with OSHA regulation 29 CFR 1910.1001. Containers shall be both air and water tight and shall be resistant to damage and rupture. The containers shall be of two parts: 1) 6-mil polyethylene bags of size to fit within the drum listed hereafter and capable of being sealed; 2) 55 gallon capacity metal drums with tight fitting lids, fiberglass containers with tight fitting lids, or heavy walled fiber drums with tight fitting lids, may be used as impermeable containers if shipped to the dump site in a fully closed, lockable vehicle.
2. Transport barrels by two-wheeled carts or other suitable device. Enclosed card may be substituted.
3. Barrels containing debris may be stored on-site in a secured dumpster or trailer.
4. Place barrels in dumpster. Do not remove debris from barrels.
5. A barrel is reusable providing it remains free of water and no visible debris after removal of bags.
6. Barrels containing bags with tears, rips or excess water shall immediately be resealed and discarded into the dumpster.
7. Barrels entering premises that are not visibly clean on both the interior and exterior, including visible dust or bulk material or unidentifiable liquid other than water, will be rejected. Rejection of any drum for any single load will require the contractor to remove from premises all drums for that shipment. The contractor will assume all additional costs for re-cleaning or purchasing additional drums.

2.2 TRANSPORT

- 2.2.1 All waste is to be hauled by a waste hauler with all required licenses from all state and local authority with jurisdiction.
- 2.2.2 Load all asbestos-containing waste material in disposal bags or leak-tight drums. All materials are to be contained in one of the following: two 6-mil disposal bags or one 6-mil disposal bag and a fiberboard drum or steel drum. Protect interior of truck or dumpster with a single layer of 6-mil poly sheeting.
- 2.2.3 Carefully load containerized waste in fully enclosed dumpsters, trucks or other appropriate vehicles for transport. Exercise care before and during transport to insure no unauthorized persons have access to the material. Vehicle or dumpster must be secured with either door lock or padlock when contractor is not working.
 1. Dumpster doors must be appropriately posted with asbestos warning signs.
- 2.2.4 Do not store containerized materials outside of the work area. Take containers from the work area directly to a sealed truck or secured dumpster with steel roof and sides.
- 2.2.5 Do not transport disposal bagged materials on open trucks. Label drums with same warning labels as bags. Uncontaminated drums may be reused. Treat drums that have been contaminated as asbestos-containing waste and dispose of in accordance with this specification.
- 2.2.6 Disposal at Landfill
 1. Contractor to familiarize workers with specific landfill procedures if any procedures are available by landfill operator.
 2. Personal protection required including one-half face respirator and disposable garments over street clothes when unloading vehicle or dumpster by hand.
 3. Automated dumping by contractor's waste hauler does not require personal protection, but is recommended.

4. In the event bags, bundles or barrels are broken, the transporter shall be equipped to immediately place broken containers into new bag or barrel.
5. In the event all asbestos debris is not contained in lining of vehicle box or dumpster, the hauler will be equipped with manual spray and disposable wipes to contain debris prior to moving vehicle from unloading site.
6. At completion of hauling and disposal of each load and within 24 hours, submit copy of Waste Transfer Chain of Custody form and landfill receipt to owner's representative.

PART 3 - EXECUTION

Comply with the following sections during all phases of this work:

Section 01 3529 Personal Protective Equipment

3.1 GENERAL

- 3.1.1 All waste is to be hauled by a waste hauler with all required licenses from all state and local authority with jurisdiction.
- 3.1.2 Load all asbestos-containing waste material in disposal bags or leak-tight drums. All materials are to be contained in one of the following:
 1. Two 6-mil disposal bags, or
 2. Two 6-mil disposal bags and sealed steel drum with no bag
- 3.1.3 Protect interior of truck or dumpster with critical and primary barriers as described in Section 01 56 16 Temporary Enclosures.
- 3.1.4 Carefully load containerized waste in fully enclosed dumpsters, trucks or other appropriate vehicles for transport. Exercise care before and during transport, to ensure that no unauthorized persons have access to the material.
- 3.1.5 Do not store containerized materials outside of the work area. Take containers from the work area directly to a sealed truck or dumpster.
- 3.1.6 Do not transport disposal bagged materials on open trucks. Label drums with same warning labels as bags. Uncontaminated drums may be reused. Treat drums that have been contaminated as asbestos-containing waste and dispose of in accordance with this specification.
- 3.1.7 Advise the landfill operator or processor at least ten days in advance of transport, of the quantity of material to be delivered.
- 3.1.8 At disposal site unload containerized waste:
 1. At a disposal site, sealed plastic bags may be carefully unloaded from the truck. If bags are broken or damaged, return to work site for re-bagging. Clean entire truck and contents. At a processing site truck and loading dock are arranged as a controlled work area and containerized waste is transferred to storage area by site personnel. All bags including broken ones, will be transferred.
- 3.1.9 Retain receipts from landfill or processor for materials disposed of.
- 3.1.10 At completion of hauling and disposal of each load, submit copy of waste manifest, chain of custody form, and landfill receipt to Owner/Owner's designated representative.

END OF SECTION

SECTION 02 82 34
PROJECT DECONTAMINATION AND WORK AREA CLEARANCE**PART 1 - GENERAL****1.1 DESCRIPTION**

- 1.1.1 The work under this section includes all labor, materials, and equipment as necessary to decontaminate all work areas to the cleanliness level required by the work area air sample fiber count clearance criteria specified herein.
- 1.1.2 This section includes the decontamination of air in the work area which has been or may have been contaminated by the elevated airborne asbestos fiber levels generated during abatement activities, or which may previously have had elevated fiber levels due to friable asbestos containing materials in the space.
- 1.1.3 Work of this section also includes the cleaning, decontamination, and removal of temporary facilities installed prior to abatement work, including primary and critical barriers, decontamination units and differential pressure systems.
- 1.1.4 Work of this section also includes the cleaning and decontamination of all surfaces (ceiling, walls, floors) of the work area and all other unprotected surfaces in the containment area including pipes, ducts, conduits, fixtures, furniture, and equipment.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- 1.2.1 Removal of gross debris is integral with the performance of abatement work and as such is specified in the Section 02 82 13 of these specifications.

1.3 CONTRACTOR RELEASE CRITERIA

- 1.3.1 The work is complete when the entire work area is visually clean to the satisfaction of the competent person or asbestos air monitoring professional.

PART 2 - PRODUCTS - NOT APPLICABLE**PART 3 - EXECUTION****3.1 START OF WORK**

- 3.1.1 During completion of the asbestos abatement work specified in other sections, the secondary barrier of polyethylene sheeting will have been removed and disposed of along with any gross debris generated by the asbestos abatement work. Exposed building surfaces, piping, and primary barriers will already be encapsulated.

- 3.1.2 Work of this section begins with the removal of the primary barrier. At start of work the following will be in place:

Primary Barrier: Two or three layers of polyethylene sheeting on the floor and one layer polyethylene of sheeting on the walls.

Critical barrier which forms the sole barrier between the work area and other portions of the building or the outside.

Critical barrier sheeting over clocks, ventilation openings, doorways, connectors, speakers, and other openings, etc.

Decontamination units for personnel and equipment in operation condition.

Differential pressure system in operation.

3.2 PRIMARY BARRIER REMOVAL

- 3.2.1 After surfaces have been encapsulated, all primary barrier poly shall be rolled up and bagged or drummed for disposal as contaminated waste. Critical barriers will remain intact through achievement of final clean and final aggressive air clearance test. Other barriers, such as those placed over mechanical and electrical items may be removed, once the final cleaning has proceeded to the point that they would no longer be affected by the cleaning activity.
- 3.2.2 Remove material decontamination unit, if there is one, leaving only the critical barriers, the decontamination unit and differential pressure system.

3.3 FINAL CLEANING

- 3.3.1 Carry out a cleaning of all existing wall, floor, and ceiling surfaces of the work area including items of remaining sheeting, tools, scaffolding and/or staging by use of damp cleaning and mopping, and or HEPA filtered vacuum. Clean all other unprotected or exposed surfaces including ducts, fixtures, pipes, conduits, equipment, and etc. Do not perform dry dusting or dry sweeping. Use each surface of a cleaning cloth one time only and then dispose of as contaminated waste. Continue this cleaning until there is no visible debris from removed materials or residue on any plastic sheeting or other surface.
- 3.3.2 Remove pre-filters in HEPA units and dispose of as asbestos containing waste in accordance with requirements of Section 028233.

3.4 VISUAL INSPECTION

- 3.4.1 After the area is dry, perform a complete visual inspection of the entire work area including: decontamination unit, all plastic sheeting, seals over ventilation openings, doorways, windows, and other openings; look for debris from any sources, residue on surfaces, dust or other matter. If any such debris, residue, dust, or other matter is found, inspection will be terminated and contractor shall repeat final cleaning and continue decontamination procedure from that point. When the area is visually clean, complete the certification at the end of this section. NOTE: visual inspection does account for this being a demolition project with cleaning requirements not to the level of re-occupancy, however, debris that can be visually identified as ACM needs to be gone from the site for the removal work to be determined to be satisfactorily completed.

3.5 COMPLETION OF ABATEMENT WORK

- 3.5.1 Seal differential pressure fan units with 6-mil polyethylene sheet and duct tape to form a tight seal at intake end before being moved from work area.
- 3.5.2 Remove all equipment, materials, debris from the work area. Dispose of all asbestos containing waste material as specified in Section 028233.

3.6 COMPLETION OF ABATEMENT WORK IN MINI-ENCLOSURE/ENCLOSURE LIMITED TO CRITICAL BARRIERS

- 3.6.1 Carry out a cleaning of all existing wall, floor, and ceiling surfaces of the work area including items of remaining sheeting, tools, scaffolding and/or staging by use of damp cleaning and mopping, and or HEPA filtered vacuum. Clean all other unprotected or exposed surfaces including ducts, fixtures, pipes, conduits, equipment, etc. Do not perform dry dusting or dry sweeping. Use each surface of a cleaning cloth one time only and then dispose of as contaminated waste. Continue this cleaning until there is no visible debris from removed materials or residue on any plastic sheeting or other surface.
- 3.6.2 Encapsulate abatement surface as necessary being careful to avoid finishes that are to remain.
- 3.6.3 Allow encapsulant to come to dryness prior to requesting final air clearance.

END OF SECTION

**SECTION 095100
ACOUSTICAL CEILINGS****PART 1 GENERAL****1.01 SECTION INCLUDES**

- A. A. Suspended metal grid ceiling system.
- B. Acoustical units.

1.02 REFERENCE STANDARDS

- A. ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2021a.
- B. ASTM C635/C635M - Standard Specification for Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings; 2022.
- C. ASTM E1264 - Standard Classification for Acoustical Ceiling Products; 2023.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Sequence work to ensure acoustical ceilings are not installed until building is enclosed, sufficient heat is provided, dust generating activities have terminated, and overhead work is completed, tested, and approved.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Shop Drawings: Indicate grid layout and related dimensioning.
- C. Product Data: Provide data on suspension system components and acoustical units.
- D. Samples: Submit two full size samples illustrating material and finish of acoustical units.
- E. Samples: Submit two samples each, 24 inches long, of suspension system main runner, cross runner, and perimeter molding.
- F. Manufacturer's Installation Instructions: Indicate special procedures and perimeter conditions requiring special attention.

1.05 QUALITY ASSURANCE

- A. Suspension System Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- B. Acoustical Unit Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.06 FIELD CONDITIONS

- A. Maintain uniform temperature of minimum 60 degrees F (16 degrees C), and maximum humidity of 40 percent prior to, during, and after acoustical unit installation.

PART 2 PRODUCTS**2.01 ACOUSTICAL UNITS**

- A. Acoustical Panels: Painted mineral fiber, with the following characteristics:
 - 1. Classification: ASTM E1264 Type III.
 - 2. Size: 24 by 48 inches (610 by 1219 mm).
 - 3. Thickness: 5/8 inch (16 mm).
 - 4. NRC Range: 70 to 75, determined in accordance with ASTM E1264.
 - 5. Ceiling Attenuation Class (CAC): 35, determined in accordance with ASTM E1264.
 - 6. Panel Edge: Square.
 - 7. Color: White.
 - 8. Suspension System: Exposed grid.

2.02 SUSPENSION SYSTEM(S)

- A. Metal Suspension Systems - General: Complying with ASTM C635/C635M; die cut and interlocking components, with perimeter moldings, hold down clips, stabilizer bars, clips, and splices as required.
 - 1. Materials:
 - a. Aluminum Grid: Aluminum sheet, ASTM B209/B209M.
- B. Exposed Suspension System: Hot-dipped galvanized steel grid with aluminum cap.
 - 1. Structural Classification: Intermediate-duty, when tested in accordance with ASTM C635/C635M.
 - 2. Profile: Tee; 15/16 inch (24 mm) face width.
 - 3. Finish: Baked enamel.
 - 4. Color: White.

2.03 ACCESSORIES

- A. Support Channels and Hangers: Galvanized steel; size and type to suit application, seismic requirements, and ceiling system flatness requirement specified.
- B. Hanger Wire: 12 gauge, 0.08 inch (2 mm) galvanized steel wire.
- C. Perimeter Moldings: Same metal and finish as grid.
 - 1. Size: As required for installation conditions and specified Seismic Design Category.
 - 2. Acoustical Sealant For Perimeter Moldings: Non-hardening, non-skinning, for use in conjunction with suspended ceiling system.

PART 3 EXECUTION**3.01 EXAMINATION**

- A. Verify existing conditions before starting work.
- B. Verify that layout of hangers will not interfere with other work.

3.02 PREPARATION

- A. Install after major above-ceiling work is complete.
- B. Coordinate the location of hangers with other work.

3.03 INSTALLATION - SUSPENSION SYSTEM

- A. Rigidly secure system, including integral mechanical and electrical components, for maximum deflection of 1:360.
- B. Lay out system to a balanced grid design with edge units no less than 50 percent of acoustical unit size.
- C. Perimeter Molding: Install at intersection of ceiling and vertical surfaces and at junctions with other interruptions.
 - 1. Install in bed of acoustical sealant.
 - 2. Use longest practical lengths.
 - 3. Overlap and rivet corners.
- D. Suspension System, Non-Seismic: Hang suspension system independent of walls, columns, ducts, pipes and conduit. Where carrying members are spliced, avoid visible displacement of face plane of adjacent members.
- E. Where ducts or other equipment prevent the regular spacing of hangers, reinforce the nearest affected hangers and related carrying channels to span the extra distance.
- F. Do not support components on main runners or cross runners if weight causes total dead load to exceed deflection capability.
- G. Support fixture loads using supplementary hangers located within 6 inches (152 mm) of each corner, or support components independently.
- H. Do not eccentrically load system or induce rotation of runners.

3.04 INSTALLATION - ACOUSTICAL UNITS

- A. Install acoustical units in accordance with manufacturer's instructions.
- B. Fit acoustical units in place, free from damaged edges or other defects detrimental to appearance and function.
- C. Fit border trim neatly against abutting surfaces.
- D. Install acoustical units level, in uniform plane, and free from twist, warp, and dents.
- E. Cutting Acoustical Units:
 - 1. Make field cut edges of same profile as factory edges.
- F. Install hold-down clips on each panel to retain panels tight to grid system; comply with fire rating requirements.

3.05 TOLERANCES

- A. Maximum Variation from Flat and Level Surface: 1/8 inch in 10 feet (3 mm in 3 m).
- B. Maximum Variation from Plumb of Grid Members Caused by Eccentric Loads: 2 degrees.

END OF SECTION

SECTION 230000
HVAC GENERAL PROVISIONS**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. This section includes general requirements for HVAC systems and HVAC motors.

1.03 CONTRACT DOCUMENT COORDINATION

- A. Contract Documents are diagrammatic in showing certain physical relationships between architectural, structural, mechanical, plumbing and electrical work.
 - 1. Verification and coordination of these relationships is the responsibility of the Contractor.
 - 2. Contractor shall verify existing conditions before starting work.
 - 3. Floor plan drawings do not necessarily indicate all required offsets, fittings, valves, etc.
 - 4. Provide all necessary piping, fittings, valves, ducts, offsets, and other specialties required without additional cost to the Owner.
- B. Should Contract Document requirements appear to make it impossible to provide a complete and operational system, or should discrepancies appear among Contract Documents, Contractor shall request clarification before proceeding with work.

1.04 QUALITY ASSURANCE

- A. Comply with all State, and local codes and ordinances.
- B. Obtain and pay for all required permits, fees and certificates of inspection of the work.
- C. Install equipment and devices to provide required access for servicing and maintenance.
- D. Mechanical Code Compliance: Comply with applicable portions of Local, City, and State Mechanical Code pertaining to mechanical materials construction and installation of products.

1.05 SUBMITTALS

- A. General: See Division 01, Section Submittal Procedures.
 - 1. Shop Drawing Submittals shall include specially prepared technical data for this project, including drawings, diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, instructions, measurements and similar information.
 - 2. Shop Drawing Submittals may also include product data which includes standard printed information on materials, products and systems; not specially prepared for this project, but with the designation of selections from among available choices for this project clearly identified.
- B. Submittal Requirements:
 - 1. Coordination and Sequencing: Coordinate preparation and processing of submittals with performance of the work so that work will not be delayed by submittals. Coordinate and sequence different categories of submittals for same work, and for interfacing units of work, so that one will not be delayed for coordination of Architect/Engineer's review with another.
 - 2. Preparation of Submittals: Provide permanent marking on each submittal to identify project, date, Contractor, Subcontractor, submittal name, specification section and similar information to distinguish it from other submittals.

3. Provide General Contractor's and Subcontractor's stamp, signed or initialed certifying that review, approval, verification of Products required, field dimensions, adjacent construction Work, and coordination of information is in accordance with the requirements of the Contract Documents. Submittals which are received from sources other than through Contractor's office will be returned by Architect/Engineer "Without Action".
 4. Items from each specification section shall be prepared as separate submittals, not grouped or bound with other items. Submittals shall clearly indicate the applicable specification section.
- C. Alternate Equipment Submittal by Contractor:
1. Equipment of greater or larger dimensions, weight, capacity, or rated performance than that which is specified may be submitted provided all connecting mechanical and electrical services, including ductwork and piping connections, circuit breakers, electrical conduit and conductors, motors, equipment supports, building structure, and equipment spaces are modified as required by the proposed equipment. If performance ratings or efficiencies of the equipment are specified, the equipment must meet or exceed these design requirements as well as any specified commissioning requirements. **NO ADDITIONAL COST WILL BE APPROVED FOR ANY SUCH CHANGES RELATED TO THE ALTERNATE EQUIPMENT.**
 2. Should proposed alternate equipment involve rearrangement of other designed equipment, a complete layout of the area involved shall be submitted by the Contractor along with the alternate equipment submittal, and shall be approved in writing by the Architect/Engineer prior to ordering, purchasing, delivery or installation of any such items of equipment.
 3. **CONTRACTOR SHALL BE RESPONSIBLE FOR ALL ADDITIONAL EXPENSE AND COORDINATION WITH OTHER TRADES RESULTING FROM THE SUBSTITUTION OF EQUIPMENT OTHER THAN THAT SPECIFIED IN THE CONTRACT DOCUMENTS.**
- D. Submittal Review:
1. Review of submittal data is only for general conformance with the design concept of the Project and general compliance with the information given in the Contract Documents. Any action shown is subject to the requirements of the plans and specifications.
 2. Review of shop drawings does not release the Contractor from further satisfactory equipment operating responsibilities. Equipment shall be approved for final acceptance when installation is completed and all equipment and systems have been operated, tested, adjusted and balanced in compliance with the contract documents.
 3. Re-submittals: When revised for resubmission, clearly indicate all changes since previous submission. Only those items required to be resubmitted shall be included.
- E. Operation and Maintenance (O&M) Manuals:
1. Prepare and submit three copies of operation and maintenance instructions for all Division 23 equipment furnished.
 - a. Provide individual 3-ring binders with a table of contents and tabbed sections for each specification section.
 - b. Identify equipment included in the manuals by the equipment mark used in the contract drawings.
 - c. Include emergency instructions, spare parts listing, copies of warranties, wiring diagrams, shop drawings, product data, signed letters of certification of inspection and similar information.
 - d. Provide documentation that training was performed for each item specified to include Owner training. Include name of Owner's representative(s) present, date and time of training.
 - e. Provide a list of manufacturer's representatives for each item of equipment including company name, address and phone number.

- f. Provide documentation that Extra Materials were received by the Owner for each section requiring Extra Materials.
 2. All information contained in equipment manufacturer's operation and maintenance manual shall be specific to equipment provided. Contractor shall mark out or not include all unrelated information.
 3. Electronic O&M Manuals: Provide electronic version of project O&M Manuals in pdf format in addition to hardcopy version of the manuals.
- F. Required Submittals List:
1. Shop Drawings shall be submitted for the items listed in each section of the specifications. Submittals in addition to those listed may be required by the Architect/Engineer.

1.06 RECORD DRAWINGS:

- A. See Division 01, Section Project Record Documents.
- B. Provide a set of mechanical drawings marked-up with actual as-built conditions for Division 23 work. Record drawings shall include all addenda and change orders.

1.07 CONTRACT DRAWING FILE REQUESTS

- A. As an instrument of service to aid in Shop Drawing Submittals, Farris Engineering (FEI) will provide AutoCAD drawing files upon request. The files will be sent upon return receipt of the "Request for Drawings" agreement signed by an officer of the requesting firm. FEI does not assure that the drawings represent all changes, addenda items, change orders or modifications that may have occurred. The drawings are simply a tool for use in producing shop drawing submittals. The drawing files will be "cleaned-up" by having the FEI logo, Professional Engineer seal, and all extraneous notes and details removed. FEI must be compensated for this additional service by the requesting firm. A minimum fee of \$400.00 for up to eight (8) sheets and \$50.00 per sheet for each additional requested drawing will be invoiced to the requesting firm once the signed agreement is received.

1.08 MECHANICAL/ELECTRICAL COORDINATION

- A. General: See Division 01, Multiple Contract Summary.
- B. Mechanical Contractor shall coordinate with Electrical Contractor and verify that proper electrical power connections to mechanical equipment which requires electrical power is provided. Unless specifically shown otherwise Electrical Contractor shall provide power connections to the equipment and Mechanical Contractor shall provide wiring required for start-stop, temperature control and safety interlock functions.
- C. If mechanical contractor has proposed alternate equipment to that specified in the contract documents, and such alternate equipment requires modified electrical power connections, mechanical contractor shall coordinate these requirements with electrical contractor prior to ordering, purchasing, delivery or installation of any electrical conduits, conductors, circuit breakers and other electrical devices serving the alternate equipment.
- D. Types of work, normally recognized as electrical but provided as mechanical include but are not necessarily limited to the following:
 1. Motors for mechanical equipment.
 2. Starters for motors of mechanical equipment, but only where specifically indicated to be furnished integrally with equipment.
 3. Wiring from motors to disconnect switches or junction boxes for motors of mechanical equipment, when specifically indicated to be furnished integrally with equipment.
 4. Electrical power connections for mechanical equipment that are not indicated on the electrical drawings.

- E. Emergency Shutdown Switches: Mechanical Contractor shall coordinate with Electrical Contractor and shall verify that required shutdown switches for all equipment which requires emergency shutdown is provided. Types of equipment provided by mechanical, kitchen or foodservice equipment suppliers that may require emergency shutdown include but is not necessarily limited to the following:

1. Boilers.

1.09 ELECTRIC MOTORS

A. Basic Motor Requirements

1. Motors smaller than 1 HP: Single-phase.
2. Motors 1 HP and Larger: Polyphase.
3. Frequency Rating: 60 Hz.
4. Voltage Rating: Determined by voltage of circuit to which motor is connected.
5. Service Factor: According to NEMA MG-1, unless otherwise indicated.
6. Capacity and Torque Characteristics: Rated for continuous duty and sufficient to start, accelerate, and operate connected loads at designated speeds, in indicated environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
7. Enclosure: Open drip proof unless otherwise indicated.

B. Polyphase Motors

1. Description: NEMA MG-1, medium induction motor.
 - a. Design Characteristics: NEMA MG-1, Design B, unless otherwise indicated.
 - b. Efficiency: NEMA Premium Energy-Efficient Design – all motors.
 - c. Stator: Copper windings, unless otherwise indicated. Multispeed motors shall have separate winding for each speed.
 - d. Rotor: Squirrel cage unless otherwise indicated.
 - e. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.
 - f. Temperature Rise: Match insulation rating unless otherwise indicated.
 - g. Insulation: Class F unless otherwise indicated.
2. Motors Used with Variable-Frequency Controllers: Definite-purpose inverter-fed motors in accordance with NEMA MG-1, Part 31. Ratings, Characteristics, and features coordinated with and approved by controller manufacturer.
 - a. Critical vibration frequencies shall not be within operating range of controller output.
 - b. Temperature Rise: Match rating for Class B insulation.
 - c. Insulation: Class H.
 - d. Thermal Protection: Where indicated, conform to NEMA MG-1 requirements for thermally protected motors.
 - e. Motor Shaft Grounding: For motors controlled by variable frequency drives, provide factory installed shaft grounding that requires no maintenance for the service life of the motor.

1.10 TEMPORARY HEATING, COOLING AND VENTILATION DURING CONSTRUCTION

- A. Existing mechanical systems may be used for temporary heating, cooling and ventilation during construction. New mechanical systems shall not be used for temporary heating, cooling and ventilation. All costs associated with providing temporary heating, cooling and ventilation during construction shall be the responsibility of the Contractor.

- B. If contractor utilizes existing mechanical system during construction, the contractor shall be required to provide monthly filter changes during construction and one final filter change at the completion of construction.

1.11 FINAL COMPLETION

- A. The Mechanical Contractor shall not call for a final completion check until all Mechanical Systems have been installed, adjusted, tested, and balanced and in full and complete satisfactory operation and the following certifications of inspection from equipment suppliers have been completed. Certifications of Inspection are required on the following equipment:
 - 1. Temperature Control Equipment.
 - 2. Variable Frequency Controllers.
 - 3. Hydronic Pumps.
 - 4. Fans and Ventilators.
 - 5. Boilers.
 - 6. Furnaces and Condensing Units.
 - 7. Chillers.
 - 8. Cooling Towers.
 - 9. Rooftop Units.
 - 10. Air Handling Units.
 - 11. Computer Room Air Conditioning (CRAC) Units.
 - 12. Variable Refrigerant Flow (VRF) Equipment.
 - 13. Water Source Heat Pumps.
 - 14. Unit Heaters.
 - 15. Humidifiers.
- B. Certifications of Inspection shall consist of letters signed by Factory-Trained and -Authorized Service Personnel stating the following:
 - 1. They have inspected all of their equipment on the project.
 - 2. They approve the condition of the equipment and its installation.
 - 3. They have fully checked its operation and certify that it is operating properly.
 - 4. They have noted any problems, conditions or objections that could lead to future operating problems.
- C. Documentation of the signed letters of Certification of Inspection shall be furnished in the Operations and Maintenance Manuals, included with the associated equipment.

1.12 GUARANTEE

- A. The one year guarantee period shall not start until the project is fully completed and the Contractor has received the Final Payment and Certificate of Completion.
- B. All equipment and all work shall be fully guaranteed, parts and labor, for one full year from the date of the Certificate of Completion. Repairs made during this period must be fully guaranteed for an additional one year period from the date of repairs.
- C. The Mechanical Contractor has the full responsibility to guarantee all equipment and work and shall assume full responsibility to repair any equipment at his cost that the manufacturer refuses to guarantee.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION**3.01 ELECTRICAL WORK PROVIDED BY MECHANICAL**

- A. All electrical equipment provided and the wiring and installation of electrical equipment shall be in accordance with the requirements of the equipment manufacturer, this Section and Division 26.

3.02 PIPE HANGING AND SUPPORT

- A. All piping systems shall be supported from building structural systems capable of supporting the applied load.
- B. Piping shall not be supported from metal roof decking.

3.03 PAINTING AND FINISHING

- A. Painting of exposed mechanical work is specified and performed under other divisions of these specifications, or as indicated on the drawings.
- B. Where factory finishes are provided on equipment and no additional field painting is specified, all marred or damaged surfaces shall be touched up or refinished so as to leave a smooth, uniform finish at the time of final inspection.
- C. Paint inside of ductwork black, where it can be seen from occupied spaces through diffusers, grilles or louvers (under any lighting condition).

3.04 WORK IN EXISTING BUILDINGS

- A. Work under this Contract includes additions and/or renovations to an existing building. It shall be the responsibility of each Bidder to fully inform himself of all conditions which affect the work contemplated by these specifications and accompanying drawings. The submission of proposal by any Bidder will be construed as an admission by him that he has examined and is fully familiar with the premises and all conditions thereon and adjacent thereto, and has included in this proposal a proper and adequate amount to cover rearrangement of existing work for the proper installation and operation of the new and existing equipment as shown on the drawings or as required by these specifications. Such work shall be neatly and properly done.
- B. Maintain existing mechanical services to occupied areas and operational facilities unless otherwise indicated or when otherwise authorized in writing by Owner and Architect.
- C. The operation of all existing equipment, fixtures and devices designated to remain shall be maintained. Provide temporary connections and devices as necessary to maintain the proper operation of the equipment designated to remain if required during construction.

3.05 REBATES

- A. Contractor shall assist the Owner with filing of applicable forms to obtain rebates. This shall include but not be limited to determination of qualifying equipment and materials and furnishing invoices for equipment and materials as required to support the rebate application.

END OF SECTION

SECTION 230010
MECHANICAL SUBMITTALS**PART 1 GENERAL****1.01 GENERAL**

- A. Submittals shall include specially prepared technical data for this project, including drawings, diagrams, performance curves, data sheets, schedules, templates, patterns, reports, calculations, instructions, measurements and similar information not in standard printed form for general application to a range of similar projects.
- B. Submittals shall also include product data which includes standard printed information on materials, products and systems; not specially prepared for this project, but with the designation of selections from among available choices for this project clearly identified.

1.02 SUBMITTAL REQUIREMENTS

- A. Coordination and Sequencing: Coordinate preparation and processing of submittals with performance of the work so that work will not be delayed by submittals. Coordinate and sequence different categories of submittals for same work, and for interfacing units of work, so that one will not be delayed for coordination of Architect/Engineer's review with another.
- B. Preparation of Submittals: Provide permanent marking on each submittal to identify project, date, Contractor, Subcontractor, submittal name and similar information to distinguish it from other submittals. Show Contractor's executed review and approval marking and providing space for Architect's/Engineer's "Action" marking. Package each submittal appropriately for transmittal and handling. Submittals which are received from sources other than through Contractor's office will be returned by Architect/Engineer "Without Action".
- C. Provide Contractor's certification on form, ready for execution, stating that information submitted complies with requirements of contract documents.
- D. The Contractor shall be responsible for and bear any expense of alterations to the building or its appurtenances resulting from the substitution of equipment to that specified in the Contract Documents.
- E. Review of submittals does not release the Contractor from further satisfactory operating responsibilities. Material and equipment shall be approved for final acceptance when construction is completed and all units and systems have been operated, tested, adjusted and balanced to the satisfaction of the Architect/Engineer. Should proposed approved alternate equipment involve rearrangement of designed equipment, a complete layout of the area involved shall be submitted by the Contractor, and shall be approved in writing before installation of any such items of equipment. Any additional expense involved shall be a Contractor-borne expense.
- F. Electronic Submittals: All submittals for shop drawings, O & M Manuals and Record Drawings shall be in electronic PDF format. Identify and incorporate information in each electronic submittal file as follows:
 - 1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
 - 2. Name file with submittal number or other unique identifier, including revision identifier.
 - a. File name shall use project identifier and Specification Section number followed by a decimal point and then a sequential number (e.g., Offutt-23 05 00). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., Offutt-23 05 00).
 - 3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Architect and/or Construction Manager.

4. Transmittal Form for Electronic Submittals: Use software-generated form from electronic project management software acceptable to Architect, Engineer and Owner, containing the following information:
- Project name.
 - Date.
 - Name and address of Architect.
 - Name of Construction Manager.
 - Name of Contractor.
 - Name of firm or entity that prepared submittal.
 - Names of subcontractor, manufacturer, and supplier.
 - Category and type of submittal.
 - Submittal purpose and description.
 - Specification Section number and title.
 - Specification paragraph number or drawing designation and generic name for each of multiple items.
 - Drawing number and detail references, as appropriate.
 - Location(s) where product is to be installed, as appropriate.
 - Related physical samples submitted directly.
 - Indication of full or partial submittal.
 - Transmittal number[, numbered consecutively].
 - Submittal and transmittal distribution record.
 - Other necessary identification.
 - Remarks.

1.03 SUBMITTAL LIST

- A. Submittals shall be submitted for, but not limited to, the items listed in each section of the specifications. Submittals, in addition to those listed, may be required by the Architect/Engineer. The following submittal register is a summary list of submittals required for the project.

SUBMITTAL REGISTER	
SECTION	ITEM
23 00 00	O&M Manuals
23 00 00	Record Drawings
23 00 00	Certification of Inspection
23 05 00	Valves
23 05 00	Piping Specialties
23 05 00	Meters and Gauges
23 05 00	Supports and Anchors
23 05 00	Mechanical Identification
23 05 00	Vibration Control
23 05 00	Access Panels
23 05 00	Joint Sealants

SUBMITTAL REGISTER	
SECTION	ITEM
23 05 93	Test & Balance Report
23 07 00	HVAC Insulation Materials Schedule
23 09 00	Electric Control & Facilities Management Systems Installation Drawings
23 09 00	Electric Control & Facilities Management Systems Control Strategies
23 09 00	Electric Control & Facilities Management Systems Equipment
23 09 00	Operation & Maintenance Manuals
23 09 33	Variable Frequency Drives
23 20 00	Pumps
23 21 13	Hydronic Piping & Fittings
23 21 13	Hydronic Specialties
23 21 13	Hydronic System Testing and Cleaning
23 25 00	Hydronic System Cleaning & Treatment
23 25 00	Glycol Solution
23 25 00	Chemical Feeders
23 30 00	Air Distribution Ductwork
23 30 00	Air Distribution Specialties
23 30 00	Ductwork Layout Shop Drawings
23 30 00	Filters
23 30 00	Duct Liner
23 30 00	Fire Dampers
23 30 00	Smoke Dampers
23 30 00	Diffusers, Registers & Grilles
23 30 00	Louvers
23 30 00	Air Terminal Units
23 34 00	Fans
23 34 00	Intake and Relief Hoods
23 34 00	Roof Curbs
23 52 00	Boiler Accessories
23 52 00	Flue Stacks
23 72 00	Energy Recovery Ventilators
23 73 13	Packaged Heating and Cooling Unit
23 81 40	VRF Heat Recovery Systems
23 81 40	VRF Indoor Units
23 81 40	VRF Outdoor Units
23 81 40	VRF Valves and Accessories
23 82 39	Electric Baseboard Heaters

END OF SECTION

SECTION 230131
AIR DUCT CLEANING**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. This Section includes cleaning of the following new and existing duct systems:
 - 1. Supply system.
 - 2. Return system.
 - 3. Exhaust system.

1.03 DEFINITIONS

- A. ASCS: Air system cleaning specialist.
- B. NADCA: National Air Duct Cleaners Association.
- C. SMACNA: Sheet Metal and Air Conditioning Contractors National Association

1.04 SUBMITTALS

- A. Manufacturers Certificates: Signed by manufacturers certifying that products comply with requirements.
- B. Qualification Data: For ASCS.
- C. Field quality-control tests reports.

1.05 QUALITY ASSURANCE

- A. ASCS Qualifications: A certified member of NADCA.
 - 1. Certification: Employ an ASCS certified by NADCA on a full time basis.
 - 2. Supervisor Qualifications: Certified as an ASCS by NADCA.
 - 3. Experience: Submit records of experience in the field of HVAC systems cleaning.
 - 4. Equipment, Materials, and Labor: Have equipment, materials, and labor required to perform specified services.
- B. Comply with current published standards of NADCA.

PART 2 PRODUCTS**2.01 MANUFACTURERS**

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards- Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.
- B. Galvanized-Steel Sheet: Lock-forming quality: complying with ASTM A 653/ A 653M and having G60 coating designation; ducts shall have mill- phosphatized finish for surfaces exposed to view.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

- D. Tie Rods: Galvanized steel 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine systems to determine appropriate methods, tools and equipment required for performance of work.
- B. Prepare written report listing conditions detrimental to performance of work.
- C. Proceed with work only after unsatisfactory conditions have been corrected.

3.02 CLEANING

- A. Engage a qualified ASCS to clean the following systems:
 - 1. Supply system.
 - 2. Return system.
 - 3. Exhaust system.
- B. Perform cleaning before air balancing or mark position of dampers and air-directional mechanical devices before cleaning.
- C. Use duct-mounted access doors, as required, for physical and mechanical entry and for inspection.
 - 1. Install additional duct-mounting access doors to comply with duct cleaning standards. Comply with requirements in Division 23 Section "Duct Accessories" for additional duct mounting access doors.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection. Replace damaged and deteriorated flexible ducts. Comply with requirements in Division 23 Section "Duct Accessories" for flexible ducts.
 - 3. Disconnect and reconnect flexible connectors as needed for cleaning and inspection. Replace damaged and deteriorated flexible connectors. Comply with requirements in Division 23 Section "Duct Accessories" for flexible connectors.
 - 4. Reseal rigid-fiberglass duct systems according to NAIMA recommended practices.
 - 5. Replace damaged fusible links on fire and smoke dampers. Replacement fusible links shall be same rating as those being replaced. Comply with requirements in Division 23 Section "Duct Accessories" for fusible links.
 - 6. Remove and reinstall ceiling components to gain access for duct cleaning. Clean ceiling components after they have been removed and replaced.
- D. Mark position of dampers and air-directional mechanical devices before cleaning and restore to their marked position on completion.
- E. Particulate Collection and Odor Control:
 - 1. Where venting vacuuming system inside building, use HEPA filtration with 99.97 percent collection efficiency for 0.3- micron size (or greater) particles.
 - 2. When venting vacuuming system outside building, use filtration to contain debris removed from the HVAC system and locate exhaust down wind and away from air intakes and other points of entry in building.
- F. Clean the following metal-duct system components by removing visible surface contaminants and deposits.
 - 1. Air outlets and inlets (registers grilles and diffusers).
 - 2. Supply and return fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, damper, and drive assemblies.

3. Air-handling-unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections and condensate collectors and drains.
 4. Coils and related components.
 5. Return-air ducts, dampers, actuators, except in the ceiling plenums and mechanical room.
 6. Supply-air ducts dampers, actuators, and turning vanes.
 7. Dedicated exhaust and ventilation components.
- G. Mechanical Cleaning Methodology:
1. Clean metal-duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building. Connect vacuum device to downstream end of ducts so areas being cleaned are under negative pressure.
 2. Use vacuum-collection devices that are operated continuously during cleaning.
 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts or duct liner.
 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment, and do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold or fungus growth.
 5. Clean coils and coil drain pans according to NADCA 2007. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
 6. Provide operative drainage system for wash down procedures.
 7. Biocidal Agents and Coatings: Apply biocidal agents if fungus is present: use according to manufacturer's written instructions after removal of surface deposits and debris.
- H. Cleanliness Verification:
1. Verify cleanliness after mechanical cleaning and before application of treatment, including biocidal agents and protective coatings.
 2. Visually inspect metal-duct systems for contaminants.
 3. Where contaminants are discovered, re-clean and re-inspect duct systems.

3.03 DUCT ACCESSORIES INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Provide duct accessories of material suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install duct-mounting access doors where access doors do not currently exist to allow for the cleaning of ducts, accessories, and terminal units as follows:
 1. On both sides of duct coils.
 2. Downstream from volume dampers, turning vanes and equipment.
 3. Adjacent to fire or smoke dampers; reset or install new fusible links.
 4. Before and after each change in direction, at maximum 50-foot spacing.
 5. On sides of ducts where adequate clearance is available.

END OF SECTION

SECTION 230500
COMMON HVAC MATERIALS AND REQUIREMENTS**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. This Section includes the following common HVAC materials and requirements.
1. Valves:
 - a. Gate
 - b. Ball
 - c. Plug
 - d. Globe
 - e. Butterfly
 - f. Check
 2. Valve Tags and Valve Schedules.
 3. Piping Specialties:
 - a. Pipe escutcheons
 - b. Pipeline strainers
 - c. Pipe sleeves
 - d. Dielectric unions
 4. Meters and Gauges:
 - a. Glass thermometers
 - b. Pressure gauges
 - c. Test plugs
 5. Supports and Anchors:
 - a. Horizontal-piping hangers and supports
 - b. Saddles and shields
 6. HVAC Identification.
 7. Vibration Control:
 - a. Spring isolators
 - b. Isolation hangers
 - c. Flexible pipe connectors
 - d. Isolation pads
 8. Access Panels.
 9. Nonshrink Grout for equipment installations.
 10. Joint sealers for sealing around mechanical materials and equipment; and for sealing penetrations in fire and smoke barriers, floors, and foundation walls.
 11. Installation requirements common to piping and equipment specification Sections.
 12. Concrete equipment base construction requirements.
 13. HVAC demolition.

14. Cutting and patching.
15. Piping tests.

1.03 DEFINITIONS

- A. Pipe, pipe fittings, and piping include tube, tube fittings, and tubing.
- B. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below the roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
- C. Exposed Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- D. Exposed Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- E. Concealed Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
- F. Concealed Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.04 SUBMITTALS

- A. Shop Drawing Submittals:
 1. General: Submit the following according to the Conditions of the Contract.
 2. Product data for following piping specialties:
 - a. Valves.
 - b. Mechanical sleeve seals.
 - c. Thermometers.
 - d. Pressure gauges.
 - e. Identification materials and devices.
 - f. Vibration Isolators.
 - g. Access panels.

1.05 QUALITY ASSURANCE

- A. All HVAC equipment, ductwork, piping and connections shall be installed per requirements of the applicable mechanical code.
- B. Qualify welding processes and operators for structural steel according to AWS D1.1 "Structural Welding Code Steel."
- C. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."
 1. Comply with provisions of ASME B31 Series "Code for Pressure Piping."
 2. Certify that each welder has passed AWS qualification tests for the welding processes involved and that certification is current.
- D. MSS Compliance: Mark valves in accordance with MSS-25 "Standard Marking System for Valves, Fittings, Flanges and Unions."
- E. ANSI Compliance: For face-to-face and end-to-end dimensions of flanged- or welded-end valve bodies, comply with ANSI B16.10 "Face-to-Face and End-to-End Dimensions of Ferrous Valves."
- F. FCI Compliance: Test and rate Y-type strainers in accordance with FCI 73-1 "Pressure Rating Standard for Y-type strainers". Test and rate other type strainers in accordance with FCI 78-1 "Pressure Rating Standard for Pipeline Strainers Other than Y-type".
- G. UL and FM Compliance: Provide meters, gauges, and supports which are UL-listed and FM approved.

- H. MSS Standard Compliance: Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.
- I. ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.
- J. Equipment Selection: Equipment of greater or larger power, dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical and electrical services, circuit breakers, conduit, motors, bases, and equipment spaces are increased. If minimum energy ratings or efficiencies of the equipment are specified, the equipment must meet the design requirements and commissioning requirements. No additional cost will be approved for any such changes.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.
- B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. When stored inside, do not exceed structural capacity of the floor.
- C. Protect flanges, fittings, and piping specialties from moisture and dirt.
- D. Protect stored plastic pipes from direct sunlight. Support to prevent sagging and bending.

1.07 SEQUENCING AND SCHEDULING

- A. Coordinate HVAC equipment installation with other building components.
- B. Arrange for chases, slots, and openings in building structure during progress of construction to allow for HVAC installations.
- C. Coordinate the installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- D. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning prior to closing in the building.
- E. Coordinate connection of electrical services.
- F. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.
- G. Coordinate requirements for access panels and doors where mechanical items requiring access are concealed behind finished surfaces.
- H. Perform demolition and new mechanical work in phases as indicated.

1.08 PROJECT CONDITIONS

- A. Conditions Affecting Selective Demolition:
 - 1. Protect adjacent materials indicated to remain. Install and maintain dust and noise barriers to keep dirt, dust, and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
 - 2. Locate, identify, and protect mechanical services passing through demolition area and serving other areas outside the demolition limits. Maintain services to areas outside demolition limits. When services must be interrupted, install temporary services for affected areas.
- B. Conditions Affecting Excavations:
 - 1. Maintain and protect existing building services which transit the area affected by excavations.
 - 2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
 - 3. Existing Utilities: Locate existing underground utilities in excavation areas. If utilities are indicated to remain, support and protect services during excavation operations.

4. Remove existing underground utilities indicated to be removed.
 - a. Uncharted or Incorrectly Charted Utilities: Contact Utility Owner immediately for instructions.
 - b. Provide temporary utility services to affected areas. Provide minimum of 48-hour notice to Owner and Engineer prior to utility interruption.
5. Use of explosives is not permitted.

PART 2 PRODUCTS

2.01 PIPE AND PIPE FITTINGS

- A. Refer to individual piping system specification Sections for pipe and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.02 JOINING MATERIALS

- A. Pipe Flange Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents.
 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, except where thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125 cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250 cast-iron and steel flanges.
 2. ASME B16.20 for grooved, ring-joint, steel flanges.
 3. AWWA C110, rubber, flat face, 1/8-inch thick, except where other thickness is indicated; and full-face or ring type, except where type is indicated.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, except where other material is indicated.
- C. Solder Filler Metal: ASTM B 32.
 1. Alloy Sn95 or Alloy Sn94: Tin (approximately 95%) and silver (approximately 5%), having 0.10% lead content.
 2. Alloy Sn50: Tin (50%) and lead (50%) (for use on nonpotable water systems only).
- D. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- E. Solvent Cements: Manufacturer's standard solvents complying with the following:
 1. Chlorinated Poly(Vinyl Chloride) (CPVC): ASTM F 493.
 2. Poly(Vinyl Chloride) (PVC): ASTM D 2564.
- F. Plastic Pipe Seals: ASTM F 477, elastomeric gasket.
- G. Flanged, Ductile-Iron Pipe Gasket, Bolts, and Nuts: AWWA C110, rubber gasket, carbon steel bolts and nuts.
- H. Couplings: Iron body sleeve assembly, fabricated to match outside diameters of plain-end pressure pipes.
 1. Sleeve: ASTM A126, Class B, gray iron.
 2. Followers: ASTM A 47 (ASTM A 47M), Grade 32510 or ASTM A 536 ductile iron.
 3. Gaskets: Rubber.
 4. Bolts and Nuts: AWWA C111.
 5. Finish: Enamel paint.

2.03 PIPING SPECIALTIES**A. Pipe Escutcheons:**

1. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.
2. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.
3. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

B. Low Pressure Pipeline Strainers:

1. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 PSI working pressure, with Type 304 stainless steel screens, with 3/64-inch perforations at 233 per square inch.
2. Threaded Ends, 2-inches and Smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.
3. Threaded Ends, 2-1/2-inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.
4. Flanged Ends, 2-1/2-inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.
5. Butt Welded Ends, 2-1/2-inches and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.
6. Grooved Ends, 2-1/2-inches and Larger: Tee pattern, ductile-iron or malleable-iron body and access end cap, access coupling with EDPM gasket.

C. Dielectric Fittings: Assembly or fitting having insulating material isolating joined dissimilar metals to prevent galvanic action and stop corrosion.

1. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld neck end types and matching piping system materials.
2. Insulating Material: Suitable for system fluid, pressure, and temperature.
3. Dielectric Unions: Factory-fabricated, union assembly for 250 PSIG minimum working pressure at a 180°F temperature.
4. Dielectric Flanges: Factory-fabricated, companion-flange assembly for 150 or 300 PSIG minimum pressure to suit system pressures.
5. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - a. Provide separate companion flanges and steel bolts and nuts for 150 or 300 PSIG minimum working pressure to suit system pressures.
6. Dielectric Couplings: Galvanized-steel coupling, having inert and noncorrosive, thermoplastic lining, with threaded ends and 300 PSIG minimum working pressure at 225°F temperature.
7. Dielectric Nipples: Electroplated steel nipple, having inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved end types and 300 PSIG working pressure at 225°F temperature.

D. Mechanical Sleeve Seals: Modular, watertight mechanical type. Components include interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve. Connecting bolts and pressure plates cause rubber sealing elements to expand when tightened.

E. Sleeves: The following materials are for wall, floor, slab, and roof penetrations:

1. Steel Sheet-Metal: 24-gauge or heavier galvanized sheet metal, round tube closed with welded longitudinal joint.
2. Steel Pipe: ASTM A 53, Type E, Grade A, Schedule 40, galvanized, plain ends.
3. Cast-Iron: Cast or fabricated wall pipe equivalent to ductile-iron pressure pipe, having plain ends and integral water stop, except where other features are specified.

2.04 VALVES

A. General: Provide factory-fabricated valves recommended by Manufacturer for use in service indicated. Provide valves of types and pressure ratings indicated; provide proper selection as determined by Installer to comply with Installation requirements. Provide end connections which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is Installer's option.

B. Gate Valves: Comply with the following requirements:

1. Gate Valves - 2-Inches and Smaller: MSS SP-80; Class 125, body and bonnet of ASTM B 62 cast bronze, threaded or solder ends, solid disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Class 150 valves meeting the above shall be used where pressure requires.
2. Gate Valves - 2-Inches and Smaller: MSS SP-80; Class 150, body and union bonnet as ASTM B 62 cast bronze, threaded or solder ends, solid disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Do not use solder end valves for hot water heating or steam piping applications.
3. Gate Valves - 2-1/2-Inches and Larger: MSS SP-70; Class 125 iron body, bronze mounted, with body and bonnet conforming to ASTM A 126 Class B, flanged ends, and "Teflon" impregnated packing and two-piece backing gland assembly.

C. Ball Valves: Comply with the following requirements:

1. Ball valves - 1-inch and Smaller: Rated for 150 PSI SWP pressure, 600 PSI non-shock WOG pressure; 2-piece construction, bronze body conforming to ASTM B 584 or B61, full port, 316 stainless steel ball, reinforced "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide extended solder ends for condenser water and chilled water; full depth ANSI threaded ends for heating hot water and low pressure steam. Provide 2-inch extended handles of non-thermal conductive material. Valve pressure ratings shall be cast into the body of the valve.
2. Ball Valves - 1-1/4-Inches to 2-Inches: Rated for 150 PSI SWP pressure, 600 PSI non-shock WOG pressure; 2-piece construction, bronze body conforming to ASTM B 584 or B61, full port, 316 stainless steel ball, reinforced and replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, and vinyl-covered steel handle. Provide extended solder ends for condenser water and chilled water; full-depth ANSI threaded ends for heating hot water and low pressure steam. Provide 2-inch extended handles of non-thermal conductive material. Valve pressure ratings shall be cast into the body of the valve.

D. Plug Valves: Comply with the following requirements:

1. Plug Valves - 2-Inches and Smaller: 150 PSI WOG, bronze body, straightaway pattern, square head, threaded ends.
2. Plug Valves - 2-1/2-Inches and Larger: MSS SP-78; 175 PSI WOG, lubricated plug type, semi-steel body, single gland, wrench operated, flanged ends.

- E. Globe Valves: Comply with the following requirements:
1. Globe Valves - 2-Inches and Smaller: MSS SP-80; Class 125, body and screwed bonnet of ASTM B 62 cast bronze, threaded or solder ends, brass or replaceable composition disc, copper-silicon alloy stem, brass packing gland, "Teflon" impregnated packing, and malleable iron handwheel. Class 150 valves meeting the above shall be used where pressure requires.
 2. Globe Valves - 2-1/2-Inches and Larger: MSS SP-85; Class 125 iron body and bolted bonnet conforming to ASTM A 126, Class B; outside screw and yoke, bronze-mounted, flanged ends, and "Teflon" impregnated packing and two-piece backing gland assembly.
- F. Butterfly Valves: Comply with the following requirements:
1. Butterfly Valves - 2-1/2-Inches and Larger: MSS SP-67; 200 non-shock PSI, cast iron body conforming to ASTM A 126, Class B. Valves shall have field replaceable EPDM sleeve, with aluminum bronze disc, 400 Series stainless steel stem, and EPDM O-ring stem seals. Sizes 2-1/2-inch through 6-inches shall have 10-position lever operators with locks, and sizes 8-inch through 24-inch shall have gear operators with position indicator. Provide wafer type valve. Drill and tap valves on dead-end service or requiring additional body strength. Valve shall be capable of bi-directional dead end service with downstream flange removed at full-rated pressure.
- G. Check Valves: Comply with the following requirements:
1. Swing Check Valves - 2-Inches and Smaller: MSS SP-80; Class 125, cast bronze body and cap conforming to ASTM B 62, horizontal swing, Y-pattern, with a bronze disc, and having threaded or solder ends. Valve shall be capable of being reground while the valve remains in the line. Class 150 valves meeting the above specifications may be used with threaded end connections where pressure requires or Class 125 valves are not available.
 2. Swing Check Valves - 2-1/2-Inches and Larger: MSS SP-71; Class 125 (Class 175 FM approved for fire protection piping systems), cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, with a bronze disc or cast iron disc with bronze disc ring, and flanged ends. Valve shall be capable of being refitted while the valve remains in the line.
 3. Wafer Check Valves: Class 250, cast iron body; with replaceable bronze seat, and non-slam design lapped and balanced twin bronze flappers and stainless steel trim and torsion spring. Valve shall be designed to open and close at approximately one foot differential pressure.

2.05 VALVE TAGS

- A. Brass Valve Tags: Provide 19-gauge polished brass valve tags for all valves with stamp-engraved piping system abbreviation in 1/4-inch high letters and sequenced valve numbers 1/2-inch high, and with 5/32-inch hole for fastener.
1. Provide 1-1/2-inch diameter tags, except as otherwise indicated.
 2. Fill tag engraving with black enamel.
- B. Valve Tag Fasteners: Manufacturer's standard solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves, and manufactured specifically for that purpose.

2.06 VALVE SCHEDULES

- A. General: Provide a valve schedule for each piping system in electronic form and printed out on standard size bond paper for inclusion in Operation and Maintenance manual. Schedule shall include valve identification number, piping system, size and location of valve, normal operating position and additional remarks as required. Identify valve use for emergency shutoff or similar special use.

2.07 METERS AND GAUGES

- A. Thermometers:
1. General: Provide thermometers of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
 2. Case: Die cast aluminum finished in baked epoxy enamel or hard powder coat finish, glass or acrylic front, 9-inches long.

3. Adjustable Joint: Die cast aluminum, finished to match case, 180° adjustment in vertical plane, 360° adjustment in horizontal plane, with locking device.
 4. Tube and Capillary: Blue organic-liquid filled, magnifying lens, ± 1 scale division accuracy, shock mounted.
 5. Scale: Satin faced, non*reflective white aluminum, permanently etched black markings.
 6. Stem: Copper-plated steel, brass or die-cast aluminum, for separable socket, length to suit installation.
 7. Thermometer Wells: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2-inch extension for insulated piping. Provide cap fastened to well when used in a non-permanent thermometer location.
 8. Thermometer wells shall be installed at each thermometer and at each point where a temperature sensing device is required by the control specifications.
 9. Range: Conform to the following:
 - a. Heating Water: 30°F to 240°F with 2°F scale divisions.
 - b. Chilled Water: 0°F to 100°F with 1°F scale divisions.
 - c. Condenser Water: 0°F to 160°F with 2°F scale divisions.
- B. Pressure Gauges:
1. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
 2. Type: General use, $\pm 1\%$ accuracy, ANSI B 40.1 Grade 1A, phosphor bronze bourdon type, bottom connection.
 3. Case: Stainless steel, glass or acrylic lens, 4-1/2-inch diameter.
 4. Connector: Brass, lower mount with 1/4-inch male NPT.
 5. Scale: White coated aluminum, with permanently etched black markings.
 6. Accessories:
 - a. Provide protective coil siphon when used for steam service.
 - b. Provide each gauge with a shut-off needle valve.
 - c. Provide pressure snubber where spikes may be present.
 7. Range: Conform to the following:
 - a. Vacuum: 30-inch Hg - 15 PSI.
 - b. Water: 0-100 PSI.
 - c. Steam: 0-200 PSI.
- C. Test plugs:
1. Description: Test-station fitting made for insertion into piping tee fitting.
 2. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
 3. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.
 4. Minimum Pressure and Temperature Rating: 500 PSIG at 200 deg F
 5. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.08 SUPPORTS AND ANCHORS**A. Horizontal-Piping Hangers and Supports:**

1. General: Except as otherwise indicated, provide factory-fabricated horizontal-piping hangers and supports complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal-piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping. Provide copper-plated hangers and supports for copper-piping systems.
2. Adjustable Steel Clevis Hangers: MSS Type 1.
3. Yoke Type Pipe Clamps: MSS Type 2.
4. Steel Double Bolt Pipe Clamps: MSS Type 3.
5. Steel Pipe Clamps: MSS Type 4.
6. Pipe Hangers: MSS Type 5.
7. Trapeze type with horizontal angle iron.

B. Saddles and Shields:

1. General: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.
2. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
3. Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation.
4. Thermal Hanger Shields: Constructed of 360 degree insert of high density, 100 PSI, water-proofed calcium silicate, encased in 360 degree sheet metal shield. Provide assembly of same thickness as adjoining insulation.

C. Roof Equipment Supports:

1. General: Construct roof equipment supports using minimum 18-gauge galvanized steel with fully mitered and welded corners, 3-inch cant, internal bulkhead reinforcing, integral base plates, pressure treated wood nailer, and 18-gauge galvanized steel counterflashing.
2. Configuration: Construct to sizes as indicated, compensate for slope in roof so top of support is dead level.

2.09 MECHANICAL IDENTIFICATION**A. Equipment Markers:**

1. General: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive or fasteners to mount on equipment.
2. Terminology: Match drawing schedules as closely as possible unless directed otherwise by Owner.
3. Data Required:
 - a. Equipment Description, (i.e. Heat Pump).
 - b. Schedule Mark, (i.e. HP-1).
4. Marker Size: 2-1/2- by 4-inches for main control valves; 4-1/2- by 6-inches for equipment.

B. Plastic Pipe Markers:

1. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1.

2. Small Pipes: For external diameters less than 6-inches (including insulation if any), provide full-band pipe markers, extending 360° around pipe at each location, fastened by the following method:
 - a. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4-inch wide; full circle at both ends of pipe marker, tape lapped 1-1/2-inches.
 3. Large Pipes: For external diameters of 6-inch and larger (including insulation if any), provide either full-band or strip-type pipe markers, but not narrower than three times letter height (and of required length), fastened by one of the following methods:
 - a. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2-inches wide, full circle at both ends of pipe marker, tape lapped 3-inches.
 4. Lettering: Comply with piping system nomenclature as specified, scheduled or shown on drawings, and abbreviate only as necessary for each application length.
 - a. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.
- C. Plastic Tape:
1. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 MILS thick, complying with ANSI A13.1.
 2. Width: Provide 1-1/2-inch wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6-inches, 2-1/2-inch wide tape for larger pipes.
- D. Color Scheme: Comply with ANSI A13.1, or as scheduled below:
- | <u>ITEM</u> | <u>COLOR SCHEME</u> |
|------------------------------------|----------------------|
| Heating Water | Black text on Yellow |
| Chilled Water | White text on Green |
| Condenser Water | White text on Green |
| Steam Supply and Condensate Return | Black text on Yellow |
| Refrigerant Liquid and Suction | Black text on Yellow |
| Fuel Oil | Black text on Yellow |

2.10 VIBRATION CONTROL

- A. Spring Isolators, Free-Standing: Except as otherwise indicated, provide vibration isolation spring between top and bottom loading plates, and with pad-type isolator bonded to bottom of bottom loading plate. Include studs or cups to ensure centering of spring on plates. Include leveling bolt with lock nuts and washers, centered in top plate, arranged for leveling and anchoring supported equipment as indicated.
1. Include holes in bottom plate for bolting unit to substrate as indicated.
- B. Isolation Hangers: Hanger units formed with brackets and including manufacturer's standard compression isolators of type indicated. Design brackets for three times rated loading of units. Fabricate units to accept misalignment of 15° off center in any direction before contacting hanger box, and for use with either rod or strap type members, and including acoustical washers to prevent metal-to-metal contacts.
1. Provide vibration isolation spring with cap in lower part of hanger and rubber hanger element in top, securely retained in unit.
 2. Provide neoprene element, with minimum deflection of 0.35-inches, securely retained in hanger box.
 3. Provide fiberglass pad or shape, securely retained in unit, with threaded metal top plate.
 4. Provide hangers, pre-compressed to rated load to limit deflection during installation. Design so hanger may be released after full load is applied.

- C. Flexible Pipe Connectors: Provide neoprene or EDPM construction consisting of multiple plies of nylon tire cord fabric and elastomer molded and cured in hydraulic rubber presses. Provide straight or elbow connector as indicated, rated at 125 PSI at 220°F.
- D. Vibration Isolation Pads: Neoprene, modular, waffle-type 3/8-inch thick pad. Provide size as required for 15% deflection at maximum loading.

2.11 ACCESS PANELS

- A. All panels shall be MILCOR, Style "M" for masonry, Style A for acoustical tile, and Style K for plaster; except that Fire Rated UL 1-1/2 hour and "B" label access panels shall be furnished in fire-rated walls and ceilings as indicated on the Drawings.
- B. Access doors shall be 12-inch x 12-inch minimum size for valves and dampers and shall be 24-inch x 36-inch for access to equipment and filters.

2.12 GROUT

- A. Nonshrink, Nonmetallic Grout: ASTM C 1107, Grade B.
 - 1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, non-staining, non-corrosive, non-gaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000 PSI, 28 day compressive strength.
 - 3. Packaging: Premixed and factory-packaged.

2.13 JOINT SEALERS

- A. General: Joint sealers, joint fillers, and other related materials compatible with each other and with joint substrates under conditions of service and application.
- B. Colors: As selected by the Architect from manufacturer's standard colors.
- C. Elastomeric Joint Sealers: Provide the following types:
 - 1. One-part, non-acid-curing, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for masonry, glass, aluminum, and other substrates recommended by the sealant manufacturer.
 - 2. One-part, mildew-resistant, silicone sealant complying with ASTM C 920, Type S, Grade NS, Class 25, for uses in non-traffic areas for glass, aluminum, and non-porous joint substrates; formulated with fungicide; intended for sealing interior joints with non-porous substrates; and subject to in-service exposure to conditions of high humidity and temperature extremes.
- D. Acrylic-Emulsion Sealants: One-part, nonsag, mildew-resistant, paintable complying with ASTM C 834 recommended for exposed applications on interior and protected exterior locations involving joint movement of not more than plus or minus 5%.
- E. Fire-Resistant Joint Sealers: Two-part, foamed-in-place, silicone sealant formulated for use in through-penetration fire-stopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors. Sealants and accessories shall have fire-resistant ratings indicated, as established by testing identical assemblies in accordance with ASTM E 814, by Underwriters' Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

PART 3 EXECUTION

3.01 PIPING SYSTEMS-COMMON REQUIREMENTS

- A. General: Install piping as described below, except where system Sections specify otherwise.
- B. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, except where deviations to layout are approved on coordination drawings.
- C. Install piping at indicated slope.
- D. Install components having pressure rating equal to or greater than system operating pressure.
- E. Install piping in concealed interior and exterior locations, except in equipment rooms and service areas.

- F. Install piping free of sags and bends.
- G. Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, except where indicated.
- H. Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal.
- I. Install piping to allow application of insulation plus 1-inch clearance around insulation.
- J. Locate groups of pipes parallel to each other, spaced to permit valve servicing.
- K. Install fittings for changes in direction and branch connections.
- L. Install pipe escutcheons for pipe penetrations of concrete and masonry walls, wall board partitions, and suspended ceilings according to the following:
 - 1. Chrome-Plated Piping: Cast-brass, one-piece, with set-screw, and polished chrome-plated finish. Use split-casting escutcheons, where required, for existing piping.
 - 2. Uninsulated Piping Wall Escutcheons: Cast-brass or stamped-steel, with set-screw.
 - 3. Uninsulated Piping Floor Plates in Utility Areas: Cast-iron floor plates.
 - 4. Insulated Piping: Cast-brass or stamped-steel, with concealed hinge, spring clips, and chrome-plated finish.
 - 5. Piping in Utility Areas: Cast-brass or stamped-steel, with set-screw or spring clips.
- M. Sleeves are not required for core drilled holes.
- N. Install sleeves for pipes passing through concrete and masonry walls, concrete floor and roof slabs, and where indicated.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2-inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring where specified.
 - 2. Build sleeves into new walls and slabs as work progresses.
 - 3. Install large enough sleeves to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. Steel Pipe Sleeves: For pipes smaller than 6-inches.
 - b. Steel Sheet-Metal Sleeves: For pipes 6-inches and larger that penetrate gypsum-board partitions.
 - c. Cast-Iron Sleeve Fittings: For floors having membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2-inches above finished floor level.
 - 4. Except for below-grade wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using elastomeric joint sealants.
- O. Above Grade, Exterior Wall, Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installation of mechanical seals.
 - 1. Install steel pipe for sleeves smaller than 6-inch.
 - 2. Install cast-iron wall pipes for sleeves 6-inch and larger.
 - 3. Assemble and install mechanical seals according to manufacturer's printed instructions.
- P. Below Grade, Exterior Wall, Pipe Penetrations: Install cast-iron wall pipes for sleeves. Seal pipe penetrations using mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installation of mechanical seals.
- Q. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestopping sealant material.

- R. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping system Sections.
1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
 3. Soldered Joints: Construct joints according to AWS "Soldering Manual," Chapter 22 "The Soldering of Pipe and Tube."
 4. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full inside diameter. Join pipe fittings and valves as follows:
 - a. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
 - b. Apply appropriate tape or thread compound to external pipe threads (except where dry seal threading is specified).
 - c. Align threads at point of assembly.
 - d. Tighten joint with wrench. Apply wrench to valve end into which pipe is being threaded.
 - e. Damaged Threads: Do not use pipe or pipe fittings having threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
 5. Welded Joints: Construct joints according to AWS D10.12 "Recommended Practices and Procedures for Welding Low Carbon Steel Pipe" using qualified processes and welding operators according to the "Quality Assurance" Article.
 6. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.
 7. Plastic Pipe and Fitting Solvent-Cement Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join pipe and fittings according to the following standards:
 - a. Comply with ASTM F 402 for safe handling of solvent-cement and primers.
 - b. Chlorinated Poly(Vinyl Chloride) (CPVC): ASTM D 2846 and ASTM F 493.
 - c. Poly(Vinyl Chloride) (PVC) Pressure Application: ASTM D 2672.
 - d. Poly(Vinyl Chloride) (PVC) Non-Pressure Application: ASTM D 2855.
 8. Plastic Pipe and Fitting Heat-Fusion Joints: Prepare pipe and fittings and join with heat-fusion equipment according to manufacturer's printed instructions.
 - a. Plain-End Pipe and Fittings: Butt joining.
 - b. Plain-End Pipe and Socket-Type Fittings: Socket joining.
- S. Piping Connections: Except as otherwise indicated, make piping connections as specified below.
1. Install unions in piping 2-inch and smaller adjacent to each valve and at final connection to each piece of equipment having a 2-inch or smaller threaded pipe connection.
 2. Install flanges in piping 2-1/2-inches and larger adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
 3. Wet Piping Systems (Water and Steam): Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.
 4. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures unless unavoidable. Install drip pan under piping that must be run through electrical spaces.
 5. Install isolation valves upstream of all dielectric unions and flanges.

3.02 EQUIPMENT INSTALLATION-COMMON REQUIREMENTS

- A. Install equipment to provide the maximum possible headroom where mounting heights are not indicated.
- B. Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to the Architect.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, except where otherwise indicated.
- D. Install HVAC equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.
- E. Install equipment giving right-of-way to piping systems installed at a required slope.

3.03 VALVE INSTALLATIONS

- A. General Application: Use ball and butterfly valves for shut-off duty; globe, ball, and butterfly for throttling duty. Refer to piping system specification sections for specific valve applications and arrangements.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves and unions for each item of equipment in a manner to allow equipment removal without system shut-down. Unions are not required on flanged devices.
- D. Install 3-valve bypass around each pressure reducing valve using throttling type valves.
- E. Install valves in horizontal piping with stem at or above the center of the pipe, and to allow full stem movement.
- F. Installation of Check Valves: Install for proper direction of flow as follows:
 - 1. Swing Check Valves: Install in horizontal position with hinge pin level.
 - 2. Wafer Check Valves: Install between two flanges in horizontal or vertical position.
 - 3. Lift Check Valve: Install in piping line with stem upright and plumb.
- G. Valve Locations:
 - 1. HVAC Hydronic Piping:
 - a. Sectional Valves: Install on each branch and riser, close to main, where branch or riser serves two or more hydronic terminals or equipment connections, and elsewhere as indicated.
 - b. Shut-off Valves: Install on inlet and outlet of each mechanical equipment item, and on inlet of each hydronic terminal, and elsewhere as indicated.
 - c. Throttling Valves: As required on plans.
 - 2. Valve Tags:
 - a. Provide valve tags for all valves and list on Valve Schedule.
 - b. Install tags on valves in piping systems, except check valves, valves within factory-fabricated equipment units and HVAC terminal devices.

3.04 VALVE PRESSURE/TEMPERATURE CLASSIFICATION SCHEDULESVALVES 2-INCHES AND SMALLER

<u>SERVICE</u>	<u>GATE</u>	<u>GLOBE</u>	<u>BALL</u>	<u>CHECK</u>
Condenser Water	125	125	150	125
Chilled Water	125	150	150	125
Heating Water	150	150	150	150
Low Pressure Steam (0 to 15 PSIG)	150	150	150	150

VALVES 2-1/2-INCHES AND LARGER

<u>SERVICE</u>	<u>GATE</u>	<u>GLOBE</u>	<u>BUTTERFLY</u>	<u>CHECK</u>
Condenser Water	125	125	200	125
Chilled Water	125	125	200	125
Heating Water	125	125	200	125
Low Pressure Steam (0 to 15 PSIG)	125	125	150	125

3.05 PIPING SPECIALTIES INSTALLATION

- A. Y-Type Strainers: Install Y-type strainers full size of pipeline, in accordance with manufacturer's installation instructions. Install pipe nipple and shut-off valve in strainer blow-down connection, full size of connection, except for strainers 2-inch and smaller installed ahead of control valves feeding individual terminals. Where indicated, provide drain line from shut-off valve to plumbing drain, full size of blow-down connection.
1. Locate Y-type strainers in supply line ahead of the following equipment, and elsewhere as indicated, if integral strainer is not included in equipment:
 - a. Pumps.
 - b. Temperature control valves.
 - c. Pressure reducing valves.
 - d. Temperature or pressure regulating valves.
 - e. Steam traps serving steam main drops.
- B. Dielectric Unions: Install at each piping joint between ferrous and nonferrous piping. Comply with manufacturer's installation instructions.
1. Install isolation valves on each side of all dielectric unions.

3.06 METERS AND GAUGES INSTALLATION

- A. Glass Thermometers:
1. General: Install glass thermometers in vertical upright position, and tilted so as to be easily read by observer standing on floor.
 2. Locations: Install in the following locations, and elsewhere as indicated:
 - a. At inlet and outlet of each hydronic zone.
 - b. At inlet and outlet of each ground loop heat exchanger.
 - c. At inlet and outlet of each hydronic boiler and chiller.
 - d. At inlet and outlet of each hydronic coil in air handling units, and built-up central systems.
 3. Thermometer Wells: Install in piping at each thermometer and temperature control sensing device in vertical upright position. Fill well with oil or graphite, secure cap.

B. Pressure Gauges:

1. General: Install pressure gauges in piping tee with pressure gauge cock, located on pipe at most readable position.
2. Locations: Install in the following locations, and elsewhere as indicated:
 - a. Across suction and discharge of each pump.
 - b. At discharge of each pressure reducing valve.
 - c. Across inlet and outlet of each hydronics coil of air handling units and built-up central systems.
 - d. Across inlet and outlet of each heat exchanger, water chiller, evaporator, etc.
 - e. Across inlet and outlet of ground loop heat exchanger.

3.07 SUPPORTS AND ANCHORS INSTALLATION

A. Hangers and Supports:

1. General: Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Install supports with maximum spacings complying with MSS SP-69. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping. **Piping shall not be supported from bottom cord of bar joist or from metal roof deck, unless approved by Structural Engineer.** Piping may be supported at panel points of bar joists.
2. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.
3. Powder-actuated fasteners shall be approved only for installation where load will be applied perpendicular to the fasteners. **Powder-actuated fasteners shall not be used where load will be applied axially to the fasteners.**
4. Support fire-water piping independently of other piping.
5. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.

B. Saddles and Shields:

1. Insulated Piping: Comply with the following installation requirements:
 - a. Shields: Where low-compressive-strength insulation or vapor barriers are indicated on cold or chilled water piping, install coated protective shields. For pipe 8-inch and over, install wood insulation saddles.
 - b. Saddles: Where insulation without vapor barrier is indicated, install protection saddles.

3.08 MECHANICAL IDENTIFICATION INSTALLATION

A. Install equipment markers with permanent adhesive or appropriate fasteners on or near each major item of mechanical equipment

1. Locate markers where accessible and visible.
2. Include markers for the following categories of equipment:
 - a. Main control and operating valves.
 - b. Boilers, pumps, compressors, chillers, condensers, cooling towers, heat exchangers, energy recovery units, fans, central station and zone-type units, heat pumps, tanks, pressure vessels, humidifiers, and similar equipment.

- B. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
 - 1. Near each valve and control device.
 - 2. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
 - 3. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
 - 4. At access doors, manholes and similar access points which permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced intermediately at maximum spacing of 50-feet along each piping run, except reduce spacing to 25-feet in congested areas of piping and equipment.
 - 7. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.09 VIBRATION CONTROL INSTALLATION

- A. General: Except as otherwise indicated, comply with manufacturer's instructions for installation and load application to vibration control materials and units. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.
- B. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.
- C. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.
- D. Locate isolation hangers as near overhead support structure as possible.
- E. Flexible Pipe Connectors: Install on equipment side of shut-off valves, horizontally and parallel to equipment shafts wherever possible.

3.10 ACCESS PANEL INSTALLATION

- A. HVAC Contractor shall locate and furnish for installation by General Contractor, all access panels as required for access to valves and dampers, and the proper servicing of equipment and piping installed under this Contract.

3.11 CONCRETE BASES

- A. Construct concrete equipment bases of dimensions indicated, but not less than 4-inches larger than supported unit in both directions. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Use 3000 PSI, 28 day compressive strength concrete and reinforcement.

3.12 ERECTION OF METAL SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- B. Field Welding: Comply with AWS D1.1 "Structural Welding Code-Steel."

3.13 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage to support and anchor mechanical materials and equipment.
- B. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.14 SELECTIVE DEMOLITION

- A. General: Demolish, remove, demount, and disconnect abandoned HVAC ductwork, piping, materials and equipment indicated to be removed and not indicated to be salvaged or saved.
- B. Materials and Equipment designated for Salvage: Remove, demount, and disconnect existing HVAC materials and equipment indicated to be removed and salvaged, and deliver materials and equipment to the location designated for storage by Owner.
- C. Disposal and Cleanup: Remove from the site and legally dispose of demolished materials and equipment not indicated to be salvaged.
- D. HVAC Materials and Equipment: Demolish, remove, demount, and disconnect the following items:
 - 1. Inactive and obsolete piping, fittings and specialties, equipment, ductwork, controls, devices, and insulation.
 - a. Piping and ducts embedded in floors, walls, and ceilings may remain if such materials do not interfere with new installations. Remove materials above accessible ceilings. Drain and cap piping and ducts allowed to remain.

3.15 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for HVAC installations. Perform cutting by skilled mechanics of the trades involved.
- B. Repair cut surfaces to match adjacent surfaces.

3.16 GROUTING

- A. Install nonmetallic nonshrink grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's printed instructions.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms for placement of grout, as required.
- D. Avoid air entrapment when placing grout.
- E. Place grout to completely fill equipment bases.
- F. Place grout on concrete bases to provide a smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout according to manufacturer's printed instructions.

3.17 PIPING TESTS

- A. No piping work, fixtures, or equipment shall be concealed or covered until they have been observed by the Engineer's representative, who shall be notified by the Contractor when the work is ready for inspection. All work shall be completely installed, tested as required by this Section and by all applicable local and State Ordinances and Safety Orders, and shall be leak-tight before inspection is requested. All tests shall be repeated upon request to the satisfaction of those making the inspection.

- B. Piping tests shall be made with the test medium and under test pressures listed in the following table. Use a calibrated Bristol Pressure Recorder, or equal, on all tests. Engineer's representative shall install and remove each chart. Recorder range shall be 0-300 pounds or required range for specific test.

PIPING TESTS			
<u>Type of Piping</u>	<u>Test Pressure</u>	<u>Test Medium</u>	
Fuel Gas, and Fuel Oil Return	50 PSIG	Air	One Hour
Steam Supply	1 st – 150 PSIG	Water	Two Hours
	2 nd – steam at operating pressure		Each Test
Condensate Return	1 st – 150 PSIG	Water	Two Hours
	2 nd – Steam at supply pressure		Each Test
Refrigeration and Fuel Suction	1 st – 150 PSIG	Nitrogen	One Hour
	2 nd – 25 in. vacuum		Each Test
Refrigeration Liquid and Hot Gas	1 st – 300 PSIG	Nitrogen	One Hour
	2 nd – 25 in. vacuum		Each Test
Heating Water, Chilled Water and Condenser Water	50 PSIG or twice operating pressure, whichever is greater	Water	One Hour

- C. Test pressure in lbs. per square inch, or inches of vacuum, gauge, are given as an initial pressure to be applied to lines being tested, together with test medium.
- D. Final pressures at the end of test period shall be no more nor less than that caused by expansion or contraction of the test medium due to temperature changes.
- E. Check of systems during application of test pressures should include visual check for water medium leakage, soap bubble or similar for air and nitrogen medium, and halide torch for refrigerant medium after charging.
- F. During heating and cooling cycles, linear expansion shall be checked at all elbows, U-bends, expansion joints, etc., for proper clearance.

END OF SECTION

SECTION 230593
HVAC TESTING, ADJUSTING AND BALANCING**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Section includes testing, adjusting and balancing the following systems and equipment:

1. Air Systems:
 - a. Constant-volume air systems.
 - b. Return air systems.
 - c. Variable-air-volume systems.
 - d. Exhaust air systems.
 - e. <Insert system>.
2. Balancing Hydronic Piping Systems:
 - a. Constant-flow hydronic systems.
 - b. Variable-flow hydronic systems.
 - c. Primary-secondary hydronic systems.
3. Balancing steam systems.
4. Refrigerant system.
5. Equipment:
 - a. Heat exchangers.
 - b. Motors.
 - c. Chillers.
 - d. Cooling towers.
 - e. Units.
 - f. Boilers.
 - g. Heat-transfer coils.
 - h. Pumps.
 - i. Fans.
 - j. Hoods.
 - k. Humidifiers.
 - l. <Insert equipment>.
6. Testing, adjusting, and balancing existing systems and equipment.
7. Sound tests.
8. Vibration tests.
9. Duct leakage tests.
10. Control system verification.
11. Space leakage tests.

1.03 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. BAS: Building automation systems.
- C. NEBB: National Environmental Balancing Bureau.
- D. TAB: Testing, adjusting, and balancing.
- E. TABB: Testing, Adjusting, and Balancing Bureau.
- F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- G. TDH: Total dynamic head.

1.04 SUBMITTALS

- A. Information Submittals:
 - 1. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
 - 2. Instrument calibration reports, to include the following:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.
 - 3. Contract Documents Examination Reports: With 60 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in part 3.
 - 4. Strategies and Procedures Plan: With 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
 - 5. System Readiness Checklists: With 60 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
 - 6. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- B. LEED Submittals: Air-Balance Report for Prerequisite IEQ 1: Documentation indicating that work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
 - 1. TAB Report for Prerequisite EA 2: Documentation indicating that work complies with ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."
- C. Closeout Submittals:
 - 1. Certified TAB reports.

1.05 QUALITY ASSURANCE

- A. TAB Specialists Qualifications: Engage a TAB entity certified by AABC, NEBB or TABB.
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC, NEBB or TABB .
 - 2. TAB Technician: employee of the TAB specialist and certified by AABC, NEBB or TABB AS A TAB TECHNICIAN.

- B. TAB Conference: Meet with Commissioning Authority on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians.
 - 1. Agenda Items:
 - a. Contract Documents examination.
 - b. The TAB plan.
 - c. Coordination and cooperation of trades and subcontractors.
 - d. Coordination of documentation and communication flow.
- C. Certify TAB field data reports and perform the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
- D. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.06 PROJECT CONDITIONS

- A. Do not proceed Closeout Submittal until work has been completed and systems and equipment are operable. Ensure that there is not latent residual work still to be completed.
- B. Do not proceed with schedules for testing, adjusting, and balancing until systems and equipment are clean and free from debris, dirt and discarded building materials.
- C. Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.07 COORDINATION

- A. Coordinate with other trades for scheduled test dates and times.
- B. Perform TAB work after leakage and pressure tests on distribution systems have been satisfactorily completed.

PART 2 PRODUCTS

2.01 PATCHING MATERIALS

- A. Except as otherwise indicated, use same products as used by original Installer for patching holes in insulation, ductwork and housings which have been cut or drilled for test purposes, including access for test instruments, attaching jigs and similar purposes. At Tester's option, plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.

2.02 TEST INSTRUMENTS

- A. Utilize test instruments and equipment for TAB work required, of type, precision, and capacity as recommended in NEBB's Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

PART 3 EXECUTION

3.01 EXAMINATION

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

- B. Examine systems for installed balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine equipment performance data including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- E. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- F. Examine test reports specified in individual system and equipment Sections.
- G. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- H. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- I. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
- J. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- K. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- L. Examine system pumps to ensure absence of entrained air in the suction piping.
- M. Examine operating safety interlocks and controls on HVAC equipment.
- N. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.02 PREPARATION

- A. Complete system-readiness checks and prepare reports. Verify the following:
 - 1. Permanent electrical-power wiring is complete.
 - 2. Hydronic systems are filled, clean, and free of air.
 - 3. Automatic temperature-control systems are operational.
 - 4. Equipment and duct access doors are securely closed.
 - 5. Balance, smoke, and fire dampers are open.
 - 6. Isolating and balancing valves are open and control valves are operational.
 - 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 - 8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
 - 1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

3.04 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. For variable-air-volume systems, develop a plan to simulate diversity.
- C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- D. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- F. Verify that motor starters are equipped with properly sized thermal protection.
- G. Check dampers for proper position to achieve desired airflow path.
- H. Check for airflow blockages.
- I. Check condensate drains for proper connections and functioning.
- J. Check for proper sealing of air-handling-unit components.
- K. Verify that air duct system is sealed as specified.

3.05 GENERAL PROCEDURES FOR BALANCING HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5%.
- B. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 - 1. Open all manual valves for maximum flow.
 - 2. Check liquid level in expansion tank.
 - 3. Check makeup water-station pressure gauge for adequate pressure for highest vent.
 - 4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
 - 5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
 - 6. Set system controls so automatic valves are wide open to heat exchangers.
 - 7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.

8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.06 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Efficiency rating.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.07 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record compressor data.

3.08 PROCEDURES FOR BOILERS

- A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.
- B. Steam Boilers: Measure and record entering-water temperature and flow and leaving-steam pressure, temperature, and flow.

3.09 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each water coil:
 1. Entering- and leaving-water temperature.
 2. Water flow rate.
 3. Water pressure drop.
 4. Dry-bulb temperature of entering and leaving air.
 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 6. Airflow.
 7. Air pressure drop.
- B. Measure, adjust, and record the following data for each electric heating coil:
 1. Nameplate data.
 2. Airflow.
 3. Entering- and leaving-air temperature at full load.
 4. Voltage and amperage input of each phase at full load and at each incremental stage.
 5. Calculated kilowatt at full load.
 6. Fuse or circuit-breaker rating for overload protection.
- C. Measure, adjust, and record the following data for each steam coil:
 1. Dry-bulb temperature of entering and leaving air.
 2. Airflow.
 3. Air pressure drop.

4. Inlet steam pressure.
- D. Measure, adjust, and record the following data for each refrigerant coil:
 1. Dry-bulb temperature of entering and leaving air.
 2. Wet-bulb temperature of entering and leaving air.
 3. Airflow.
 4. Air pressure drop.
 5. Refrigerant suction pressure and temperature.

3.10 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

- A. Perform a preconstruction inspection of existing equipment that is affected by the renovation work and that is to remain and be reused as indicated on the drawings.
 1. Measure and record the operating speed, airflow, and static pressure of each fan.
 2. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
- B. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
 1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
 2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
 3. Balance each air outlet.

3.11 TOLERANCES

- A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10% for fan capacity less than 5000 cfm. Plus or minus 5% for fan capacity of 5000 cfm and larger.
 2. Air Outlets and Inlets: Plus or minus 10%.
 3. Water Flow Rate: Plus or minus 10%.

3.12 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 2. Include a list of instruments used for procedures, along with proof of calibration.
- B. Final Report Contents: In addition to certified field-report data, include the following:
 1. Pump curves.
 2. Fan curves.
 3. Manufacturers' test data.
 4. Field test reports prepared by system and equipment installers.
 5. Other information relative to equipment performance; do not include Shop Drawings and product data.
- C. General Report Data: In addition to form titles and entries, include the following data:
 1. Title page.
 2. Name and address of the TAB contractor.
 3. Project name.

4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
- D. Final Inspection:
1. After testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner Representative.
 2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Commissioning Authority.
 3. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10% of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
 4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
 5. If the number of "FAILED" measurements is greater than 10% of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- E. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
 2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.
- F. Prepare test and inspection reports.

3.13 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB at the Engineer's request to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

SECTION 230700
HVAC INSULATION**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Section includes insulating the following duct services:
1. Indoor, concealed supply and outdoor air.
 2. Indoor, exposed supply and outdoor air.
 3. Indoor, concealed return located in unconditioned space.
 4. Indoor, exposed return located in unconditioned space.
 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
 7. Outdoor, concealed supply and return.
 8. Outdoor, exposed supply and return.
- B. Section includes insulating the following HVAC piping systems:
1. Condensate drain piping, indoors.
 2. Heating hot-water piping, indoors.
 3. Refrigerant suction and hot-gas piping, indoors and outdoors.
- C. Section includes insulating the following HVAC equipment that is not factory insulated:
1. Heating, hot-water pumps.
 2. Expansion/compression tanks.
 3. Air separators.
 4. Piping system filtration unit housings.
- D. Related Sections:
1. Division 23 "Metal Ducts" for Duct liners.

1.03 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation and accessory.
1. Submit schedule showing manufacturer's product number, k-value, thickness, and furnished accessories for each mechanical system requiring insulation.

1.04 QUALITY ASSURANCE

- A. Furnish insulation and materials bearing the manufacturer's label. Only mechanics skilled at such work shall apply materials. Insulation and materials shall be by one of the manufacturers listed. Specialty material shall be of the manufacturer indicated or approved equal. Fire and smoke hazard classification ratings on insulation, jacket, and adhesive shall conform to NFPA 255 (2006), ASTM E 84, or UL-723 as follows:
1. Flame Spread Index not exceeding 25.
 2. Smoke Developed Index not exceeding 50.
- B. Certifications: Submit certifications or other data as necessary to show compliance with these specifications and governing regulations. Include proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.06 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields.
- B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate insulation and testing of heat tracing.

1.07 SCHEDULING

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

PART 2 PRODUCTS**2.01 MANUFACTURERS**

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Armacell LLC.
 - 2. Dow Chemical Company.
 - 3. Johns-Manville Corp.
 - 4. Keene Corp.
 - 5. Knauf Fiber Glass.
 - 6. Nomaco K-Flex.
 - 7. Owens-Corning Fiberglass Corp.
 - 8. Pittsburg Corning Corp.
 - 9. Or equal as approved by Owner.

2.02 MATERIALS

- A. Thermal Conductivity Average Maximum in Btu-in/hr-ft² at 75°F Mean Temperature:
 - 1. Fiberglass Board = 0.26.
 - 2. Fiberglass Blanket = 0.30.
 - 3. Fiberglass Preformed Pipe Insulation = 0.26.
 - 4. Cellular Glass = 0.30.
 - 5. Flexible Elastomeric Cellular = 0.27.
 - 6. Polyisocyanurate = 0.19.
 - 7. Calcium Silicate = 0.60 @ 500°F.
- B. Vapor retarder film and tape shall have a maximum permeance of 0.030 perm.
- C. All pre-formed pipe insulation shall be provided with self-adhering and self-sealing overlapping flap.
- D. Pipe Insulation Protection:
 - 1. Pipe insulation exposed in finished areas shall be protected with 0.030 inches thick PVC plastic jacketing covers, Ceel-Co 300 Series or approved equal.
 - 2. Pipe insulation exposed in mechanical and electrical equipment rooms, indoor parking garages and other unfinished areas 8'-0" or less above finish floor shall be protected with 0.030 inches thick, ultraviolet resistant, PVC plastic jacketing covers, Ceel-Co 300 Series or approved equal.

3. Pipe insulation exposed to weather shall be protected with a pre-fabricated self-adhering and self-sealing sheet type waterproof membrane. Membrane shall be installed according to manufacturer's recommendations. The waterproof membrane shall be Flex-Clad 400 as manufactured by MFM Building Products Corporation of Coshocton, OH or approved equal.
 4. Pipe insulation exposed to weather or abuse shall be protected with a factory-fabricated aluminum jacket, 0.032-inch thick. Moisture barrier membrane for insulation exposed to weather shall be 3-mil thick polyethylene and kraft paper, installed according to manufacturer's recommendations.
- E. Duct Insulation Protection:
1. Ductwork Exposed to Weather: 2-inch thick, 4-PCF density spun fiberglass rigid insulation board with FSK facing. Adhere insulation board to the duct with asphalt mastic and metal clips. Cover insulation board with a pre-fabricated self-adhering and self-sealing sheet type waterproof membrane. Adhere the waterproof membrane to insulation according to manufacturer's recommendations. The waterproof membrane shall be Flex-Clad 400 as manufactured by MFM Building Products Corporation of Coshocton, OH or approved equal.
 2. Ductwork Exposed to Weather or Abuse: 2-inch thick, 4-PCF density spun fiberglass rigid insulation board with FSK facing. Adhere insulation board to the duct with asphalt mastic and metal clips. Cover insulation boards with factory-fabricated aluminum jacket, 0.032-inch thick, installed according to manufacturer's recommendations.

PART 3 EXECUTION

3.01 PIPING INSULATION SCHEDULE

- A. Exposed Piping.
1. Refer to pipe insulation protection paragraphs above.
- B. Air Conditioning Coil Condensate Drain Piping – above ground.
1. Fiberglass: 1-inch thick 4-PCF density with fire-resistive ASJ vapor barrier jacket.
 2. Elastomeric closed-cell plastic foam: 1/2-inch thick.
 3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.
- C. HVAC Make-up water - 1-1/4-inch and smaller.
1. Fiberglass: 1/2-inch thick 4-PCF density with fire-resistive ASJ vapor barrier jacket.
 2. Elastomeric closed-cell plastic foam: 1/2-inch thick.
 3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.
- D. HVAC Make-up water - 1-1/2-inch and larger.
1. Fiberglass: 1-inch thick 4-PCF density with fire-resistive ASJ vapor barrier jacket.
 2. Elastomeric closed-cell plastic foam: 1-inch thick.
 3. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.
- E. Refrigerant Suction Piping – 1-1/2-inch and smaller.
1. Elastomeric closed-cell plastic foam: 1-inch thick.
 2. Polyisocyanurate closed-cell: 1-inch thick with vapor retarder film.
- F. Refrigerant Suction Piping – 2-inch and larger.
1. Elastomeric closed-cell plastic foam: 1-1/2-inch thick.
 2. Polyisocyanurate closed-cell: 1-1/2-inch thick with vapor retarder film.
- G. Hot Water Heating Piping to 200 °F – 1-inch and smaller.
1. Fiberglass: 1-1/2-inch thick 4-PCF density with fire-resistive ASJ vapor barrier jacket.
- H. Hot Water Heating Piping to 200 °F – 1-1/2-inch and larger.
1. Fiberglass: 2-inch thick 4-PCF density with fire-resistive ASJ vapor barrier jacket.

3.02 DUCT INSULATION SCHEDULE

- A. Ductwork Exposed to Weather or Abuse.
 - 1. Refer to duct insulation protection paragraphs above.
- B. Concealed Low Velocity Rectangular Supply Air Ductwork (< 2000 FPM)
 - 1. Fiberglass Blanket: 2-inch thick 0.75-PCF density with heavy duty FSK vapor barrier.
 - 2. Duct Liner: 1-1/2 inch thick 1.5-PCF density.
- C. Concealed Low Velocity Rectangular Return Air Ductwork (< 2000 FPM)
 - 1. Fiberglass Blanket: 2-inch thick 0.75-PCF density with heavy duty FSK vapor barrier.
 - 2. Duct Liner: 1-1/2 inch thick 1.5-PCF density.
- D. Concealed Low Velocity Round Supply and Return Air Ductwork (< 2000 FPM)
 - 1. Fiberglass Blanket: 2-inch thick 0.75-PCF density with heavy duty FSK vapor barrier.
- E. Concealed High Velocity Supply Air Ductwork (> 2000 FPM)
 - 1. Fiberglass Blanket: 2-inch thick 1.5-PCF density with heavy duty FSK vapor barrier.
- F. Concealed Outside Air Ductwork (untempered).
 - 1. Fiberglass Blanket: 3-inch thick 0.75-PCF density with heavy duty FSK vapor barrier.
 - 2. Fiberglass Rigid Board: 1-1/2-inch thick 3-PCF density with heavy duty FSK vapor barrier.
- G. Concealed Ventilation Air Ductwork (tempered outside air).
 - 1. Fiberglass Blanket: 2-inch thick 0.75-PCF density with heavy duty FSK vapor barrier.
 - 2. Duct Liner: 1-1/2 inch thick 1.5-PCF density.
- H. Concealed Low Velocity Ductwork in Unconditioned Space.
 - 1. Fiberglass Blanket: 3-inch thick, 0.75-PCF density with heavy duty FSK vapor barrier.
 - 2. Duct Liner: 2-inch thick 1.5-PCF density.
- I. Supply, Return, and Mixed Air Ductwork and Plenums in Equipment rooms.
 - 1. Fiberglass Blanket: 2-inch thick 1.5-PCF density with heavy duty FSK vapor barrier.
 - 2. Fiberglass Rigid Board: 1-1/2-inch thick 3-PCF density with heavy duty FSK vapor barrier.
 - 3. Duct Liner: 1-1/2 inch thick 1.5-PCF density.
- J. Air Transfer Ductwork.
 - 1. Duct Liner: 1-inch thick 1.5-PCF density.
- K. Double-Wall Ductwork.
 - 1. Refer to Division 23 Section "Metal Ducts."

3.03 EQUIPMENT INSULATION SCHEDULE

- A. VAV Terminal Unit Reheat Coils:
 - 1. Fiberglass Blanket: 2-inch thick 0.75-PCF density with heavy duty FSK vapor barrier.
- B. Heating Hot Water Air Separator:
 - 1. Fiberglass Rigid Board: 2-inch thick 6-PCF density.
- C. Boiler Flue Stack and Boiler Combustion Air Duct:
 - 1. Fiberglass Rigid Board: 2-inch thick 6-PCF density.
- D. Vent and Intake Piping for Boilers in Unconditioned Space.
 - 1. Elastomeric closed-cell plastic foam: 1-1/2-inch thick.

3.04 EXAMINATION

- A. Examine substrates and condition for compliance with requirements for installation and other conditions affecting performance of insulation application.
 - 1. Verify that systems and equipment to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
 - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.05 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

3.06 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation products in accordance with manufacturer's written instructions, and in accordance with the MICA National Commercial and Industrial Insulation Standards to ensure that insulation serves its intended purpose.
- B. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- C. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
- D. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- E. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- F. Install multiple layers of insulation with longitudinal and end seams staggered.
- G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- H. Keep insulation materials dry during application and finishing.
- I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- J. Install insulation with least number of joints practical.
- K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- O. For above ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.
- P. Provide neatly beveled edge at interruptions of insulation.

3.07 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
 - 1. Comply with requirements in Division 07 for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 - 1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2-inches.

2. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07.

4. **INSTALLATION OF PIPING INSULATION**

- a. Install insulation on pipe systems subsequent to testing and acceptance of tests.
- b. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other. The appearance of the completed insulation shall be a significant factor in determining the acceptability of the work.
- c. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
- d. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
- e. Where vapor retarders are specified, elbows and fittings shall be wrapped with vapor retarder tape 3-inches wide or shall have PVC jacketing.
- f. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation applied to adjoining pipe run. Install factory-molded, pre-cut or job-fabricated units (at installer's option) except where specific form or type is indicated.
- g. Insulation of Piping Specialties on Cold Piping Services: Insulate union, flanges, strainers, flexible connections, hoses, and expansion joints on cold piping services with flexible elastomeric cellular insulation. Thickness of flexible elastomeric cellular insulation shall be equivalent to thickness of insulation on the piping service as specified in this Section or as shown on the drawings. Insulation shall be sealed to provide a vapor tight barrier. Cold piping services include chilled water systems, and geothermal heat pump water loop systems.
- h. Piping Insulation Omitted: Omit insulation on hot piping within radiation enclosures or unit cabinets.
- i. Insulated piping systems shall be supported on the exterior of the insulation surface. Install protective metal shields and insulated inserts wherever needed to prevent compression of insulation.
- j. Metal shields: Conform to table below for minimum length of shield:

<u>PIPE SIZE</u>	<u>INSULATION THICKNESS</u>	<u>LENGTH OF SHIELD</u>
Less than 1"	Up to 1"	3"
1"-2"	1"	4-1/2"
1"-2"	1-1/2"	5-1/2"
2-1/2"-4"	1"	6-1/2"
2-1/2"-4"	1-1/2"	7-1/2"
2-1/2"-4"	2"	8-1/2"
2-1/2"-4"	2-1/2"	9-1/2"
5" and Larger	1"	13"
5" and Larger	1-1/2"	14"
5" and Larger	2"	15"
5" and Larger	2-1/2"	16"
5" and Larger	3" and Larger	18"

- k. Pipe Hanger, Trapeze, and Roller Support Insulation Inserts: Butt pipe insulation against pipe hanger insulation inserts. Apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3-inch wide vapor barrier tape or band.

3.08 INSTALLATION OF EQUIPMENT INSULATION

- A. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.
- B. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.
- C. Do not apply insulation to hot equipment.
- D. Apply insulation using the staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.
- E. Coat insulated surfaces with layer of insulating cement, troweled in workmanlike manner, leaving smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.
- F. Cover insulated surfaces with glass cloth jacketing neatly fitted and firmly secured. Lap seams at least two inches. Apply over vapor barrier where applicable.
- G. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.
- H. For below ambient services, remove equipment nameplate and re-install on exterior insulation surface or provide duplicate nameplate for field installation on exterior insulation surface.
- I. Equipment Exposed to Weather: Protect outdoor insulation from weather by installation of weather-barrier mastic protective finish, or jacketing, as recommended by manufacturer.

3.09 INSTALLATION OF DUCTWORK INSULATION

- A. Install insulation materials with smooth and even surfaces.
- B. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.
- C. Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage.
- D. Flexible Fiberglass Insulation: Apply insulation with edges tightly butted secure on 15-inch centers with approved adhesive and pins. Secure joints by overlapping facing or 4-inch wide strips of same material adhered with Benjamin Foster 85-20 adhesive.
- E. Lined Ductwork: Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.
- F. Corner Angles: Except for oven and hood exhaust duct insulation, install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.
- G. Flexible Duct Connections: Install insulation materials over flexible duct connections wherever ductwork connect to vibration isolated equipment. Provide adequate flexibility to allow for thermal, axial, transverse, and torsional movement.

3.10 PROTECTION AND REPLACEMENT

- A. Protection: Provide protection for insulation work during remainder of construction period, to avoid damage and deterioration.
- B. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

3.11 PIPE INSULATION SCHEDULE

- A. Piping Insulation Application Schedule - Aboveground Inside Building (In Buildings, Pipe Chase and Other Aboveground Locations Not Listed):

PIPE INSULATION THICKNESS (INCHES)								
SERVICE APPLICATION				NOMINAL PIPE SIZE (INCHES)				
Operating Temperature Range/Service	Insulation Material	Jacket	Vapor Barrier	<1	1 to <1-1/4	1-1/2 to <4	4 to <8	≥8
VRF SYSTEM								
DX Refrigeration	Flexible Elastomeric Cellular (FE)	None PVC AL ASJ	Yes	1.5	1.5	1.5	1.5	1.5
AC Condensate Drains 35-70°F	Flexible Elastomeric Cellular (FE)	None PVC AL ASJ	Yes	1.0	1.0	1.0	---	---
HEATING HOT WATER (200°F)								
Heating Hot Water	Mineral Fiber (MF)	None PVC AL ASJ	No	1.5	1.5	2.0	2.0	2.0

POTABLE/NON-POTABLE WATER AND STORM WATER								
Domestic Cold/Non-Potable Water 40-65° F	Mineral Fiber (MF)	None PVC AL ASJ	Yes	1.0	1.0	1.0	1.0	1.0
Domestic Hot and Recirculation Water 100-150°F	Mineral Fiber (MF)	None PVC AL ASJ	No	1.0	1.0	1.5	1.5	1.5
Roof and Overflow Drains 32-65° F	Mineral Fiber (MF)	None PVC AL ASJ	Yes	1.0	1.0	1.0	1.0	1.0

B. Duct Insulation Application Schedule:

SERVICE	INSULATION MATERIAL	JACKET	VAPOR BARRIER	THICKNESS (INS.)
Supply Air Systems				
*Supply Ducts (55°F)	Flexible Fiberglass Blanket (FF)	ASJ	Yes	1.5
Supply Ducts (-30°F)	Flexible Fiberglass Blanket (FB)	ASJ	Yes	2.0
Outside Air Systems				
Round Outside Air Ducts	Flexible Fiberglass Blanket (FF)	ASJ	Yes	2.0
Rectangular Outside Air Ducts	Fiberglass Board (FB)	ASJ	Yes	2.0
Exhaust Air Systems				
**Round Exhaust Air Ducts	Flexible Fiberglass Blanket (FF)	ASJ	No	2.0
**Rectangular Exhaust Air Ducts	Fiberglass Board (FB)	ASJ	No	2.0
Transfer Air Systems				
**Round Exhaust Air Ducts	Duct (DL) Liner	NONE	No	1.0
**Rectangular Exhaust Air Ducts	Duct (DL) Liner	NONE	No	1.0

END OF SECTION

SECTION 230933
VARIABLE FREQUENCY DRIVES**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Section includes separately enclosed, preassembled, combination VFC's, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.
- B. Related Requirements:
 - 1. Division 26 "Motor Control Centers" for VFC's installed in motor control centers.

1.03 DEFINITIONS

- A. CE: Conformance Europeene (European Compliance).
- B. CPT: Control power transformers.
- C. DDC: Direct digital controller.
- D. EMI: Electromagnetic interference.
- E. LED: Light-emitting diode.
- F. NC: Normally closed.
- G. NO: Normally open.
- H. OCPD: Overcurrent protective device.
- I. PID: Control action, proportional plus integral plus derivative.
- J. RFI: Radio-frequency interference.
- K. VFC: Variable-frequency motor controller.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's specifications for variable frequency drives showing dimensions, weights, capacities, ratings, performance characteristics, gages and finishes of materials and installation instructions.
- B. Coordination Data: Submit nameplate information for each motor to be operated by the variable frequency drive.
- C. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, weight loadings, construction details, required clearances and field connection details.
- D. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to variable frequency drives. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- E. Maintenance Data: Submit maintenance instructions, trouble-shooting maintenance guide, motor and drive replacement and spare parts lists. Include this data, product data and shop drawings in maintenance manuals; in accordance with requirements of Division 23.

1.05 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms who regularly engaged in manufacture of variable frequency drives, of types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than five years.
- B. Installer's Qualifications: Firm with at least three years of successful installation experience on projects with variable frequency drives similar to that required for project.

C. Codes and Standards:

1. Electrical Standards: Provide electrical components of variable frequency drives which comply with NEC 430.120 for Adjustable Speed Drive Systems and IEC 16800 Parts 1 and 2.
2. NEMA Compliance: Comply with NEMA ICS 7.0 AC Adjustable Speed Drives pertaining to components and devices.
3. Underwriters Laboratories: Provide variable frequency drives with UL508C listing.
4. Institute of Electrical and Electronic Engineers: Comply with IEEE 519 guide for harmonic analysis for jobsite total harmonic voltage and harmonic current distortion.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Handle variable frequency drives carefully to prevent damage, breaking, denting and scoring. Do not install damaged electric equipment or components; replace with new.
- B. Store variable frequency drives in clean, dry place. Protect from weather, dirt, fumes, water, construction debris and physical damage.
- C. Comply with manufacturer's rigging and installation instructions for unloading variable frequency drives and installing them to final location.

1.07 WARRANTY

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

PART 2 - PRODUCTS**2.02 MANUFACTURERS**

- A. Manufacturer: Subject to compliance with requirements, provide variable frequency drives of one of the following:
 1. ABB Group
 2. Allen Bradley
 3. Eaton
 4. Emerson
 5. Rockwell Automation
 6. Siemens
 7. Square D; Schneider Electric
 8. Yaskawa
 9. Or equal as approved by Owner.

2.03 VARIABLE FREQUENCY DRIVES

- A. General: Variable frequency drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor. The drive manufacturer shall supply the drive and all necessary options as herein specified.
- B. Assembly: VFD and options shall be UL listed as a complete assembly. The variable frequency drive shall be UL-listed for 100,000 AIC without the need for input fuses.
- C. Enclosure: UL-listed Type 1 enclosure exceeding NEMA enclosure design criteria completely assembled and tested by the manufacturer in an ISO9001 facility. The VFD tolerated voltage window shall allow the VFD to operate at line voltage from +30% to -35% nominal voltage. Enclosure shall be UL listed as a plenum rated VFD.
- D. Operating Conditions: VFD shall be capable of continuous operation at 0° to 50° C ambient temperature as indicated on the submittal. All circuit boards shall have conformal coating.

- E. Interface: Digital display and keypad. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.
1. The keypad shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate a bumpless transfer of speed reference when switching between Hand and Auto modes. There shall be fault reset and Help buttons on the keypad. The Help button shall include on-line assistance for programming and troubleshooting.
 2. The Keypad shall include a backlit LCD display. The display shall be in English for programming and fault diagnostics. The keypad shall include the following assistants:
 - a. Start-up assistant
 - b. Parameter assistants
 - c. Maintenance assistant
 - d. Troubleshooting assistant
 - e. Drive optimizer assistants
 3. All applicable operating values shall be capable of being displayed in engineering units. A minimum of three operating values shall be capable of being displayed in English:
 - a. Output Frequency
 - b. Motor Speed (RPM, percent, or units)
 - c. Motor Current
 - d. Motor Torque
 - e. Motor Power
 - f. DC Bus Voltage
 - g. Output Voltage
 4. Time clock provided in the VFD keypad with a battery backup with 10 years minimum life span. The clock shall be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays. The VFD shall have a digital input that allows an override to the time clock for a programmable time frame. Provide four separate, independent timer functions that have both weekday and weekend settings.
- F. Applications: The VFD shall utilize pre-programmed applications designed to facilitate start-up. Provide one command to reprogram all parameter interfaces for a particular application and two user macros to allow the end-user to create and save custom settings.
- G. Fans: Provide cooling fans designed for replacement without requiring removing the VFD from the wall or removal of circuit boards. The VFD cooling fan shall operate only when required.
- H. Coasting: The VFD shall be capable of starting into a coasting load either forward or reverse operation up to full speed and accelerate or decelerate to set point without tripping or component damage.
- I. Automatic Restart: The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.
- J. Overload Rating: VFD overload rating shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL for 4-pole motors.
- K. Impedance Reactors: Provide internal 5% equivalent impedance reactors. The 5% equivalent impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFDs with only one DC reactor shall add an AC line reactor.
- L. Input Current Rating: The VFD shall be no more than 3% greater than the output current rating.

- M. Surge Suppression: Provide a coordinated AC transient surge protection system with 5% equivalent impedance reactors.
- N. Programming: Loss-of-load signal through a keypad warning, including a programmable time delay for motor acceleration from zero speed without signaling a false loss-of-load condition, with user defined programmable underload and overload curve functions.
- O. PID Algorithms: Multiple two zone PID algorithms that allow the VFD to maintain PID control from two separate feedback signals (4-20 mA, 0-10 V, and / or serial communications). The two zone control PID algorithm will control motor speed based on a minimum, maximum, or average of the two feedback signals.
- P. Loss of Reference: If input reference is lost, the VFD shall give the user the option of stopping and displaying a fault, running at a programmable preset speed, maintaining the VFD speed based on the last reference received, or issuing a warning. Provide sleep and wake up programmable functions to start and stop from a process feedback signal.
- Q. Adjustments: Provide all of the following adjustments:
 - 1. Three fully adjustable programmable critical frequency lockout ranges.
 - 2. Two PID set point controllers. The PID set point shall be adjustable from the VFD keypad, analog inputs, or over the communications bus.
 - 3. Independent second PID loop utilizing the second analog input to modulate one of the analog outputs.
 - 4. Two programmable analog inputs.
 - 5. Two programmable analog outputs.
 - 6. Six programmable digital inputs.
 - 7. Three programmable digital relay outputs with delay times.
 - 8. Two separate safety interlock inputs shall be provided.
 - 9. Programmable time delay for VFD start and keypad indication from 0 – 120 seconds.
 - 10. Seven programmable preset speeds.
 - 11. Two independently adjustable acceleration and deceleration ramps.
 - 12. Motor flux optimization circuit with selectable software for optimization of motor noise, energy consumption, and motor speed control.
 - 13. Automatic carrier frequency control circuit.
 - 14. Password protection against parameter changes.
- R. Serial Communications: Provide EIA-485 port and standard certified protocols including Modbus, Johnson Controls N2, Siemens Building Technologies FLN, and BACnet. Optional protocols for LonWorks, Profibus, Ethernet, BACnet IP, and DeviceNet shall be available.
- S. EMI/RFI filters: Onboard filters to permit the assembly to be CE Marked and meet product standard EN 61800-3 for the First Environment restricted level with up to 100 feet of motor cable.
- T. Total Harmonic Distortion: The VFD manufacturer shall provide calculations specific to the installation, indicating total harmonic voltage distortion less than 5%. Input filters shall be sized and provided as required by the VFD manufacturer to ensure compliance with IEEE Standard 519. All VFDs shall include a minimum of 5% equivalent impedance reactors.

2.04 OPTIONAL FEATURES

- A. Provide optional features as indicated, furnished and mounted by the VFD manufacturer. All optional features shall be UL-listed by the VFD manufacturer as a complete assembly.
 - 1. Bypass Controller: Factory-wired and tested bypass system consisting of an output contactor and bypass contactor.
 - 2. Disconnect: Door interlocked, pad-lockable circuit breaker for all input power from the drive and all internally mounted options.

3. Disconnect: Door interlocked, pad-lockable disconnect switch for all input power from the drive and all internally mounted options.
4. Fieldbus Adapters: LonWorks, DeviceNet, Ethernet IP, ModBus TCP, BACnet IP, and Profibus shall be available with the addition of an optional card.

2.05 BYPASS CONTROLLER

- A. General: Complete factory wired and tested bypass system consisting of an output contactor, bypass contactor, and quick response VFD input fuses. Bypass contactors shall be standard 120 VAC coils. Bypass shall operate at line voltage from +30% to -35% nominal voltage. Motor overload protection and shall be provided in both normal and bypass modes.
- B. Disconnect: Door interlocked, pad-lockable circuit breaker or disconnect for all input power from the drive and all internally mounted options. The enclosure door and VFD enclosure shall be mechanically interlocked such that the disconnecting device must be in the "Off" position before the enclosure may be accessed.
- C. Drive Isolation Fuse: Fast acting fuses shall be provided to allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection.
- D. UL Listing: The VFD and bypass package shall have a UL listed short circuit current rating (SCCR) of 100,000 amps and shall be indicated on the UL data label.
- E. Single Phase Protection: Detect single phase input power condition while running in bypass, disengage the motor and signal single phase input power.
- F. Stand Alone Operation: The bypass system shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the system. Serial communications shall remain functional with the VFD removed.
- G. Serial Communications: The bypass shall be capable of being monitored and controlled via serial communications. On-board communications protocols shall include ModBus; Johnson Controls N2; Siemens Building Technologies FLN; and BACnet.
- H. Transfer Bypass: Keypad adjustment to select manual or automatic transfer bypass. The user shall be able to select via keypad programming which drive faults will result in an automatic or manual transfer to the bypass mode. The user may select whether the system shall automatically transfer from drive to bypass mode on the following drive fault conditions:
 1. Over current
 2. Over voltage
 3. Under voltage
 4. Loss of analog input
- I. Operators: The Keypad shall include a backlit LCD display. The display shall be in English for programming and fault diagnostics. The keypad shall include the following operators:
 1. Bypass Hand-Off-Auto
 2. Drive mode selector
 3. Bypass mode selector
 4. Bypass fault reset
 5. Bypass LCD display
- J. Indicating Lights and Display: Keypad display indications shall be provided. A test mode or push to test feature shall be included.
 1. Power-on
 2. Run enable
 3. Drive mode selected
 4. Bypass mode selected

5. Drive running
 6. Bypass running
 7. Drive fault
 8. Bypass fault
 9. Bypass Hand-Off-Auto mode
 10. Automatic transfer to bypass
 11. Safety open
 12. Damper opening
 13. Damper end-switch made
- K. Bypass Controller: Provide a minimum of six programmable digital inputs, and five programmable relay outputs. Bypass I/O shall be available to the building management system even with the VFD removed.
- L. Customer Interlock Terminal Strip: A separate terminal strip for independent connection of up to four inputs. External safety interlocks shall remain fully functional whether the system is in VFD or Bypass mode. The remote start/stop contact shall operate in VFD and bypass modes.
- M. Smoke Control Override Mode: A dedicated digital input to transfer motor from VFD mode to bypass mode from a dry contact closure at the fire alarm control system meeting the intent of UL864/UUKL.
- N. Fireman's Override Mode: A programmable override input to permit the user to configure the unit to acknowledge digital inputs, to react to fire protection requirements.

PART 3 - EXECUTION

3.02 EXAMINATION

- A. Examine areas and conditions under which variable frequency drives are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer.

3.03 INSTALLATION OF VARIABLE FREQUENCY DRIVES

- A. General: Install system and materials in accordance with manufacturer's instructions and roughing-in drawings, and details on drawings. Install electrical components and use electrical products complying with requirements of applicable electrical specifications. Mount controllers at convenient locations and heights.
- B. Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.
- C. Support units with mounting brackets anchored to building substrate.
- D. Coordinate with other trades to assure correct size for wall mounted units.
- E. Protect units with protective covers during balance of construction.

3.04 ELECTRICAL WIRING

- A. Power wiring shall be completed by the electrical contractor, complying with NEC code 430.122 wiring requirements based on the VFD input current. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.05 STARTUP

- A. Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly of components and installation of variable frequency drives, including electrical connections. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer. Report results in writing.
1. Test and adjust controls and safeties.

2. Operate motors and verify proper rotation and connections.
3. Operate controls and verify proper response to control inputs.
4. Submit a list of all adjustable and non-adjustable operating parameters and actual settings and adjustment ranges.
5. Replace damaged and malfunctioning controls and equipment.

3.06 TRAINING

- A. General: The VFD manufacturer shall provide a comprehensive, HVAC Drive Computer Based Training (CBT) product. The CBT product shall include detailed, interactive sections covering VFD unpacking, proper mechanical and electrical installation, and programming.
- B. The CBT product shall allow the user to provide just-in-time training to new personnel or refresher training for maintenance and repair personnel on the user's site. The CBT product shall be repeatable, precise and shall include record keeping capability. The CBT product shall record answers to simulations and tests by student ID. The CBT product must be professionally produced and have interactive sections, student tests, and include video clips of proper wiring and installation
- C. Schedule training with Owner, through Engineer, with at least seven days' advance notice.

3.07 CLEANING

- A. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

END OF SECTION

SECTION 230993
SEQUENCE OF OPERATION**PART 1 GENERAL****1.01 WORK INCLUDED**

- A. Sequence of operation is hereby defined as the manner and method by which controls function. Requirements for each type of control system operation are specified in this section.

1.02 SUBMITTALS

- A. Shop Drawings: Submit shop drawings for each system automatically controlled, containing the following information:
1. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves and control devices.
 2. Label each control device with setting or adjustable range of control.
 3. Indicate pneumatic piping; factory and field wiring.
 4. Indicate each control panel required, with internal and external piping and wiring clearly indicated. Provide detail of panel face, including controls, instruments, and labeling. Include verbal description of sequence of operation.
- B. Maintenance Data: Include copy of shop drawings in each Maintenance Manual.

PART 2 PRODUCTS (not applicable to this section).**PART 3 EXECUTION****3.01 TERMINAL UNITS' CONTROL SEQUENCES**

- A. Unit Heater Control: Provide single-temperature room thermostat to cycle fan motor to maintain constant space temperature.
1. Provide strap-on aquastat on unit return piping, to de-energize fan motor when fluid temperature falls below adjustable setting of aquastat.
 2. Provide thermostat sub-base containing summer fan OFF-ON switch.
- B. Unit Heater Control: Provide single-temperature room thermostat to cycle fan motor and electric element to maintain constant space temperature. Provide integral residual heat sensor to continue fan operation until element temperature falls below pre-set point.
1. Provide thermostat sub-base containing summer fan OFF-ON switch.
- C. Variable Volume Box Control: Provide space thermostat to modulate damper motor to vary air supply to maintain required space temperature.
- D. Variable Volume Box Control: Provide dual-temperature thermostat to modulate damper motor to vary air supply to maintain 76°F (adjustable) during cooling cycle and 70°F (adjustable) during heating cycle.
1. On rise in space temperature, modulate radiation valve to closed position and modulate valve to open position on falling space temperature.
 2. On rise in space temperature, de-energize electric auxiliary radiation and energize radiation on falling space temperature.
- E. Duct Heating Coil: A room thermostat shall modulate the (steam or) hot water coil valve to maintain the space temperature.

3.02 HVAC ZONE CONTROL SEQUENCES

- A. Hot Water Supply Control: Provide controller with outdoor sensor to modulate 3-way mixing valve to vary supply water temperature in accordance with predetermined reset schedule.
1. Provide for remote control point adjustment.
 2. When outside temperature rises above 61°F, de-energize pump(s).

- B. Hot Water Reset Control: Heating Control shall be provided by an outdoor master stat resetting a sub-master controller, with its element in the hot water supply from the boiler and modulating the 3-way valve. Locate bulb on north exposure. Reset schedule (adjustable) shall be from 70°F to 200°F leaving water temperature as outside air temperature varies from 65°F to 0°F.
- C. Occupied-Unoccupied Control: Provide main ATC control panel including seven-day 24 hour time clock with weekend skip feature and individual zone "occupied-unoccupied-automatic" switch for each zone listed on drawings. When switches are in "automatic" position, select occupied or unoccupied operation by means of time clock. When switches are in "occupied" or "unoccupied" position, operate units as specified for each type of unit for mode.
 - 1. Provide override switch as noted on drawings to restore zone to "occupied" in event of unscheduled occupancy.
 - 2. Provide washout cycle to ensure that all areas locally switched to "occupied" are returned to unoccupied at 11:00 PM (adjustable).

3.03 VENTILATION CONTROL SEQUENCES

- A. Combustion Air Control, (Gravity): Provide boiler room outdoor damper to open automatically whenever burner(s) start, and to close when burner(s) stop.
- B. Combustion Air Control, (Mechanical): Provide relay to start Boiler Room outdoor air fan whenever burner(s) start and to stop fan when burner(s) stop.
 - 1. Provide space thermostat to activate outdoor air fan when space temperature reaches 78°F (adjustable).
- C. Combustion Air Damper Control: The common combustion air damper shall serve all direct fired equipment including boilers, water heaters, etc. When any of the direct fired equipment operating controls call for burner operation, a solenoid air valve shall be energized, opening the combustion air damper. When the damper is proven 100% open, normally open end switches shall close completing the burner control circuit. When all operating controls are satisfied, the combustion air damper shall close. Combustion air damper of the normally open design.
- D. Combustion Air Damper Control: The combustion air damper shall serve the boiler. When the boiler operating controls call for burner operation, a solenoid air valve shall be energized, opening the combustion air damper. When the damper is proven 100% open, normally open end switches shall close completing the burner control circuit. When all operating controls are satisfied, the combustion air damper shall close to 10% open position. Combustion air damper by T.C. Subcontractors of the normally open design. Damper shall be set at 10% open position when closed, to provide combustion air to hot water heater.
- E. Gravity Roof Ventilator Control: Open gravity roof ventilator dampers on occupied cycle and close damper on unoccupied cycle.
- F. Mechanical, Electrical and Elevator Equipment Room Ventilation Fans Control: A line voltage thermostat shall start the fans at 80°F and above. When the system fan is energized, the normally closed intake and exhaust dampers shall operate to full open position.
- G. Exhaust Fan Control: Energize exhaust fans noted as "ATC" on drawings during occupied cycle and de-energize during unoccupied cycle. When indicated on drawings, provide space thermostats to energize fans on rise in space temperature and de-energize fans on fall in space temperature.
 - 1. When fan is activated, open fresh air intake damper; close damper when fan stops.
- H. Make-Up Air Unit Control: Provide relay to energize make-up air unit when exhaust fan(s) are energized. Open outside air damper and maintain fixed discharge temperature of 72°F (adjustable) controlling heat input from discharge air controller.
 - 1. If companion exhaust fan is equipped with delay timer, maintain make-up air unit in operation for entire period.

3.04 AIR DAMPER CONTROL SEQUENCE TYPES

- A. Air Damper Control Type D-1, (Mixed air control with minimum position switch): A controller sensing mixed air temperature shall modulate the fresh air, return air and exhaust air dampers to maintain 55°F (adjustable) mixed air temperature. When the outside temperature is above 75°F (adjustable), the fresh air damper shall automatically return to a minimum (adjustable) setting. When the system fans are off the outside air and exhaust air dampers shall be closed.
- B. Air Damper Control Type D-2, (Mixed air control with enthalpy override and minimum position switch): When the systems fans are energized the damper control shall become operative. In addition to a dry bulb sensor to maintain 55°F (adjustable) mixed air temperature by modulating the fresh air, return air and exhaust air dampers, an enthalpy controller shall be provided to automatically sense heat content of return air and outside air and position dampers to utilize air stream with lowest heat content. A minimum adjustable fresh air positioning control shall be provided. When the system fans are off, the outside air and exhaust air dampers shall be closed.
- C. Air Damper Control Type D-8: When the air handling systems are operating in the night setback mode, the outdoor air and exhaust air dampers shall be closed and return air damper opened.
- D. Air Damper Control Type D-9, (Ventilating Systems): When the system fan is energized the normally closed intake and exhaust dampers shall operate to full open position.
- E. Air Damper Control Type D-10, (Exhaust Systems): When the system fan is energized the normally closed exhaust damper shall operate to full open position.

3.05 HEATING COIL CONTROL SEQUENCE TYPES

- A. Heating Coil Control Type HC-1: Space thermostat shall modulate the 2-way hot water or steam coil valve.
- B. Heating Coil Control Types HC-2: When the outside air temperature is below 60°F, a 2-way coil valve shall be modulated by a room thermostat to maintain a set space temperature.
- C. Heating Coil Control Type HC-5, (2-way coil valve from discharge controller which is reset from return air temperature): A discharge controller shall modulate a 2-way coil valve to maintain its set point. The discharge controller shall be reset by return air sensor controller in reverse ratio to provide 110°F (adjustable) hot air at return air temperatures of 60°F and 70°F (adjustable) hot air at return air temperatures of 70°F.
- D. Heating Coil Control Type HC-6, (2-way coil valve from discharge controller which is reset from space thermostats thru logic relay): A discharge controller shall modulate a 2-way coil valve to maintain its set point. The discharge controller shall have its control point reset thru a logic relay from the space thermostats to allow the space thermostat requiring the most heating to control.

3.06 FREEZE PROTECTION CONTROL SEQUENCE TYPES

- A. Freeze Protection Control Type FZ-1, (Downstream from Heating Coil): A controller with 20-feet of capillary tube installed downstream from the coil shall stop the unit fan at temperature below its setting of 35°F.
- B. Freeze Protection Control Type FZ-3, (Downstream from Heating Coil): Provide freezestat serpentine across leaving side of water or steam coil adjacent to outside air connection. De-energize unit fan when temperature falls to 35°F and close outside air damper.
- C. Freeze Protection Control Type FZ-4: Provide freezestat to activate freeze protection pump when outside air temperature falls below 40°F or as selected.

3.07 SYSTEMS ON-OFF CONTROL SEQUENCE TYPES

- A. On-Off Control Type TC-1: A seven (7) day programming clock shall be provided to start and stop the systems fans on a pre-determined weekly schedule.
- B. On-Off Control Type TC-2: A seven (7) day programming clock shall be provided to start and stop the systems fans on a pre-determined weekly schedule. Time clock shall also control morning warm up cycle.

- C. On-Off Control from Outside Temperature Controller Type TC-3: When outside temperature drops to setpoint of controller 60°F (adjustable), the systems motor shall be started.
- D. Warm Up Cycle Type WU-1, (VAV System with Perimeter Radiation): On the warm up cycle, as controlled by the seven (7) day clock, the fan inlet vanes are to be positioned to deliver approximately 50% of total system supply air. Warm up time shall be adjustable with a thermostat sensing return air as an override. On the warm up cycle, all volume control boxes on interior spaces shall be near full open position and all volume control boxes on perimeter zone with heating units shall remain in control of perimeter thermostats. If perimeter thermostat is calling for heating volume, control box will be closed. Perimeter thermostats set from night to day setting in conjunction with warm up cycle. The heating coil valve on the air handling unit shall position for full flow thru coil during warm up cycle.
- E. On-Off Control Type SW-1: Furnish and install a switch (either pneumatic or electrical) to start and stop the unit motor from location shown.
- F. On-Off Control Type AQ-1: Provide an aquastat to sense system fluid temperature and turn unit motor on at temperature below its setting.
- G. On-Off Control Type PS-1: Provide a pressure switch to turn unit motor on at pressure below its setting.

3.08 CONTROL INTERLOCK SEQUENCE TYPES

- A. Fan Interlock Control Type FI-1: Supply and return fan systems shall be equipped with H-O-A Switches. Return fan shall be interlocked thru auxiliary contact in supply fan starter to run when supply fan starter is energized.

3.09 STATIC PRESSURE CONTROL TYPES

- A. Supply duct static pressure control Type DS-1.
 - 1. Vortex Damper Control: Provide static pressure sensor and controller to modulate vortex damper, by means of heavy-duty operator, to maintain constant discharge static pressure. Static pressure sensors shall be located approximately 2/3 the way down the air distribution duct.
- B. Building Static Pressure Control Type BS-1.
 - 1. Building Static Pressure Control: A static pressure controller shall cycle the two (2) exhaust fans in sequence to maintain a differential pressure of .05" between the corridor and the outside pressure. The exhaust fan dampers shall be closed when the fan is off and modulate when the fan is on. Minimum position shall be 50% open when the fan is on.

3.10 AIR HANDLING UNITS CONTROL SEQUENCES

- A. Control Sequence for Air Handling Systems shall be as scheduled herein utilizing previously described damper, cooling coil, heating coil, freeze protection, fire protection, on-off, control interlock, and static pressure sequence types.
- B. Air Handling Unit (AH-) (VAV with DX cooling, 100% outside air economizer, hot water heating coil, inlet vane static pressure control and static pressure control relief fan).
 - 1. Air Damper Control (Mixed air control with minimum position switch): A controller sensing mixed air temperature shall modulate the fresh air and return air dampers to maintain 55°F (adjustable) mixed air temperature. When the outside temperature is above 75°F (adjustable), the fresh air damper shall automatically return to a minimum (adjustable) setting. When the system fans are off, the outside air and relief air dampers shall be closed.
 - 2. Cooling Control (Discharge Controller to Operate DX Condensing Unit): When outside temperature is 55°F and above (adjustable), DX condensing unit shall be operative. A solid state discharge controller furnished with condensing unit shall sequence the DX condensing unit to provide supply air temperature at adjustable setpoint.

3. Heating Coil Control Type HC-3 (2-way valve controlled from mixed air discharge controller): The mixed air discharge controller shall modulate the 2-way coil valve to maintain the set discharge temperature.
4. Freeze Protection Control (Downstream from Heating Coil): A controller with 20-feet of capillary tube installed downstream from the coil shall stop the unit fan at temperature below its setting of 35°F.
5. Fire Protection Control (Smoke activated): Smoke detectors approved for duct installation shall be installed and arranged to automatically shut down fans and provide signals for fire alarm systems. For this purpose, smoke detectors approved for duct installation shall be provided as follows:
 - a. At a suitable location in the return air stream prior to exhausting from the building or being diluted by outside air and at a suitable location in the main supply duct on the downstream side of the filters. Smoke dampers shall be furnished and installed in such a manner as to restrict circulation of smoke, and arranged to close automatically when the system is not in operation and also by operation of the smoke detecting apparatus. Indicate smoke damper locations on shop drawings.
6. On-Off Control: A seven (7) day programming clock shall be provided to start and stop the systems fans on a pre-determined weekly schedule.
7. Supply Duct Static Pressure Vortex Damper Control: Provide static pressure sensor and controller to modulate vortex damper, by means of heavy-duty operator, to maintain constant discharge static pressure. Static pressure sensors shall be located approximately 2/3 the way down the air distribution duct.
8. Building Static Pressure Control: A static pressure controller shall modulate open the relief damper and cycle the exhaust fan in sequence to maintain a differential pressure of .05" between the corridor and the outside pressure. The exhaust fan damper shall be closed when the fan is off and modulate when the fan is on. Minimum position shall be 50% open when the fan is on.

3.11 MISCELLANEOUS CONTROL SEQUENCES

- A. Pump Differential Pressure Control: Provide differential pressure control to maintain system differential by modulating normally closed system bypass control valve.
- B. Emergency Burner Control: Provide emergency burner switches, located as shown on drawings, to interrupt fuel feed to burner(s).
- C. Domestic Hot Water Heater Control: Sensing element in the storage tank shall, thru a controller, modulate a steam valve to maintain the set water temperature at 140°F (adjustable).

END OF SECTION

SECTION 232000
HYDRONIC PUMPS**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Close-coupled, in-line centrifugal pumps.
 - 2. Close-coupled, end-suction centrifugal pumps.
 - 3. Separately coupled, horizontal, in-line centrifugal pumps.
 - 4. Separately coupled, vertical, in-line centrifugal pumps.
 - 5. Separately coupled, base-mounted, end-suction centrifugal pumps.
 - 6. Separately coupled, vertical-mounted, turbine centrifugal pumps.
 - 7. Automatic condensate pump units.
 - 8. Pump Specialty Fittings.

1.03 DEFINITIONS

- A. Buna-N: Nitrile rubber.
- B. EPT: Ethylene propylene terpolymer.

1.04 SUBMITTALS

- A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
 - 1. Pump Curve: Provide calibrated catalog pump curve for each pump in addition to computer generated pump selection curve.
- B. Closeout Submittals:
 - 1. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

- A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 (2020), Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
- B. Store pumps in dry location.
- C. Retain protective covers for flanges and protective coatings during storage.
- D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
- E. Comply with pump manufacturer's written rigging instructions.

1.07 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

1.08 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.
 - 1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 PRODUCTS**2.01 GENERAL REQUIREMENTS**

- A. Pump selection shall be for operation near center-right of performance curve and near “best operating efficiency point.”
- B. Pump selection shall allow impeller replacement with either a larger or smaller impeller within the same pump casing.

2.02 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.03 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers:
 - 1. Armstrong Pumps Inc.
 - 2. Aurora Pump; Division of Pentair Pump Group.
 - 3. Bell & Gossett; Div. of ITT Industries.
 - 4. Grundfos Pumps Corporation.
 - 5. PACO Pumps.
 - 6. Patterson Pump Co.
 - 7. Taco, Inc.
 - 8. Or equal as approved by Owner.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 125 PSIG minimum working pressure and a continuous water temperature of 225°F.
- C. Pump Construction:
 - 1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gauge tappings at inlet and outlet, and threaded companion-flange connections.
 - 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
 - 3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
 - 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N or EPT bellows and gasket. Include water slinger on shaft between motor and seal.
 - 5. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 - 6. Pump Bearings: Permanently lubricated ball bearings.
- D. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; and rigidly mounted to pump casing.
 - 1. Motor shall be non-overloading over full range of pump performance curve.

2. Motor shall be rated for inverter duty if designated for use with variable frequency controller.

2.04 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

- A. Manufacturers:
 1. Armstrong Pumps Inc.
 2. Bell & Gossett; Div. of ITT Industries.
 3. PACO Pumps.
 4. Patterson Pump Co.
 5. Taco, Inc.
 6. Or equal as approved by Owner.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally. Rate pump for 125 PSIG minimum working pressure and a continuous water temperature of 250°F.
- C. Pump Construction:
 1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gauge tapings at inlet and outlet, and flanged connections.
 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
 3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N or EPT bellows and gasket. Include water slinger on shaft between motor and seal.
 5. Pump Bearings: Permanently lubricated ball bearings.
- D. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; rigidly mounted to pump casing with integral pump support.
 1. Motor shall be non-overloading over full range of pump performance curve.
 2. Motor shall be rated for inverter duty if designed for use with variable frequency controller.

2.05 PUMP SPECIALTY FITTINGS

- A. Suction Diffuser: Angle pattern, 175 PSIG pressure rating, cast-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 CONCRETE BASES

- A. Install concrete bases of dimensions indicated for pumps and controllers.
 1. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.03 PUMP INSTALLATION

- A. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
- B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- C. Install continuous-thread hanger rods and elastomeric hangers of sufficient size to support pump weight. Fabricate brackets or supports as required.
- D. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
 - 1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4- to 1-1/2-inches between pump base and foundation for grouting.
 - 2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.
- E. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

3.04 CONNECTIONS

- A. Install piping adjacent to machine to allow service and maintenance.
- B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- D. Install triple-duty valve on discharge side of pumps.
- E. Install suction diffuser and shutoff valve on suction side of pumps.
- F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- G. Install pressure gauges on pump suction and discharge, at integral pressure-gauge tapping, or install single gauge with multiple input selector valve.
- H. Install check valve and gate or ball valve on each condensate pump unit discharge.
- I. Install electrical connections for power, controls, and devices in compliance with Division 26.

3.05 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 6. Start motor.
 - 7. Open discharge valve slowly.

3.06 DEMONSTRATION

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

END OF SECTION

SECTION 232113
HYDRONIC PIPING AND SPECIALTIES**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 - 1. Hot-water heating piping.
 - 2. Makeup-water piping.
 - 3. Condensate-drain piping.
 - 4. Air-vent piping.
 - 5. Safety-valve-inlet and -outlet piping.
 - 6. Hydronic system valves.
 - 7. Air control devices.
 - 8. Hydronic system specialties.
 - 9. Chemical feeders.
- B. Refer to Division 26 for the following work:
 - 1. Automatic Chemical Feeders: Power supply wiring from power source to power connection on unit. Include starters, disconnects and required electrical devices, except where specified as furnished or factory-installed by manufacturer.
- C. Provide the following electrical work as work of this Section, complying with requirements of Division 26 Sections:
 - 1. Provide electrical power to operate electrically powered purge system pumps and accessories.

1.03 SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
 - 2. Air control devices.
 - 3. Hydronic specialties.
 - 4. Chemical feeders.
- B. LEED Submittal: Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
- C. Closeout Submittals:
 - 1. Operation and Maintenance Data: For air control devices, hydronic specialties, special-duty valves, and chemical feeders to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

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

- B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 PRODUCTS

2.01 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. Wrought-Copper Fittings: ASME B16.22.
- D. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
- E. Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230° F for use with housing, and steel bolts and nuts.
- F. Wrought-Copper Unions: ASME B16.22.

2.02 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- H. Grooved Mechanical-Joint Fittings and Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Anvil International, Inc.
 - b. Central Sprinkler Company; a division of Tyco Fire & Building Products.
 - c. National Fittings, Inc.
 - d. S. P. Fittings; a division of Star Pipe Products.
 - e. Victaulic Company of America.
 - f. Or equal as approved by Owner.

2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- I. Steel Pressure-Seal Fittings:
 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Victaulic Company of America.
 - b. Or equal as approved by Owner.
 2. Housing: Steel.
 3. O-Rings and Pipe Stop: EPDM.
 4. Tools: Manufacturer's special tool.
 5. Minimum 300 PSIG working-pressure rating at 230°F.
- J. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.03 PLASTIC PIPE AND FITTINGS

- A. PVC Plastic Pipe: ASTM D 1785, Schedules 40 and 80, plain ends as indicated in Part 3 "Piping Applications" Article.
- B. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

2.04 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- F. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Solvent Cements for Joining Plastic Piping:
 1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.05 TRANSITION FITTINGS

- A. Plastic-to-Metal Transition Fittings: PVC one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cement-joint end.
- B. Plastic-to-Metal Transition Unions: MSS SP-107, PVC union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and threaded union.

2.06 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated union assembly, for 250 PSIG minimum working pressure at 180°F.
- D. Dielectric Flanges: Factory-fabricated companion-flange assembly, for 150 or 300 PSIG minimum working pressure as required to suit system pressures.
- E. Dielectric-Flange Kits:
 - 1. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 2. Separate companion flanges and steel bolts and nuts shall have 150 or 300 PSIG minimum working pressure where required to suit system pressures.
- F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300 PSIG minimum working pressure at 225°F.
- G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300 PSIG minimum working pressure at 225°F.

2.07 VALVES

- A. Bronze, Calibrated-Orifice, Balancing Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - c. Flow Design Inc.
 - d. Griswold Controls.
 - e. Taco.
 - f. Or equal as approved by Owner.
 - 2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
 - 3. Ball: Brass or stainless steel.
 - 4. Plug: Resin.
 - 5. Seat: PTFE.
 - 6. End Connections: Threaded or socket.
 - 7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
 - 8. Handle Style: Lever, with memory stop to retain set position.
 - 9. CWP Rating: Minimum 125 PSIG.
 - 10. Maximum Operating Temperature: 250°F.

- B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - c. Flow Design Inc.
 - d. Griswold Controls.
 - e. Taco.
 - f. Or equal as approved by Owner.
 2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
 3. Ball: Brass or stainless steel.
 4. Stem Seals: EPDM O-rings.
 5. Disc: Glass and carbon-filled PTFE.
 6. Seat: PTFE.
 7. End Connections: Flanged or grooved.
 8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
 9. Handle Style: Lever, with memory stop to retain set position.
 10. CWP Rating: Minimum 125 PSIG.
 11. Maximum Operating Temperature: 250°F.
- C. Diaphragm-Operated Safety Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - d. Conbraco Industries, Inc.
 - e. Spence Engineering Company, Inc.
 - f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - g. Or equal as approved by Owner.
 2. Body: Bronze or brass.
 3. Disc: Glass and carbon-filled PTFE.
 4. Seat: Brass.
 5. Stem Seals: EPDM O-rings.
 6. Diaphragm: EPT.
 7. Wetted, Internal Work Parts: Brass and rubber.
 8. Inlet Strainer: Removable without system shutdown.
 9. Valve Seat and Stem: Noncorrosive.
 10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

D. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - a. Flow Design Inc.
 - b. Griswold Controls.
 - c. Hays.
 - d. Hydronic Components, Inc. (HCI)
 - e. Nexus.
 - f. Or equal as approved by Owner.
2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5% over system pressure fluctuations.
8. Minimum CWP Rating: 300 PSIG.
9. Maximum Operating Temperature: 250°F.

2.08 HOSE KITS

- A. Manufacturers: Subject to compliance with requirements, provide products of one (1) of the following:
 1. Flow Design, Inc.
 2. Griswold Controls.
 3. Hays.
 4. Hydronic Components, Inc. (HCI)
 5. Nexus.
 6. Pro-Hydronic Specialties.
 7. Or equal as approved by Owner.
- B. General: Hose kits shall be designed for minimum 400 PSIG working pressure, and operating temperatures from 25 to 211°F. Hose Kits shall be approved by State Fire Codes for use in rated return air plenum. Tag hose kits to equipment designations.
- C. Hose: Minimum diameter, equal to pipe connection size to water-source heat-pump.
- D. Isolation Valves: Two-piece bronze-body full port ball valves with stainless-steel ball and stem and galvanized-steel lever handle. Provide valve for supply and return.
- E. Strainer: Y-type with blowdown valve in supply connection.
- F. Balancing Device: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gauge.
 1. Automatic balancing valve, factory set to operate within 10% of design flow rate over a 40:1 differential pressure range of 2 to 80 PSIG.
- G. Control Valve: Provide 2-position, quick-opening (15 seconds maximum to full open), slow-closing valve to allow water flow through unit.
- H. Maximum pressure drop through hose kit assembly, valves, automatic flow control valve and heat pump unit shall be 25-feet of water head loss.

2.09 AIR CONTROL DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
 - 1. Amtrol, Inc.
 - 2. Armstrong Pumps, Inc.
 - 3. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - 4. John Wood Co.
 - 5. Patterson Pump.
 - 6. Spirotherm, Inc.
 - 7. Taco.
 - 8. Thrush
 - 9. Wessels Co.
 - 10. Or equal as approved by Owner.
- B. Manual Air Vents:
 - 1. Body: Bronze.
 - 2. Internal Parts: Nonferrous.
 - 3. Operator: Screwdriver or thumbscrew.
 - 4. Inlet Connection: NPS 1/2.
 - 5. Discharge Connection: NPS 1/8.
 - 6. CWP Rating: 150 PSIG.
 - 7. Maximum Operating Temperature: 225°F.
- C. Automatic Air Vents:
 - 1. Body: Bronze or cast iron.
 - 2. Internal Parts: Nonferrous.
 - 3. Operator: Noncorrosive metal float.
 - 4. Inlet Connection: NPS 1/2.
 - 5. Discharge Connection: NPS 1/4.
 - 6. CWP Rating: 150 PSIG.
 - 7. Maximum Operating Temperature: 240°F.
- D. Bladder-Type Expansion Tanks:
 - 1. Tank: Welded steel, rated for 125 PSIG working pressure and 375°F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
 - 3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
- E. Tangential-Type Air Separators:
 - 1. Tank: Welded steel; ASME constructed and labeled for 125 PSIG minimum working pressure and 375°F maximum operating temperature.
 - 2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
 - 3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.

4. Blowdown Connection: Threaded.
 5. Size: Match system flow capacity.
- F. In-Line Air Separators:
1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
 2. Maximum Working Pressure: Up to 175 PSIG.
 3. Maximum Operating Temperature: Up to 300°F.
- G. Air Purgers:
1. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
 2. Maximum Working Pressure: 150 PSIG.
 3. Maximum Operating Temperature: 250°F.
- H. Air & Dirt Separators:
1. Tank: Welded steel; ASME constructed and rated for 150 PSIG working pressure with entering velocities not to exceed 4 feet per second at specified GPM.
 2. Internal Parts: Unit shall include an internal bundle to suppress turbulence and provide high efficiency. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism. Unit shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Separator shall have the vessel extended below the pipe connections an equal distance for dirt separation. Air Eliminators shall be capable of removing 100% of the free air, 100% of the entrained air, and up to 99.6% of the dissolved air in the system fluid. Dirt separation shall be at least 80% of all particles 30 micron and larger within 100 passes.
 3. Separator shall include a removable head to facilitate removal of bundle assembly for inspection or cleaning, blow down valve at bottom of unit, gauge tap on both inlet and outlet connections, and sight glasses on upper and lower sections of unit.

2.10 HYDRONIC PIPING SPECIALTIES

- A. Y-Pattern Strainers:
1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
 2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
 3. Strainer Screen: Mesh startup strainer, and perforated stainless-steel basket with 50% free area.
 4. CWP Rating: 125 PSIG.
- B. Basket Strainers:
1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
 2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
 3. Strainer Screen: Mesh startup strainer, and perforated stainless-steel basket with 50% free area.
 4. CWP Rating: 125 PSIG.
- C. Stainless-Steel Bellows, Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
 2. End Connections: Threaded or flanged to match equipment connected.

3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 PSIG.
5. Maximum Operating Temperature: 250°F.
- D. Pump Suction Diffusers: Cast-iron body, with threaded connections for 2-inch or smaller, flanged connections for 2-1/2-inch and larger; 175 PSIG working pressure, 250°F maximum operating temperature; and complete with the following features:
 1. Inlet vanes with length 2-1/2 times pump suction diameter or greater.
 2. Cylinder strainer with 3/16-inch diameter openings with total free area equal to or greater than five times cross-sectional area of pump suction, designed to withstand pressure differential equal to pump shutoff head.
 3. Disposable fine mesh strainer to fit over cylinder strainer.
 4. Permanent magnet, located in flow stream, removable for cleaning.
 5. Adjustable foot support, designed to carry weight of suction piping.
 6. Blowdown tapping in bottom; gage tapping in side.

2.11 CHEMICAL FEEDERS

- A. Manufacturer: Subject to compliance with requirements, provide hydronic system treatment products from one (1) of the following:
 1. Manual Chemical Feeders:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. General Treatment Products.
 - d. ITT Fluid Technology Corp.; ITT Bell & Gossett
 - e. J.L. Wingert Co.
 - f. Taco, Inc.
 - g. Or equal as approved by Owner.
 2. Automatic Chemical Feeders:
 - a. General Treatment Products.
 - b. J.L. Wingert Co.
 - c. John Wood Co.
 - d. Wessels.

2.12 CHEMICAL FEEDERS

- A. Manual Chemical Feeders: Bypass type chemical feeders of 5-gallon capacity, welded steel construction; 175 PSIG working pressure; complete with fill funnel and inlet, outlet and drain valves. Quarter-turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

PART 3 EXECUTION

3.01 PIPING APPLICATIONS

- A. General: Pipe material selected shall be in compliance with all applicable codes.
- B. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be one (1) of the following:
 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
 2. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

- C. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be one (1) of the following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
 - 2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 - 3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
- D. Hot-water heating piping installed belowground and within slabs shall be the following:
 - 1. Type K, annealed-temper copper tubing, without joints.
- E. Makeup-water piping installed aboveground: Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- F. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, without joints.
- G. Condensate-Drain Piping shall be one (1) of the following:
 - 1. Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
 - 2. Schedule 40 PVC plastic pipe and fittings and solvent-welded joints. PVC piping shall not be installed in return air plenums.
- H. Air-Vent Piping:
 - 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
 - 2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.
- I. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

3.02 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply and return mains, and at supply and return connections to each piece of equipment.
- B. Install balancing valves or automatic flow control valves in the return pipe of each heating or cooling terminal.
- C. Install Y-type strainers upstream of each automatic flow control valve.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
- F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.03 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install condensate drain piping from rooftop units to within 12 inches of nearest roof drain or gutter.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- M. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- N. Install piping at a uniform grade of 0.2% upward in direction of flow.
- O. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- P. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- S. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- T. Install sleeves for piping penetrations of walls, ceilings, and floors.
- U. Install sleeve seals for piping penetrations of concrete walls and slabs.
- V. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.04 HANGERS AND SUPPORTS

- A. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
 - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
 - 6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- B. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4-inch.
 - 2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4-inch.

3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8-inch.
 4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8-inch.
 5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8-inch.
 6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8-inch.
 7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2-inch.
 8. NPS 6: Maximum span, 17 feet; minimum rod size, 1/2-inch.
 9. NPS 8: Maximum span, 19 feet; minimum rod size, 5/8-inch.
 10. NPS 10: Maximum span, 20 feet; minimum rod size, 3/4-inch.
 11. NPS 12: Maximum span, 23 feet; minimum rod size, 7/8-inch.
 12. NPS 14: Maximum span, 25 feet; minimum rod size, 1-inch.
 13. NPS 16: Maximum span, 27 feet; minimum rod size, 1-inch.
 14. NPS 18: Maximum span, 28 feet; minimum rod size, 1-1/4-inches.
 15. NPS 20: Maximum span, 30 feet; minimum rod size, 1-1/4-inches.
- C. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4-inch.
 2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4-inch.
 3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8-inch.
 4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8-inch.
 5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8-inch.
 6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8-inch.
- D. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
- E. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
- F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.05 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. Brazed Joints: Construct joints according to AWS' "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

- F. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
 - 4. PVC Nonpressure Piping: Join according to ASTM D 2855.
- I. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
- J. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
- K. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.
- L. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.06 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.
- C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2% upward slope toward tank.
- D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.
- E. Install air separator in pump suction. Install blowdown piping with full-port ball valve; extend full size to nearest floor drain.
- F. Install pump suction diffusers on pump suction inlet, adjust foot support to carry weight of suction piping. Install blowdown piping nipple with full-port ball valve.
- G. Install expansion tanks as shown on drawings. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

3.07 CHEMICAL FEEDER INSTALLATION

- A. Install manual chemical feeders in each hydronic system where indicated; in upright position with top of funnel not more than 48-inches above floor. Install feeder in bypass line with ball valves on each side of feeder. Pipe drain, with ball valve, to nearest floor drain.
- B. Install automatic chemical feeders within 10 feet of injection point in each hydronic system where indicated.

3.08 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

- B. Install control valves in accessible locations close to connected equipment.
- C. Install ports for pressure gauges and thermometers at coil inlet and outlet connections.

3.09 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
 - 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 - 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 - 3. Isolate expansion tanks and determine that hydronic system is full of water.
 - 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90% of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 - 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 - 6. Prepare written report of testing.
- C. Perform the following before operating the system:
 - 1. Open manual valves fully.
 - 2. Inspect pumps for proper rotation.
 - 3. Set makeup pressure-reducing valves for required system pressure.
 - 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 - 5. Set temperature controls so all coils are calling for full flow.
 - 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 - 7. Verify lubrication of motors and bearings.

END OF SECTION

SECTION 233000
AIR DISTRIBUTION**PART 1 GENERAL****1.01 WORK INCLUDED**

- A. Extent of air distribution work required by this section is indicated on drawings and schedules and by requirements of this section.
- B. Types of air distribution work specified in this section include the following:
 - 1. Air filters and gages:
 - a. Replaceable (Throwaway).
 - b. Extended service.
 - c. Filter gages.
 - 2. Metal Ductwork:
 - a. Fiberglass Duct liner.
 - b. Non-fibrous duct liner.
 - c. Flexible Duct.
 - 3. Ductwork Accessories:
 - a. Manual dampers.
 - b. Smoke dampers.
 - c. Fire dampers.
 - d. Turning vanes.
 - e. Flexible connections.
 - f. Floor curbs.
 - 4. Air outlets and inlets:
 - a. Diffusers, registers and grilles.
 - b. Louvers.
 - 5. Air terminals:
 - a. Shut-off single duct.
 - b. Fan-powered boxes.
- C. Duct mounted smoke detector installation is included as work of this section.

1.02 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air distribution products of types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Installer's Qualifications: Firm with at least three (3) years of successful installation experience on projects with air distribution systems similar to that required for Project.
- C. Codes and Standards Compliance:
 - 1. SMACNA "HVAC Duct Construction Standards, Metal and Flexible" 1995 2nd Edition.
 - 2. NFPA 90A (2021) "Standard for the Installation of Air Conditioning and Ventilating Systems".
 - 3. NFPA 96 (2021) "Standard for Ventilation Control and Fire Protections of Commercial Cooking Operations".
 - 4. NFPA 90B (2021) "Standard for the Installation of Warm Air Heating and Air Conditioning Systems".

5. UL Standard 555 "Fire and Smoke Dampers ".
6. AMCA 500 "Test Method for Louvers, Dampers and Shutters".
7. ARI Compliance: Provide air terminals which have been tested and rated in accordance with ARI 880 "Industry Standard for Air Terminals" and bear ARI certification seal.
8. ASTM C 1071: Duct liner shall comply with ASTM C 1071.
9. NAIMA FGDLS: Install duct liner in accordance with NAIMA FGDLS (North American Insulation Manufacturers Association's Fibrous Glass Duct Liner Standard).
10. ASHRAE Compliance: Comply with provisions of ASHRAE Standard 52 for method of testing and rating air filter units.

1.03 SUBMITTALS

- A. Submit submittals required as noted in Division 23 Section Submittals.
- B. Product Data: Submit manufacturer's technical product data on all air distribution work, including performance data for air flow pressure drops through filters, noise criteria, air inlet, outlet and terminal room schedules, material construction and installation instructions.
- C. Submittals: Submit manufacturer's assembly-type shop drawings, including dimensions, materials, finish, mounting details and methods of assembly for all air distribution equipment. Coordinate sound output of each air device and modify sizes or arrangements as required to meet sound criteria listed on drawings.
- D. Ductwork Drawings: Submit scaled layout drawings of ductwork and fittings. Reproduction of bid documents does not constitute a ductwork shop drawing. Shop drawing to include, but not limited to duct sizes, section lengths, weights, locations, elevations, offsets, wall/floor penetrations, and connections. Note ductwork that is lined or wrapped, including sheet metal dimensions. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that free area, materials and rigidity are not reduced.
- E. Coordination Drawings: Submit drawings to general contractor consisting of ductwork layout drawings that have been coordinated with other trades to show structure, ceiling grid, light fixtures, fire sprinkler heads, etc.
- F. Maintenance Data: Submit maintenance data and spare parts lists, cleaning and troubleshooting instructions. Include this data, product data and shop drawings in Maintenance Manual.
- G. Record Drawings: At project closeout, submit record drawings of installed ductwork, duct accessories and air outlets and inlets.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Manufacturer: Subject to compliance with requirements, provide air distribution equipment of one (1) of the following:
 1. Air Filters
 - a. American Air Filter Co.
 - b. Camfil Farr
 - c. Continental Air Filters
 - d. Eco-Air Products, Inc.
 - e. Flanders.
 - f. Or equal as approved by Owner.
 2. Filter Gages
 - a. Camfil Farr
 - b. Dwyer Instruments, Inc.
 - c. Or equal as approved by Owner.

3. Round Spiral Ductwork and Fittings:
 - a. Ductmate Industries, Inc.
 - b. Eastern Sheet Metal.
 - c. Flexmaster USA
 - d. LaPine Metal Products.
 - e. Lewis and Lambert.
 - f. Lindab, Inc.
 - g. Norlock.
 - h. S.E.T. Duct Mfg.
 - i. Sheet Metal Connectors, Inc.
 - j. Spiral Pipe of Texas (SPOT).
 - k. United McGill.
 - l. Wesco.
 - m. Wichita Sheet Metal.
 - n. Or equal as approved by Owner.
4. Fiberglass Duct Liner:
 - a. Johns Manville – Permacote Linacoustic
 - b. Or equal as approved by Owner.
5. Non-Fibrous Duct Liner:
 - a. AP Armaflex SA
 - b. Nomaco K-Flex Gray
 - c. Solcoustic.
 - d. Or equal as approved by Owner.
6. Duct Lagging:
 - a. Kinetics.
 - b. Or equal as approved by Owner.
7. Flexible Ductwork:
 - a. Flexmaster USA.
 - b. TechnaFlex Type 57-C.
 - c. ThermaFlex Type M-KE.
 - d. Or equal as approved by Owner.
8. Fabric Ductwork:
 - a. DuctSox
 - b. Or equal as approved by Owner.
9. Fire and Smoke Dampers
 - a. Air Balance, Inc.
 - b. Carnes.
 - c. Greenheck
 - d. Leader, Dampers & Louvers
 - e. Louver & Dampers, Inc.
 - f. Nailor Industries

- g. NCA
 - h. Pottorf
 - i. Ruskin
 - j. Sheet Metal Connectors.
 - k. United Enertech
 - l. Or equal as approved by Owner.
10. Access Doors:
- a. Air Balance, Inc.
 - b. Ductmate Industries, Inc.
 - c. Sheet Metal Connectors, Inc.
 - d. United Enertech
 - e. Or equal as approved by Owner.
11. Diffusers, Registers and Grilles:
- a. Air Balance, Inc.
 - b. Anemostat
 - c. Carnes
 - d. Krueger
 - e. E.H. Price
 - f. Metal Aire
 - g. Nailor Industries
 - h. Raymon Donco Air Distribution.
 - i. Rickard Air Diffusion
 - j. Titus
 - k. Tuttle & Bailey
 - l. United Enertech
 - m. Or equal as approved by Owner.
12. Louvers:
- a. Air Balance Industries
 - b. Aerolite
 - c. Airline Products Co.
 - d. Airstream Products Division of Penn Ventilator Co.
 - e. American Warming
 - f. Arrow
 - g. Carnes
 - h. Greenheck
 - i. Louvers & Dampers Inc.
 - j. NCA
 - k. Nailor Industries
 - l. Pottorf
 - m. Reliable
 - n. Ruskin

- o. Safe-Air/Dowes
 - p. TAMCO
 - q. United Enertech
 - r. Or equal as approved by Owner.
13. Air Terminal Control Units:
- a. Carnes
 - b. Environmental Technologies
 - c. Krueger
 - d. Metal Aire
 - e. Nailor Industries
 - f. Price Industries
 - g. Titus
 - h. Trane
 - i. Tuttle & Bailey
 - j. Or equal as approved by Owner.

2.02 AIR FILTERS AND GAGES

- A. Replaceable (Throwaway) Panel Filters: Provide factory-fabricated, viscous-coated, flat panel type replaceable air filters with holding frames; as indicated, in sizes indicated, with 2-inch thick UL Class 2 throwaway media material; construct media of interlaced glass fibers, spray with non-flammable adhesive, frame in throwaway fiberboard casings, and sandwich between perforated metal grills. Construct ductwork-holding frames of 20-gage galvanized-steel, capable of holding media and media frame in place, and gasketed to prevent unfiltered air by-passing between media frames and holding members. Provide filters with rated face velocity of 500 FPM, initial resistance of not greater than 0.30-inch w.g., final rated resistance of 0.50-inch WC and average arrestance of 80%.
- B. Extended Surface Filters: Provide factory-fabricated, dry, extended surface filters with holding frames; where shown, in sizes indicated. Equip with UL Class 1 fibrous media material formed into 6-inch deep V-shaped pleats and held by self-supporting wire frames. Construct holding frames of 18-gage galvanized-steel and provide suitable fasteners and gasketing to hold media and media frame and to prevent unfiltered air passing between media frames and holding devices. Design holding frames which are suitable for bolting together into built-up filter banks. Provide filters with rated face velocity of 500 FPM, initial resistance of 0.50-inch w.g. with 60-65% dust spot efficiency, and 0.60-inch WC with 90-95% dust spot efficiency and final rated resistance 1.2-inch WC.
- C. Class 2 30/30 Filters
- 1. Air Filters - Air filters shall be 2-inch Farr 30/30, medium efficiency, pleated, disposable type. Each filter shall consist of a non-woven cotton and synthetic fabric media, media support grid and enclosing frame. The filter shall be listed by Underwriters' Laboratories as Class 2.
 - 2. Filter Media - Filter media shall be of the non-woven cotton fabric type. The filter media shall have an efficiency of 30% on ASHRAE Test Standard 52-76. It shall have an average arrestance of 90-92% in accordance with that test standard. The effective filter media shall be not less than 4.6 square feet of media per 1.0 square foot of filter face area and shall contain not less than 15 pleats per linear foot. Initial resistance at 500 FPM approach velocity shall not exceed .28-inch w.g.
 - 3. Media Support Grid - The media support shall be a welded wire grid with an effective open area of not less than 96%. The welded wire grid shall be bonded to the filter media to eliminate the possibility of media oscillation and media pull away. The media support grid shall be formed in such a manner that it effects a radial pleat design, allowing total use of filter media.

4. Enclosing Frame - The enclosing frame shall be constructed of a rigid, heavy-duty, high wet-strength beverage board, with diagonal support members bonded to the air entering and air exit side of each pleats, to ensure pleat stability. The inside periphery of the enclosing frame shall be bonded to the filter pack, thus, eliminating the possibility of air bypass.
 5. Holding Frame - Holding frames shall be Farr Type 8, factory fabricated of 16-gage galvanized-steel and shall be equipped with gaskets and four (4) spring type positive sealing fasteners. Fasteners shall be capable of being attached or removed without the use of tools.
- D. Provide manometer-type filter gage for each filter bank, with logarithmic curve tube gage, with integral leveling gage, graduated to read from 0- to 3-inch w.g.
1. Provide pressure tips, tubing, gage connections and mounting bracket.

2.03 METAL DUCTWORK

A. Materials:

1. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains and discolorations and other imperfections, including those which would impair painting.
2. Sheet Metal, General: Provide sheet metal in thicknesses indicated, packaged and marked as specified in ASTM A 700.
3. Galvanized Sheet Steel: Lock-forming quality, ASTM A 653, Coating Designation G 90. All shipping labels, markings or identification tags shall be removed from galvanized steel upon installation. Where duct is indicated to be painted, provide mill phosphatized finish for exposed surfaces of ducts exposed to view. Refer to architectural plans for extent of painted surfaces. All other surfaces of duct exposed to view shall have bright finish.
4. PVC-Coated Galvanized-steel: UL-181 Class 1 Listing. Lock-forming quality galvanized sheet steel with ASTM A 653, Coating Designation G 90. Provide with factory-applied, 4 MIL, PVC coating on the exposed surfaces of ducts and fittings (exterior of ducts and fittings for underground applications and 1 MIL PVC coating on the interior side of the ducts and fittings. Provide 4 MIL PVC coating on the interior of ducts and fittings for fume-handling applications.
5. Carbon Steel Sheets: ASTM A 366, cold-rolled sheets, commercial quality, with oiled, exposed matte finish.
6. Stainless Steel: ASTM A 480, Type 316, sheet form, with No. 4 finish on exposed surface for ducts exposed to view; Type 304, sheet form, with No. 1 finish for concealed ducts.
7. Aluminum Sheets: ASTM B 209, Alloy 3003, Temper H14, sheet form; with standard, one-side bright finish where ducts are exposed to view and mill finish for concealed ducts.
8. Reinforcement Shapes and Plates: Unless otherwise indicated, provide galvanized-steel reinforcing where installed on galvanized sheet metal ducts. For aluminum and stainless steel ducts provide reinforcing of compatible materials.

B. Miscellaneous Materials:

1. Tie Rods: Galvanized-steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36-inches.
2. Fiberglass Duct Liner: Fiberglass duct liner with durable fire-resistant, black coated mat surface on the air stream side, 1.5 lbs/ft³ density, thermal conductivity no higher than .25 at 75°F mean temperature, complying with ASTM C 1071 and ASHRAE 90.1-2016, of thickness indicated in schedule on drawings. Air stream surface of duct liner shall contain an EPA registered anti-microbial agent.
 - a. Flame/Smoke Ratings: Provide duct liner and adhesives with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255, 2006) method, meeting requirements of NFPA 90A (2021).

- b. Acoustical Performance: NRC not less than 0.65 for 1-inch thickness, not less than 0.85 for 1-1/2-inch thickness and not less than 0.95 for 2-inch thickness.
 - c. Operating Limits: 250°F maximum temperature (ASTM C411) and 6,000 FPM maximum air velocity (ASTM C1071).
 - 3. Non-Fibrous Duct Liner: Non-fibrous flexible polyimide foam insulation, acrylic anti-microbial coating, of thickness indicated in schedule on drawings. Air stream surface of duct liner shall contain an EPA registered anti-microbial agent.
 - a. Flame/Smoke Ratings: Provide duct liner and adhesives with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255, 2006) method, meeting requirements of NFPA 90A (2021).
 - 4. Duct Liner Adhesive: Comply with ASTM C 916 "Specifications for Adhesives for Duct Thermal Insulation".
 - 5. Duct Liner Fasteners: Comply with SMACNA HVAC Duct Construction Standards, Article S2.11 on Page 2.25.
 - 6. Duct Lagging: Mass-loaded limp vinyl with reinforced aluminum foil facing. Lagging shall have a nominal density of 1.0 lbs/sq. ft. and minimum thermal conductivity "k" value of 0.29.
 - 7. Joint and Seam Sealant: Indoor/Outdoor Water Based Duct Sealant shall be all purpose duct sealant for use on all types of metal duct, glass fiber duct board, and flex duct, as well as duct fabric and flexible tubing runouts. The sealant incorporates a built-in fiber reinforcement for exceptional strength, with UV inhibitors for outdoor use. UL 181A-M Listed / UL 181B-M Listed. Provide Versa-Grip 181 Hard cast or approved equal.
 - 8. Flanged Joint Mastics: One-part, acid-curing, silicone elastomeric joint sealants, complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
 - 9. Fire Resistant Sealant: Provide one-part elastomeric sealant formulated for use in a through-penetration fire-stop system for filling openings around duct penetrations through walls and floors, having fire-resistance ratings indicated as established by testing identical assemblies per ASTM E 814 by Underwriters Laboratory, Inc. or other testing and inspecting agency acceptable to authorities having jurisdiction.
 - 10. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized-steel fasteners, anchors, rods, straps, wire rope, trim and angles for support of ductwork. Hang all ductwork from the structure only. Do not hang from metal deck.
 - 11. Flexible Duct: Factory pre-insulated duct composed of a corrosion-resistant reinforcing wire helix permanently bonded and enclosed in polyester film, then covered with 1-1/2-inch, 3/4 lb. density fiberglass insulation blanket sheathed in a vapor barrier of aluminum metalized polyester film laminated to glass mesh, elastomer back-coated. The duct must comply with the latest NFPA Standard 90A (2021) and be listed as a Class 1 Air Duct Material, UL Standard 181.
 - 12. Floor Curbs: At all ductwork penetrations through floors above grade provide concrete or steel angle curb extending 3-inches above finish floor level and provide watertight seal at floor line.
- C. Fabrication:
- 1. General: Fabricate rectangular ducts in accordance with SMACNA "HVAC Duct Construction Standards," Tables 1-3 through 1-16 and 1-21 through 1-25, including their associated details.
 - 2. Static Pressure Classifications: Except where otherwise indicated, construct duct systems to the following pressure classifications:
 - a. Supply Ducts: Where no specific duct pressure class designations are indicated, fabricate duct system for 3-inch water gage pressure class, except for ducts upstream from variable air volume boxes. Fabricate duct system components upstream from variable air volume boxes for 3-inch WC pressure class.

- b. Ventilation Ducts: 3-inch WC pressure class.
 - c. Outside Air and Mixed Air Ducts: 3-inch WC pressure class.
 - d. Return Ducts: 2-inch WC, negative pressure.
 - e. Exhaust Ducts: 2-inch WC, negative pressure.
- 3. Provide materials that are free from visual imperfections such as pitting, seam marks, roller marks, stains and discolorations.
 - 4. Fabricate ductwork with duct liner in each section of duct where indicated. Laminate liner to internal surfaces of duct in accordance with instructions by manufacturers of lining and adhesive and fasten with mechanical fasteners.
 - 5. Cross breaking or Cross Beading: Cross break or bead duct sides that are 19-inches and larger and are 20-gage or less, with more than 10 square feet of unbraced panel area, as indicated in SMACNA "HVAC Duct Construction Standard," Figure 1-4, unless they are lined or are externally insulated.
 - 6. Rectangular Duct Fittings: Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA "HVAC Metal Duct Construction Standard," 1995 Edition, Figures 2-1 through 2-8.
 - a. Radius elbow limit as follows:
 - (1) $R/W=1.0$ for 1000 FPM and below.
 - (2) $R/W=1.5$ above 1000 FPM.
 - b. Square elbows with turning vanes only. Limit single thickness vanes to 36" maximum.
 - (1) $R = 2.0$ for 1000 FPM and below.
 - (2) $R = 4.5$ above 1000 FPM.
 - c. Radius elbow limit $R/W=1.0$ for 1000 FPM and below; $R/W=1.5$ above 1000 FPM.
 - d. Square elbows with turning vanes only. Limit single thickness vanes to 36" maximum. For 1000 FPM and below, $R = 2.0$; for greater than 1000 FPM, $R = 4.5$.
 - e. Offsets limit 30" maximum.
 - f. Branch connections 45 degree entry high efficiency type only.
 - 7. Ductmate Fittings: Joints constructed in accordance with SMACNA Standards that use four (4) corner connections shall be equal to products manufactured by Ductmate Industries Inc., Ward Industries Inc. or an approved equal. Refer to manufacturer's guidelines.
 - a. Radius elbows limit as follows:
 - (1) $R/W=1.0$ 1000 FPM and below.
 - (2) $R/W=1.5$ above 1000 FPM.
 - b. Square elbows with turning vanes only.
 - (1) Double thickness $R=4.5$ above 1000 FPM.
 - c. Radius elbows limit $R/W=1.0$, 1000 FPM and below and $R/W=1.5$ above 1000 FPM
 - d. Square elbows with turning vanes only. Limit single thickness Double thickness $R=4.5$ above 1000 FPM.
- D. Round Concealed Ductwork: Fabricate round supply ducts using seam types identified in SMACNA "HVAC" Duct Construction Standards, "1995 Edition, Figure 3-1, RL-1, RL-4 or RL-5. Seams Types RL-2 or RL-3 may be used if spot-welded on 1-inch intervals. Comply with SMACNA "HVAC" Duct Construction Standards", Table 3-2A and 3-2B for galvanized-steel gages.
- 1. Fittings: Provide radius type fittings fabricated of multiple sections with maximum 15 degree change of direction per section. Unless specifically detailed otherwise, use 45 degree laterals and 45 degree elbows for branch takeoff connections. Where 90 degree branches are indicated, provide conical type tees.

- E. Longitudinal Seams: Pittsburgh lock shall be used on all longitudinal seams.
1. Pittsburgh lock shall be used on all non-gasketed longitudinal seams.
 2. Snap-lock seams are acceptable when provided with a rubber gasket. Duct pressure loss shall be limited to 0.05-inches H₂O per 50 linear feet of duct.
 3. If SMACNA seal Class A or B is specified, the longitudinal seam shall be sealed from the inside.
- F. Seal Fittings: Provide double legged EPDM gasketed seal fitting for spiral duct. Gasket shall be mechanical attached to fitting with 180 degree hemmed edge. Fitting shall be inserted in spiral duct and fastened with self-tapping sheet metal screws.
1. Seal fitting shall be pressure tested to SMACNA leakage Class III for -2-inches WC to +10-inches WC. Fittings shall be manufactured by Sheet Metal Connectors, Inc. or approved equal.
- G. Round Exposed Ductwork: Construct of galvanized sheet steel complying with ASTM A 527 by the following methods and in minimum gages listed:

<u>DIAMETER</u>	<u>MINIMUM GAGE</u>	<u>METHOD OF MANUFACTURE</u>
3-inch to 14-inch	26	Spiral Lockseam
15-inch to 26-inch	24	Spiral Lockseam
27-inch to 36-inch	22	Spiral Lockseam
37-inch to 50-inch	20	Spiral Lockseam
51-inch to 60-inch	18	Spiral Lockseam
Over 60-inch	16	Longitudinal Seam

1. Fittings and Couplings: Construct of minimum gages listed. Provide continuous welds along seams.

<u>DIAMETER</u>	<u>MINIMUM GAGE</u>
3-inch to 36-inch	20
38-inch to 50-inch	18
Over 50-inch	16

2. Transverse spiral and round duct joints for all exposed ductwork shall be made with the Spiralmate round duct connector or an approved equal. The Spiralmate components shall be of standard catalogue manufacture as supplied by Ductmate Industries, Inc., Sheet Metal Connectors, Inc., Ward Industries Inc. or an approved equal.
 3. The installation of the spiral duct connector shall be in accordance with the manufacturer's printed instruction and installation manuals.
 4. The spiral duct connector consists of the following components:
 - a. Two (2) mating round duct connector flanges with an integral sealant.
 - b. A gasket between the two (2) mating flanges.
 - c. A roll-formed closure ring that is drawn tight with a bolt and nut.
- H. Flat Oval Ducts: Install using the Ovalmate Connection system manufactured by Ductmate Industries, Inc. Consult the manufacturer for installation and construction guidelines.
- I. Underslab Ducts: For ductwork placed in concrete slabs, or under slabs on grade, ductwork shall be PVC duct system of spiral galvanized-steel with 4 MIL coating of polyvinyl on the exterior and 1 MIL coating of polyvinyl on the interior. Joints shall be 4 MIL PVC-coated Ductmate, "Spiralmate" type system or approved equal.

- J. Kitchen Exhaust Ducts: Fabricate kitchen exhaust ducts and supports, used for smoke and vapor removal from cooking equipment, with 16-gauge, carbon steel sheets for concealed ducts and 18-gauge stainless steel for exposed ducts. Weld and flange seams and joints. Conform to NFPA Standard 96 (2021).
- K. Dishwasher Exhaust Ductwork: Fabricate dishwasher exhaust ducts with Type 304 stainless steel, minimum 18-gauge. Weld and flange seams and joints.

2.04 HDPE PLASTIC DUCTWORK

- A. HDPE Ductwork: For ductwork placed under slabs on grade or direct buried, ductwork shall be fabricated of high density polyethylene (HDPE) integrally insulated plastic. Fittings, boots and duct section connectors shall be fabricated with HDPE. Joints shall be gasketed and sealed according to manufacturer's recommendations. Acceptable manufacturer: CDC Enterprises Akduct or approved equal.

2.05 DUCTWORK ACCESSORIES

- A. Low Pressure Manual Dampers: Provide dampers of single blade type or multiblade type, constructed in accordance with SMACNA "Low Pressure Duct Standards".
- B. Fire Dampers: Provide fire dampers, of types and sizes indicated. Fire Dampers shall be dynamic type and shall be constructed and tested in accordance with UL Safety Standard 555. Fire dampers used for the protection of openings in walls, partitions or floors with fire resistance ratings of less than three (3) hours shall have 1-1/2 hour fire protection rating. Fire dampers used for the protection of openings in walls, partitions or floors having a fire resistance rating of three (3) hours or more, shall have a three (3) hour fire protection rating.
 - 1. Provide fusible link rated at 165°F unless otherwise indicated.
 - 2. Fire dampers shall be equipped for vertical or horizontal installation as required by the location shown. Fire dampers shall be installed in wall and floor openings utilizing steel sleeves, angles, other materials and practices required to provide an installation equivalent to that utilized by the manufacturer when dampers were tested at UL. Fire dampers shall include UL label.
 - 3. Each dynamic fire damper shall include a steel sleeve and retaining angles furnished by the damper manufacturer to ensure appropriate installation.
 - 4. Submittal information shall include the fire protection rating, maximum velocity/pressure ratings and the manufacturer's UL installation instructions. Each fire damper shipment shall include the same UL installation instructions.
 - 5. Dampers shall be Style B or equal design providing a nominal 100% free area fire damper. Ruskin Type DIBD or approved equal.
 - 6. Provide 12-inch x 12-inch (minimum) duct access door at fire dampers to allow maintenance and visual inspection per NFPA requirements.
 - 7. Dampers upstream of VAV terminal units shall be rated for 3,000 FPM velocity and 4 in. W.C.
- C. Ceiling Radiation Dampers: Provide ceiling radiation dampers of types and sizes as indicated. Fire Dampers shall be constructed and tested in accordance with UL. Each fire dampers shall have a 1-1/2 hour fire protection rating. Provide fusible link at 165°F. Fire dampers shall be suited for round or rectangular openings as shown. Fire dampers shall include UL Label.
 - 1. Dampers shall be Ruskin CFD or CFDR or equal.
 - 2. Shop drawings shall include manufacturer's recommended installation instruction as tested by UL.
 - 3. Damper Blade Assembly: Multi-blade type.
 - 4. Blade Material: Steel, match casing.

- D. Smoke Dampers: Smoke dampers shall be UL Labeled according to UL Standard 555S, Standard for Leakage Rated Dampers for Use in Smoke Control Systems." Combination fire and smoke dampers shall also be UL Labeled for 1-1/2 hour rating according to UL Standard 555 "Standard for Fire Dampers."
1. Provide replaceable, 165°F or 212°F rated fusible link as required.
 2. Frame and blades shall be constructed of 16-gauge galvanized-steel.
 3. Provide factory-installed, 18-gage galvanized-steel mounting sleeve of length to suit wall or floor applications. All smoke dampers shall be leakage Class II with a maximum leakage of 10 CFM/SF at 1-inch WC unless indicated otherwise.
 4. All combination fire/smoke dampers shall incorporate an integral resettable and reusable UL Listed electric-ambient temperature link, UL Listed releasing device/mechanical lock assembly. This assembly shall replace the standard fusible link and spring lock clip device. The link shall be activated by duct ambient temperature to permit the damper to close and lock independent of the motor actuator position. Upon normalization of duct ambient temperature the link shall return to its reset position enabling the damper to be fully recycled by the actuator automatically. A manual reset button shall also be acceptable to return damper to its normal position.
 5. All combination fire/smoke dampers shall be installed in accordance with the manufacturers UL installation instructions.
 6. Electric motor actuators shall be Underwriters Laboratories listed and furnished with all necessary mounting and location hardware from the factory for installation outside of the ductwork unless specifically shown otherwise on the drawings. The actuators shall be (power open/spring closed operation – 120 V.A.C.-). The combination fire/smoke dampers shall be furnished with connecting shafts and linkage utilizing not more than one (1) actuator for single and multiple assembly sizes up to 23 square feet. Smoke damper and fire/smoke damper actuators shall be manufactured by Belimo or approved equal.
 7. All smoke dampers shall have fail close operation and shall have a maximum of 15 second open and 15 second close response time.
 8. Provide 12-inch x 12-inch minimum duct access door where possible at fire/smoke dampers to allow maintenance and visual inspection per NFPA requirements. For ductwork less than 12-inch width, provide removable length of duct to allow maintenance and visual inspection.
- E. Where fire, smoke or fire/smoke dampers are above inaccessible ceilings, provide access panel assemblies in ceilings with flush accessible cover. Where smoke detectors are required at dampers, coordinate size, quantity and location of access panels to maintain access to detectors. Coordinate installation of all access panels with Architect prior to installation.
- F. Manufactured Turning Vanes: Provide turning vanes constructed of 1-1/2-inch wide curved blades set at 3/4-inch O.C., supported with bars perpendicular to blades set at 2-inch O.C. and set into side strips suitable for mounting in ductwork. Accepted Manufacturers:
1. Ductmate Prorail.
 2. Turning Vane and rail system.
 3. Sheet Metal Connectors, Inc.
 4. Or equal as approved by Owner.
- G. Flexible Duct Connections: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement and also capable of absorbing vibrations of connected equipment.

- H. Connectors shall comply with NFPA 90A (2021), "Installation of Air Conditioning and Ventilation Systems" and NFPA 90B (2021), "Installation of Warm Air Heating and Air Conditioning Systems".
1. Indoor installations shall be of a UL 214 Listed, fire-retardant vinyl coated woven nylon or Neoprene coated woven fiberglass fabric. Minimum density of vinyl is 22 ounces/sq. yd. and rated to 180°F. Minimum density of Neoprene 30 ounces/sq. yd. and rated to 200°F.
 2. Outdoor installations shall be of a UL 214 Listed UV-resistant Hypalon coated woven fiberglass fabric. Minimum density 24 ounces/sq. yd. and rated to 250°F.
 3. High Temperature Applications shall be a UL 214 Listed, silicone coated satin weave fiberglass fabric. Minimum density 17.5 ounces/sq. yd. and rated to 500°F.
 4. Chemical Resistant Applications shall be of Teflon coated woven fiberglass fabric. Minimum density 18 ounces/sq. yd. and rated to 500°F.
 5. Connector shall be Ductmate Proflex or approved equal.
- I. Duct Damper Access: Where duct balancing dampers are above inaccessible ceilings, provide "Young Regulator" or equal damper extension rods and access panel assemblies in ceilings with flush accessible cover.
1. Provide access doors of adequate size to allow easy access to the equipment that will require maintenance. Provide insulated or acoustical line doors where duct is of the same construction.
 2. Systems designed for 3-inch WC and less (SMACNA Seal Class B or C) shall utilize hinged, cam or hinged and cam square-framed access door.
 3. Systems designed for 4-inch WC and above (SMACNA Seal Class A) shall utilize sandwich-type access door. Construct doors in accordance with Figure 2-10 of the 1995 SMACNA Manual, "HVAC Duct Construction Standards, Metals and Flexible" Second Edition.
 4. Manufacturer to provide an installed neoprene gasket around perimeter of access door for airtight seal.
 5. Grease exhaust duct doors shall be grease and air tight, UL 1978 Listed, meet NFPA 96 (2021) Standards and all Mechanical Codes. Grease duct access door can be sandwich type or with a weld on frame, with/without hinge.
 6. Acceptable Manufacturers: Ductmate Industries, Inc. or approved equal.

2.06 AIR OUTLETS AND INLETS

- A. Diffusers, Registers, and Grilles:
1. General: Except as otherwise indicated, provide manufacturer's standard air diffusers, registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation. Include seal bearing AMCA certified rating.
 2. Performance: Provide air diffusers, registers, and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.
 3. Ceiling and Wall Compatibility: Provide diffusers, registers, and grilles with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling and wall systems which will contain each type of air diffuser, register and grille.
 4. Finish: Diffusers, registers and grilles shall have an off-white factory applied finish, unless shown otherwise.
 5. Dampers and Accessories: See schedule on drawings for required dampers and accessories.
 6. Types: Unless designated herein, provide diffusers, registers, and grilles of type, capacity and with accessories and finishes as listed on schedules and details, shown on drawings.

2.07 LOUVERS

- A. General: Except as otherwise indicated, provide manufacturer's standard louvers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated and as required for complete installation.
- B. Performance: Provide louvers that have 50% minimum free area, and .10-inch maximum pressure drop for each type as listed in manufacturer's current data.
- C. Substrate Compatibility: Provide louvers with frame and sill styles that are compatible with adjacent substrate and that are specifically manufactured to fit into construction openings with accurate fit and adequate support, for weatherproof installation. Refer to general construction drawings and specifications for types of substrate which will contain each type of louver.
- D. Materials: Construct of aluminum extrusions, ASTM B 221, Alloy 6063-T5. Louver shall bear the AMCA Seal. Weld units or use stainless steel fasteners. Louver finish shall be anodized with color to match building window frames. Provide five (5) year warranty on finish.
- E. Louver Screens: On inside face of exterior louvers, provide 1/2-inch square mesh anodized aluminum wire bird screens mounted in removable extruded aluminum frames.
- F. Blade: Blade shall be 6-inches in depth and of drainable type construction for sizes larger than 24-inches x 24-inches. Louver sizes below 24-inches x 24-inches shall have a 4-inch blade depth of drainable construction.
- G. Manufacturer: Provide a Ruskin ELF6375DX (6-inch) or ELF375DX (4-inch) louver or approved equal.

2.08 AIR TERMINALS

- A. General: Provide factory-fabricated and tested air terminals as indicated, selected with performance characteristics which match or exceed those indicated on schedule.
- B. Casing: Construct of die-cast aluminum or sheet metal of the following minimum thicknesses:

	<u>Steel</u>	<u>Aluminum</u>
1. Upstream Pressure Side:	24-gage	0.032-inch
2. Downstream Pressure Side:	26-gage	0.025-inch

 - 3. Provide hanger brackets for attachment of supports.
 - 4. Linings: Line inside surfaces of casings with lining material to provide acoustic performance, thermal insulation, and to prevent condensation on outside surfaces of casing. Provide minimum thickness of 1/2-inch. Secure lining to prevent delamination, sagging or settling.
 - a. Cover liner surfaces and edges with coating or perforated metal.
 - 5. Access: Provide removable panels in casings to permit access to air dampers and other parts requiring service, adjustment or maintenance.
 - a. Provide airtight gasket and quarter-turn latches.
 - 6. Leakage: Construct casings such that when subjected to 0.5-in WC pressure for low pressure units, and 3.0-in WC pressure for high pressure units, total leakage does not exceed 4% of specified air flow capacity with outlets sealed and inlets wide open. Construct air dampers such that when subjected to 6.0-in WC inlet pressure with damper closed, total leakage does not exceed 10% of specified air flow capacity.
- C. Air Dampers: Construct of materials that cannot corrode, do not require lubrication, nor require periodic servicing. Provide maximum volume dampers, both pressure dependent and pressure compensated, that are calibrated in cfm, factory-adjusted, and marked for specified air capacities. Provide mechanism to vary air volume through damper for minimum to maximum, in response to signal from temperature control system.
- D. Hot Water Heating Coils: Provide minimum 2-row heating coil constructed of copper tubes and aluminum fins with galvanized-steel casing.

- E. Controls: Provide controls accurate to 1.5°F and adjustable from 65°F to 85°F.
 - 1. Provide the following minimum control items compatible with Control System.
 - a. Static pressure probes.
 - b. Control power transformer.
 - c. Fan relay.
- F. Identification: Provide label on each unit indicating Plan Number, cfm range, cfm factory-setting, and calibration curve (if required).
- G. Hardware: Provide hardware as detailed and required to complete ceiling system including unit mounting brackets, trim pieces, alignment channels, return air diffusers, dummy diffusers, etc.
- H. Fan Powered Terminals:
 - 1. Fan Section: Provide galvanized-steel plenum, acoustically lined, housing forward curved fan with belt or direct driven permanent split capacitor motor. Provide air filter and backdraft damper.
 - 2. Hot Water Heating Coils: Provide heating coils constructed of copper tubes and aluminum fins with galvanized-steel casing.
 - 3. Electrical Accessories: Provide Box mounted electronic fan speed control and shut-off switch, fan anti-backspin switch, manufacturer mounted, non-fused disconnect switch. Provide single-point electrical connection. Units which have more than one (1) motor shall have a single-point electrical connection and shall have individual short circuit protection (fuse or circuit breaker) provided integral with equipment for each motor.
 - 4. Filters: Provide 1-inch thick throw-away filters on plenum air inlet opening.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions under which air distribution systems will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Engineer.

3.02 INSTALLATION OF AIR FILTERS

- A. Install air filters and holding devices of types indicated, and where shown; in accordance with air filter manufacturer's written instructions and with recognized industry practices; to ensure that filters comply with requirements and serve intended purposes.
- B. Locate each filter unit accurately in position indicated, in relation to other work. Position unit with sufficient clearance for normal service and maintenance. Anchor filter holding frames securely to substrate.
- C. Install air filter gage pressure taps upstream and downstream of filters to indicate air pressure drop through air filter. Mount filter gages on outside of filter housing or filter plenum, in accessible position. Adjust and level inclined gages if any, for proper readings.

3.03 INSTALLATION OF METAL DUCTWORK

- A. General: Assemble and install ductwork in accordance with recognized industry practices which will achieve air tight (5% leakage for systems rated 3-inches WC and under; 1% for systems rated over 3-inches WC) and noiseless (no objectionable noise) systems, capable of performing each indicated service. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling. Support vertical ducts at every floor. Comply with all SMACNA HVAC Duct Construction Standards.
- B. The Contractor shall form and erect all ductwork to avoid joists, beams, pipes, light fixtures, etc., and shall maintain fixed ceiling heights and clearances. Provide all drops, raises or offsets in ductwork as required by conditions at building.

- C. All openings for ductwork in new and existing construction shall be provided by the General Contractor; however, it shall be this Contractor's responsibility to properly layout and locate all openings required for the installation of these items. All patching and refinishing shall be done in a manner satisfactory to the Architect.
- D. Sealing of Rectangular Ductwork: All transverse joints and longitudinal seams shall conform to SMACNA's Class A sealing requirements as defined on Page 1-8, of the 1995 SMACNA Manual, Second Edition.
- E. Flexible Ducts: Maximum installed length (from diffuser or grille to sheet metal ductwork), shall be 3-feet-0-inches.
- F. Underslab Ductwork: Underslab ductwork shall be encased in sand fill or concrete all around outside areas of the duct system as indicated.
 - 1. Install underslab ducts in accordance with SMACNA "HVAC Metal Duct Construction Standards," Figures 3-11 and 3-12 and as indicated.
 - 2. Protect ducts from damage by powered vibrators and other equipment used in placement of concrete on or around ducts.
 - 3. Provide temporary protection for duct openings.
- G. Penetrations: Where ducts pass through interior partitions and exterior walls, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gage as duct. Overlap opening on four (4) sides by at least 1-1/2-inch. Fasten duct and substrate.
 - 1. Where ducts pass through fire-rated floors, walls or partitions, provide firestopping between duct and substrate.

3.04 INSTALLATION OF HDPE DUCTWORK

- A. General: Assemble and install HDPE plastic ductwork in accordance with manufacturer's recommendations. Provide gasketed seals with screws or clamps. Pressure test ductwork according to manufacturer's testing procedures.
- B. Direct Buried Ducts: For ductwork placed under slabs on grade or direct buried, provide sand or light aggregate bedding material and pea gravel or sand backfill material. Thoroughly tamp buried duct in place.
 - 1. Protect ducts from damage by powered vibrators and other equipment used in placement of concrete on or around ducts.
 - 2. Provide temporary protection for duct openings.

3.05 INSTALLATION OF KITCHEN EXHAUST DUCTS

- A. General: Fabricate joints and seams with continuous welds for watertight construction. Provide for thermal expansion of ductwork through 2000°F temperature range. Install without dips or traps which may collect residues, except where traps have continuous or automatic residue removal. Provide access openings at each change in direction, located on sides of duct 1-1/2-inch minimum from bottom and fitted with grease tight covers of same material as duct.

3.06 DISHWASHER EXHAUST DUCT INSTALLATIONS

- A. Install dishwasher exhaust duct systems in accordance with SMACNA "HVAC Duct Construction Standards, Metal and Flexible" Figure 2-18. Grind smooth excess weld material and deburr exposed corners and ends. Provide a #4 architectural finish polished with a 120-180 grit belt.

3.07 INSTALLATION OF DUCTWORK ACCESSORIES

- A. Install ductwork accessories in accordance with manufacturer's installation instructions, with applicable portions of details of construction as shown in SMACNA Standards and in accordance with recognized industry practices to ensure that products serve intended function.

- B. At each branch takeoff of supply, return and exhaust systems provide manual volume damper. Provide additional dampers where indicated on drawings. Dampers shall be at least one (1) gage heavier than ducts in which installed, have stiffened edges, shall operate freely and not rattle in any position. Each damper shall have accessible indicating locking quadrant. For concealed quadrants provide 6-inch diameter hand access opening with cover plate flush with finish surface.
- C. Install turning vanes in square or rectangular 90 degree elbows in supply and exhaust air systems, and elsewhere as indicated.
- D. Install fire and smoke dampers according to the manufacturer's UL Approved printed instructions. Install access door in ductwork per UL and NFPA requirements. Provide approved ductwork access doors on one (1) side of wall.
- E. Install fusible links in fire dampers.

3.08 INSTALLATION OF FIBERGLASS DUCT LINER

- A. General: Install duct liner in accordance with NAIMA FGDLS SMACNA HVAC Duct Construction Standards. Duct liner thicknesses and locations are specified in duct insulation schedule on drawings. Where duct liner is required the sizes shown on drawings shall be inside clear of liner.

3.09 INSTALLATION OF NON-FIBROUS DUCT LINER

- A. General: Install non-fibrous duct liner in accordance with manufacturer's recommendations. Duct liner thicknesses and locations are specified in duct insulation schedule on drawings. Where duct liner is required the sizes shown on drawings shall be inside clear of liner.

3.10 INSTALLATION OF DUCT LAGGING MATERIAL

- A. General: Install duct lagging noise barrier material around pipe or duct in accordance with manufacturer's recommendations. Fasten material with adhesive, tape, mechanical fasteners or bands.

3.11 SEAM AND JOINT SEALING

- A. General: Seal duct seams and joints as follows:
- B. Pressure Classifications Greater Than 3-Inch WC: All transverse joints, longitudinal seams, and duct penetrations.
- C. Pressure Classification 2 and 3-Inch WC: All transverse joints and longitudinal seams.
- D. Pressure Classification Less than 2-Inch WC: Transverse joints only.
- E. Seal externally insulated ducts prior to insulation installation.

3.12 CONNECTIONS

- A. Equipment Connections: Connect equipment with flexible connectors in accordance with manufacturer's recommendations.
- B. Branch Connections: Comply with SMACNA "HVAC Duct Construction Standards," Figures 2-5 and 2-6.
- C. Outlet and Inlet Connections: Comply with SMACNA "HVAC Duct Construction Standards," Figures 2-14 through 2-16.
- D. Terminal Units Connections: Comply with SMACNA "HVAC Duct Construction Standards," Figure 2-17.

3.13 INSTALLATION OF AIR OUTLETS AND INLETS

- A. General: Install air outlets and inlets in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended functions.
- B. Locate diffusers, registers and grilles in center of acoustical ceiling modules.
- C. Repair all marred surfaces with manufacturer's touch-up paint.

3.14 INSTALLATION OF LOUVERS

- A. General: Install louvers in accordance with manufacturers written instructions and in accordance with recognized industry practices to insure that product serves intended functions.

3.15 HIGH AND MEDIUM PRESSURE DUCT SYSTEM LEAKAGE TEST

- A. Each section of high and medium pressure ductwork (systems over 2-inch WC and 2000 FPM velocity) shall be tested for leakage prior to being insulated. Leakage test shall be in accordance with Chapter 10 of the SMACNA high velocity duct manual and as follows:
- B. Test apparatus shall consist of the following:
 - 1. A portable source of high pressure air with pressure and volume control capabilities.
 - 2. A flow measuring device consisting of an orifice assembly with straightening vanes and an orifice plate mounted in a straight tube with properly located pressure taps. Each orifice assembly shall be calibrated with its own calibration curve. Pressure and flow readings taken with U-tube manometers.
- C. Test Procedure:
 - 1. Test for audible leaks as follows:
 - a. Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a section of flexible duct.
 - b. Start the blower with its control damper closed.
 - c. Gradually open the inlet damper until the duct pressure reaches 2-inches WC in excess of designed duct operating pressure.
 - d. Survey all joints for audible leaks. Mark each leak and repair after shutting down blower. Do not apply a retest until sealants have set.
 - 2. After all audible leaks have been sealed, the remaining leakage should be measured with the orifice section of the test apparatus as follows:
 - a. Start blower and open damper until pressure in duct reaches 2-inches WC in excess of designed duct operating pressure and read orifice section flow rate.
 - b. Total allowable leakage should not exceed 1% of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.

3.16 INSTALLATION OF AIR TERMINALS

- A. General: Install air terminals as indicated, and in accordance with manufacturer's installation instructions.
- B. Location: Install each unit level and accurately in position indicated in relation to other work; and maintain sufficient clearance for normal service and maintenance, but in no case less than that recommended by manufacturer.

3.17 INSTALLATION OF DUCT MOUNTED SMOKE DETECTORS

- A. Detectors shall be furnished and wired by Electrical Contractor. Mechanical Contractor shall install the detectors in the metal ductwork maintaining accessibility of the detectors for cleaning and service. Installation shall comply with manufacturer's recommendations.

3.18 CLEANING

- A. Clean ductwork internally, unit-by-unit as it is installed, of dust and debris.
- B. Clean external surfaces of foreign substances that might cause corrosion, deterioration of the metal or where ductwork is to be painted.
- C. Interior surfaces shall be free of dust and debris prior to initial startup.

END OF SECTION

SECTION 233113
METAL DUCTS**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Section Includes:
1. Single-wall rectangular ducts and fittings.
 2. Double-wall rectangular ducts and fittings.
 3. Single-wall round ducts and fittings.
 4. Single-wall spiral round and flat-oval ducts and fittings.
 5. Double-wall spiral round and flat-oval ducts and fittings.
 6. Sheet metal materials.
 7. Duct liner.
 8. Sealants and gaskets.
 9. Hangers and supports.

1.03 SUBMITTALS

- A. Product Data: For each type of the following products:
1. Liners, adhesives, and sealants.
 2. Double-wall ducts and fittings.
- B. LEED Submittals:
1. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
 2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."
 3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1-2004, Section 6.4.4.2.2 - "Duct Leakage Tests."
 4. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1-2004, Section 7.2.4 - "Ventilation System Start-Up."
 5. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
- C. Coordination Drawings: Ductwork plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Penetrations of smoke barriers and fire-rated construction.
 2. Items penetrating finished ceiling including, but not limited to, the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.

- f. Cable tray.

1.04 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
- B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 PRODUCTS

2.01 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.02 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. McGill AirFlow LLC.
 - 2. Sheet Metal Connectors, Inc.
 - 3. Or equal as approved by Owner.
- B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.
- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A (2021), or NFPA 90B (2021); and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x° F at 75° F mean temperature.

2. Cover insulation with polyester film complying with UL 181, Class 1.
- G. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A (2021) or NFPA 90B (2021).
 1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x ° F at 75° F mean temperature.
- H. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch diameter perforations, with overall open area of 23%.

2.03 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Longitudinal Seams: Fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 1. Seam type shall be one of the following:
 - a. RL-2 or RL-3 – Lap and Rivet or Tack weld
 - b. RL-4 – Butt weld or Lap and Seam weld.
 - c. RL-5 – Grooved Seam, Pipe lock, Flat lock, Pittsburgh lock.
 2. Snap-lock seams are not acceptable.
- E. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eastern Sheet Metal.
 - b. Lewis & Lambert.
 - c. Lindab Inc.
 - d. McGill AirFlow LLC
 - e. Norlock.
 - f. SEMCO Incorporated.
 - g. Sheet Metal Connectors, Inc.
 - h. Spiral Pipe of Texas.
 - i. W.E.S.C.O.
 - j. Wichita Sheet Metal.
 - k. Or equal as approved by Owner.

- F. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- G. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in exposed ductwork: Beaded sleeve slip joint or Keating coupling by Ward Industries, or approved equal.
 - 2. Transverse Joints in Ducts Larger Than 60-Inches in Diameter: Flanged.
- H. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Longitudinal seams in exposed ductwork: Spiral lockseam.
 - 2. Fabricate round ducts larger than 60-inches in diameter with butt-welded or grooved seam/pipe lock longitudinal seams.
 - 3. Fabricate flat-oval ducts larger than 60-inches in width (major dimension) with butt-welded or grooved seam/pipe lock longitudinal seams.
- I. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.04 DOUBLE-WALL SPIRAL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eastern Sheet Metal.
 - 2. Lewis & Lambert.
 - 3. Lindab Inc.
 - 4. McGill AirFlow LLC.
 - 5. Norlock
 - 6. SEMCO Incorporated.
 - 7. Sheet Metal Connectors, Inc.
 - 8. Spiral Pipe of Texas.
 - 9. W.E.S.C.O.
 - 10. Wichita Sheet Metal.
 - 11. Or equal as approved by Owner.
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Transverse Joints in exposed ductwork: Beaded sleeve slip joint or Keating Coupling by Ward Industries, or approved equal.
 - b. Transverse Joints in Ducts Larger Than 60-Inches in Diameter: Flanged.
 2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Longitudinal seams in exposed ductwork: Spiral lockseam.
 - b. Fabricate round ducts larger than 60-inches in diameter with butt-welded or grooved seam/pipe lock longitudinal seams.
 - c. Fabricate flat-oval ducts larger than 60-inches in width (major dimension) with butt-welded or grooved seam/pipe lock longitudinal seams.
 3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch diameter perforations, with overall open area of 23%.
- E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A (2021), or NFPA 90B (2021); and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x ° F at 75° F mean temperature.
 2. Cover insulation with polyester film complying with UL 181, Class 1.
- F. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A (2021) or NFPA 90B (2021).
1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x ° F at 75° F mean temperature.

2.05 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
1. Galvanized Coating Designation: G90 (Z275).
 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
1. Galvanized Coating Designation: G90 (Z275).

2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil thick on opposite surface.
3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.
- D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- F. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- G. Factory- or Shop-Applied Antimicrobial Coating:
 1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
 2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 5. Shop-Applied Coating Color: White.
 6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
- H. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- I. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36-inches or less; 3/8-inch minimum diameter for lengths longer than 36-inches.

2.06 HDPE PLASTIC DUCTWORK

- A. HDPE Plastic Ductwork: For ductwork installed under slabs on grade or direct buried, ductwork shall be fabricated of high density polyethylene (HDPE) integrally insulated plastic. Fittings, boots and duct section connectors shall be fabricated with HDPE. Joints shall be gasketed and sealed according to manufacturer's recommendations.
- B. Acceptable Manufacturer: CDC Enterprises Akduct or approved equal.

2.07 DUCT LINER

- A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A (2021), or NFPA 90B (2021); and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation; Insulation Group.
 - b. Johns Manville.
 - c. Knauf Insulation.
 - d. Owens Corning.
 - e. Or equal as approved by Owner.

2. Maximum Thermal Conductivity:
 - a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x ° F at 75° F mean temperature.
 - b. Type II, Rigid: 0.24 Btu x in./h x sq. ft. x ° F at 75° F mean temperature.
 3. Noise Reduction Coefficient (NRC) at 1-inch thickness: 0.70.
 4. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 5. Water-Based Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A (2021) or NFPA 90B (2021).
- B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet material complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A (2021) or NFPA 90B (2021).
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA Inc.
 - b. Armacell LLC.
 - c. Rubatex International, LLC
 - d. Or equal as approved by Owner.
 2. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x ° F at 75° F mean temperature.
 3. Noise Reduction Coefficient (NRC) at 1-inch thickness: 0.50.
 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 5. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A (2021) or NFPA 90B (2021).
- C. Flexible Polyester Duct Liner: Preformed polyester sheet material with FSK facing complying with ASTM C518, and with NFPA 90A (2021) or NFPA 90B (2021).
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ductmate.
 - b. Or equal as approved by Owner.
 2. Maximum Thermal Conductivity: 0.20 Btu x in./h x sq. ft. x ° F at 75° F mean temperature.
 3. Noise Reduction Coefficient (NRC) at 1-inch thickness: 0.65.
 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 5. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A (2021) or NFPA 90B (2021).
- D. Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2-inches in diameter.
- E. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

2.08 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Water-Based Joint and Seam Sealant:
 - 1. Application Method: Brush on.
 - 2. Solids Content: Minimum 65%.
 - 3. Shore A Hardness: Minimum 20.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. VOC: Maximum 75 g/L (less water).
 - 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 - 8. Service: Indoor or outdoor.
 - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- C. Flanged Joint Sealant: Comply with ASTM C 920.
- D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- E. Round Duct Joint O-Ring Seals:
 - 1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
 - 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 - 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.09 HANGERS AND SUPPORTS

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

PART 3 EXECUTION**3.01 PERFORMANCE REQUIREMENTS**

- A. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

3.02 DUCT INSTALLATION

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

3.03 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.
- F. Provide paintable surface finish for ducts designated to be field painted.

3.04 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2% to drain grease back to the hood.
- B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2-inches from bottom of duct.
- C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.05 DUCT SEALING

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

3.06 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24-inches of each elbow and within 48-inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.07 CONNECTIONS

- A. Make duct connections to equipment with flexible connectors.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.
- C. Provide duct transition fittings as required to connect branch ductwork to diffusers, registers, grilles and terminal units.

3.08 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.
- B. Provide paint grip finish on all exposed ductwork that is designated for field painting. Coordinate with General Contractor.

3.09 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

3. Test for leaks before applying external insulation.
 4. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
- C. Duct system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.10 DUCT CLEANING

- A. Clean interior surfaces of new and re-used existing duct system(s) of all dust and debris before testing, adjusting, and balancing and prior to initial system start up. Clean ductwork as it is installed and seal open ducts during construction.
- B. Clean exterior surfaces of new and re-used existing duct system(s) of foreign substances that could cause corrosion or deterioration of the ductwork; and where ductwork is designated to be painted.

3.11 START UP

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

3.12 DUCT SCHEDULE (Unless otherwise indicated, construct ducts according to the following:)

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
- B. Round and Flat-Oval exposed ductwork: Spiral lockseam.
- C. Underground Ducts: PVC-coated, spiral galvanized sheet steel with 4 MIL coating of PVC on the exterior and 1 MIL coating of PVC on the interior. Joints shall have 4 MIL coating of PVC.
- D. Supply Ducts:
1. Supply Air Ducts (unless otherwise indicated):
 - a. Pressure Class: Positive 2-inch wg.
 - b. Minimum SMACNA Seal Class: B.
 2. Ducts Connected Downstream of Air Terminal Units:
 - a. Pressure Class: Positive 2-inch wg.
 - b. Minimum SMACNA Seal Class: B.
 3. Ducts Connected Upstream of Air Terminal Units:
 - a. Pressure Class: Positive 3-inch wg.
 - b. Minimum SMACNA Seal Class: B.
- E. Return Ducts:
1. Return Air Ducts (unless otherwise indicated):
 - a. Pressure Class: Negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: B.
- F. Exhaust Ducts:
1. Exhaust Air Ducts (unless otherwise indicated):
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. Minimum SMACNA Seal Class: B.
 2. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96 (2021).
 - a. Exposed to View: Type 304, stainless-steel sheet, 18 gauge, No. 4 finish.
 - b. Concealed: Carbon-steel sheet, 16 gauge.
 - c. Welded seams and joints.

- d. Pressure Class: Negative 3-inch wg.
- e. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
- 3. Ducts Connected to Dishwasher Hoods:
 - a. Type 304, stainless-steel sheet, 18 gauge.
 - b. Exposed to View: No. 4 finish.
 - c. Concealed: No. 2D finish.
 - d. Welded seams and flanged joints with watertight EPDM gaskets.
 - e. Pressure Class: Positive or negative 3-inch wg.
 - f. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
- 4. Ducts Connected to Fans Exhausting Laboratory and Process (ASHRAE 62.1, Class 3 and 4) Air:
 - a. Type 316 or Type 304, stainless-steel sheet, 18 gauge.
 - (1) Exposed to View: No. 4 finish.
 - (2) Concealed: No. 2D finish.
 - b. Pressure Class: Positive or negative 3-inch wg.
 - c. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
- G. Outdoor-Air and Ventilation Air Ducts:
 - 1. Outside Air and Ventilation Air Ducts:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: B.
- H. Duct Liner: Refer to Division 23 Section "Mechanical Insulation".
- I. Elbow Configuration:
 - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 centerline radius-to-width ratio.
 - b. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Round Elbows, 12-Inches and Smaller in Diameter: Stamped or pleated with minimum 1.5 centerline radius-to-diameter ratio
 - b. Round Elbows, 14-Inches and Larger in Diameter: Standing seam or welded with minimum 1.5 centerline radius-to-diameter ratio.
- J. Branch Configuration:
 - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connections."
 - a. Rectangular Main to Rectangular Branch: Factory fabricated 45-degree take-off fitting with sealed joints and seams.
 - b. Rectangular Main to Round Branch: Factory fabricated straight-sided high efficiency take-off fitting with sealed joints and seams and gasketed flange.

2. Round and Flat Oval Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 fpm or Higher: 45-degree lateral or conical tap.

END OF SECTION

SECTION 237200
AIR-TO-AIR ENERGY RECOVERY EQUIPMENT**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Section Includes:
 - 1. Packaged energy recovery units (with heating and/or cooling).

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Closeout Submittals:
 - 1. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.04 ELECTRICAL COORDINATION

- A. Provide the following electrical work as work of this section, in compliance with electrical specifications:
 - 1. Control and interlock wiring between operating controls, indicating devices and unit control panels.
- B. See Mechanical/Electrical Coordination Schedule on drawings for further clarification.

1.05 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 (2020), by a qualified testing agency, and marked for intended location and application.
- B. AHRI Compliance:
 - 1. Capacity ratings for air-to-air recovery equipment shall comply with AHRI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
 - 2. Capacity ratings for air coils shall comply with AHRI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils."
- C. ASHRAE Compliance:
 - 1. Applicable requirements in ASHRAE 62.1-2004, Section 5 – "Systems and Equipment" and Section 7 – "Construction and Startup."
 - 2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."
- D. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.
- E. UL Compliance:
 - 1. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Non-ducted Heat Recovery Ventilators."

2. Electric coils shall comply with requirements in UL 1995, "Heating and Cooling Equipment."

1.06 COORDINATION

- A. Coordinate layout and installation of air-to-air energy recovery equipment and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression systems, and partition assemblies.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.
- C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.07 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
 1. Warranty Period for Packaged Energy Recovery Units: Two years.
 2. Warranty Period for Fixed-Plate Total Heat Exchangers: 10 years.
 3. Warranty Period for Compressors and Control Boards: Five years.

1.08 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: One set of each type of filter specified.

PART 2 PRODUCTS

2.01 PACKAGED ENERGY RECOVERY UNITS (WITH HEATING AND/OR COOLING)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Aeon.
 2. Addison.
 3. Greenheck.
 4. GovernAir.
 5. Trane.
 6. Venmar CES, Inc.
 7. Or equal as approved by Owner.
- B. General:
 1. Factory assembled and tested unit designed specifically for air to air energy recovery application. Consisting of compressors, water cooled condensers (heat pump circuit), evaporator coils, condenser and evaporator and exhaust fans, energy recovery wheel, refrigeration, controls, filters and dampers all incorporated into a single factory assembled package.
 2. Sound Power Level Ratings: Comply with AHRI 270, "Standard for Sound Rating of Outdoor Unitary Equipment."
 3. Units shall be safety certified by an accredited testing laboratory in accordance with UL Standard UL4565 and ANSI Standard Z21.47. . Unit nameplate shall carry the label of the certification agency.
 4. Unit shall be completely factory assembled, piped, wired, and shipped in one piece by the manufacturer including all standard items and optional items.
 5. Unit shall be 100% run tested by the manufacturer with a copy of the run test report shipped with the unit.

6. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
- C. Housing:
1. General: Manufacturer's standard construction with corrosion-protection coating and exterior finish, hinged access doors with neoprene gaskets for inspection and access to internal parts, minimum 2-inch thick fiberglass or urethane foam insulation (minimum R-13 value), knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.
 2. Outdoor units shall be specifically designed for outdoor rooftop application with a fully weatherproof cabinet.
 3. Cabinet shall be constructed entirely of G90 galvanized metal with 16-gauge corner posts and top panels constructed of 18-gauge or heavier material.
 4. The unit roof shall be cross broken and/or sloped assure drainage.
 5. Unit shall be equipped with double wall insulated service access panels mounted with stainless steel hinges and equipped with 1/4-turn cam operated adjustable latches, minimum 24-inch clear opening.
 6. Unit constructed of hot-dipped G90 chemically treated with zinc phosphate, coated with primer and finished with top coat. Unit shall meet or exceed 1,000 hr. salt spray test per ASTM B 11897.
 7. Cabinet shall be mounted on corrosion-protected steel rails with integral lifting lugs to facilitate installation.
- D. Energy Recovery Device: Fixed-plate heat exchanger.
- E. Filters:
1. Comply with NFPA 90A (2021).
 2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 3. Disposable Panel Filters:
 - a. Minimum Merv: 5, according to ASHRAE 52.2.
 4. Extended-Surface, Disposable Panel Filters:
 - a. Minimum Merv: 8, according to ASHRAE 52.2.
- F. Refrigerant System:
1. General: System shall include the compressor, crankcase heater, copper tube-aluminum plate-fin evaporator air coils, accumulator and coaxial type water-to-refrigerant heat exchanger. The refrigerant circuit shall include the filter-drier, high pressure safety control (manual reset), low pressure safety control/loss of charge protector (auto-reset), sight glass-moisture indicator, dual gauge connections for high and low pressure readings, liquid line pressure tap to facilitate refrigerant recovery and thermal expansion valve with adjustable superheat.
 2. Provide hot gas bypass on the lead compressor circuit where indicated. The bypass valve shall reduce compressor capacity to between 25% and 50%.
 3. Cooling Coils: Rated according to AHRI 410, AHRI 210/240 or AHRI 360 and ASHRAE 33 and bearing the AHRI label.
 4. Access: Fabricate coil section to allow removal and replacement of coil to allow in-place access for service and maintenance of coil(s).
 5. Units shall have hot gas reheat coil for operation on both refrigerant circuits (face-split) with modulating hot gas reheat valve. Provide water regulating valves on the water side to maintain minimum head pressure for reheat capacity.

6. Safety controls shall include an anti-short cycle timer on the lead compressor. Unit shall have face split coils for maximum dehumidification at part load cooling conditions.
- G. Condensate Drain Pans:
 1. Fabricated from stainless-steel sheet and sloped in multiple planes to collect and drain condensate from cooling coils, coil piping connections, coil headers, and return bends.
 2. Bottom insulated with closed cell neoprene insulation.
 3. Complying with requirements in ASHRAE 62.1-2004.
 4. Drain Connections: At low point of pan with threaded nipple.
 5. Units with stacked coils shall have an intermediate drain pan to collect and drain condensate from top coil.
- H. Electrical Coils, Controls, and Accessories: Comply with UL 1995.
 1. Casing Assembly: Slip-in or flanged type with galvanized-steel frame.
 2. Access: Fabricate coil section to allow removal and replacement of coil to allow in-place access for service.
 3. Sheathed Heating Elements: Coiled resistance wire of 80% nickel and 20% chromium surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to death.
 4. Open Heating Elements: Resistance wire of 80% nickel and 20% chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supported brackets, and mounted in galvanized-steel frame.
 5. Over temperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 6. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 7. Control Panel: Unit mounted with disconnecting means and overcurrent protection.
 - a. Solid-state, stepless pulse controller.
 - b. Toggle switches, one per step.
 - c. Step controller.
 - d. Time-delay relay.
 - e. Pilot lights, one per step.
 - f. Airflow proving switch.
- I. Evaporator Blower and Motor:
 1. Blower shall be statically and dynamically balanced, un-housed, airfoil or backward-inclined centrifugal plenum fan. The blower wheel shall be mounted on a solid steel shaft supported by sealed ball bearings. The standard blower assembly shall be mounted on spring isolators.
 2. The shaft shall be belt driven with adjustable drive sheave connected to nominal 1725 RPM open drip-proof motor with sealed ball bearings. The bearings on both the blower shaft and motor shall be permanently lubricated.
 3. Standard motors up to three horsepower shall be internally protected (auto-reset).
 4. Motors five horsepower and larger and high-efficiency motors shall be externally protected (manual reset).
- J. Air Intake: Outside air intake shall be through a 2-position motor operated outdoor air damper and return air damper constructed of extruded aluminum, air foil blades with rubber edge seals and aluminum end seals.

- K. Variable Frequency Controllers: Unit shall be furnished with variable frequency controllers for supply and exhaust fan motors. VFC's shall be factory installed and wired, mounted in the unit with service access doors.
- L. Weather Hoods: Outdoor units shall be furnished with weather hoods and bird screens on all exposed air inlets and outlets. Hoods shall be shipped loose for field installation.
- M. Electrical Power: Entire energy recovery unit shall have single point power connection with a single unit mounted disconnect. Unit shall be provided with phase and brown-out protection to shut down all motors in the unit if the phases are more than 10% out of balance on voltage or the voltage shall be more than 10% under design voltage. Unit shall be provided with a factory installed and wired 115-volt, 13-amp ground fault service receptacle.
 - 1. Electric Motors: Provide premium efficiency type NEMA MG 1, general purpose, continuous duty, open, drip-proof design.
- N. Control System:
 - 1. The energy recovery unit shall be equipped with a factory installed, programmed and run-tested direct digital control (DDC) controller and necessary sensors to provide control of post conditioning coil functions and unit operation. All controls shall be solid state components. Post conditioning valves, piping components and controls of coils shall be field supplied. Controller shall be mounted in a panel with an integral door interlocking disconnect.
 - 2. The energy recovery unit manufacturer shall provide a direct communication interface as an integral part of the system. The communication interface shall be BACnet, LonWorks or others as determined by the Owner. Any interface to convert from any communication driver to the Owner's building management system shall be the responsibility of ERV unit manufacturer. The communication interface shall transmit to and receive data acquisition points from the energy recovery unit as specified in the Sequence of Operation I/O Summary.
- O. Piping and Wiring: Fabricate units with space within housing for piping and electrical conduits. Wire motors and controls so only external connections are required during installation.
 - 1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
 - 2. Outdoor Enclosures: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
 - 3. Include nonfused disconnect switches.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or molded damaged.
- C. Examine roughing-in for electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install fixed-plate heat exchangers so supply and exhaust airstreams flow in opposite directions.
 - 1. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to heat exchanger.
- B. Install ground-mounted units on 6-inch high concrete base.

- C. Install units with clearances for service and maintenance.
- D. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.03 CONNECTIONS

- A. Install piping adjacent to unit to allow service and maintenance.
- B. Connect piping to units mounted on vibration isolators with flexible connectors.
- C. Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.
- D. Electrical Connections: Comply with applicable requirements in Division 26 Sections.
 - 1. Install electrical devices furnished with units but not factory mounted.

3.04 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections:
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Tests and Inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Adjust seals and purge.
 - 3. Test and adjust controls and safeties: Replace damaged and malfunctioning controls and equipment.
 - 4. Set initial temperature and humidity set points.
 - 5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.05 DEMONSTRATION

- A. Engage a factory –authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION

SECTION 238140**VARIABLE REFRIGERANT FLOW EQUIPMENT AND SYSTEMS****PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Section includes variable refrigerant flow (VRF) air conditioning equipment.
 - 1. Outdoor and indoor compressor/heat exchanger units,
 - 2. Indoor fan/coil units,
 - 3. Refrigerant branch circuit controllers.
 - 4. Direct digital controls
 - 5. Special pipe fittings, and other related materials.
- B. Sections includes VRF systems:
 - 1. Capabilities of heating and cooling (heat pump) and heat recover operation.
 - 2. Water and air source compressor/heat exchanger units.
 - 3. VRF zoning system for simultaneous cooling and heating split system heat pumps.
 - 4. Integral equipment controls and microprocessors for independent or group control of indoor units.

1.03 RELATED REQUIREMENTS

- A. Division 23 "Common HVAC Materials and Requirements".
- B. Division 23 "HVAC General Provisions".
- C. Division 23 "HVAC Insulation".
- D. Division 23 "Building Management and Control System".

1.04 DEFINITIONS

- A. Air-source compressor/heat exchanger units. Contains outdoor refrigerant compressor(s) refrigerant/air coil(s), fan(s) including refrigerant & oil management.
 - 1. Units manage system loads and heating – cooling operation.
- B. Branch circuit controllers interchangeably referred to as heat recovery units or branch selector boxes. Contains refrigerant directional control valves and valving heaters to and from outdoor and indoor units. Controllers direct refrigerant flow for heating or cooling and heat recover for each indoor fan/coil unit based on zone requirements.
- C. Indoor fan/coil units. Contains coil for cooling/heating and fan to circulate air to conditioned space. Units meter refrigerant flow and can vary fan speeds to maintain zone temperature and humidity requirements.
- D. Brushless digitally controlled (BLDC).
- E. Electronic controlled expansion valves (EEV).

1.05 PERFORMANCE REQUIREMENTS

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of variable refrigerant flow zoning systems, of types and capacities required, whose products have been in satisfactory use in similar service for not less than five (5) years .

- B. The systems shall be designed by a factory-authorized certified VRF system designer and installed by a factory-authorized certified VRF installer, and verified with a completed commissioning report submitted to the manufacturer's service department. The mandatory contractor service and install training shall be performed by the manufacturer.

1.06 QUALITY ASSURANCE

- A. Comply with NFPA 70 (2020).
- B. ASHRAE 62.1 Compliances: Applicable requirements in ASHRAE 62.1, Section 5 – “Systems and Equipment” and Section 7 – “Construction and Startup.”.
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 – “Heating, Ventilating and Air-Conditioning”.
- D. ASHRAE 15 Compliance: Applicable requirements in ASHRAE 15 – “Safety Standards for Refrigeration Systems”.
- E. Units listed by Electrical Laboratories and bear the ETL label.
- F. Wiring in accordance with the National Electrical Code.
- G. Units manufactured in a facility registered to ISO 9001 and ISO 14001.
- H. Comply with AHRI Standard 1230 – “Performance rating or VRI multisplit air conditioning and heat pump equipment.
- I. Comply with Division 23 HVAC General Provisions for equipment certification requirements.
- J. Comply with UL 1995 for duct-system connections.

1.07 SUBMITTALS

- A. Product Data: Manufacturer's technical product data, including:
 - 1. Rated capacities of selected model clearly indicated,
 - 2. Dimensions.
 - 3. Required clearances, weights.
 - 4. Furnished specialties and accessories
 - 5. Installation and start-up instructions.
- B. Submittals:
 - 1. Detailed mounting, securing, and flashing of the units to the roof structure. Indicate coordinating requirements with roof membrane system.
 - 2. Project-specific piping diagram arrangements include total piping lengths, sizes, and refrigerant quantities clearly indicated. Drawing shall be to scale and reflect coordination with all other trades and disciplines.
 - 3. Manufacturer's wiring diagrams electrical requirements for power supply wiring for variable refrigerant flow zoning systems.
 - 4. Manufacturer's ladder-type wiring diagrams for interlock and control wiring. Differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- C. Close-Out Data:
 - 1. Operation and Maintenance data and parts list for each type and size unit, accessory and control. Include "troubleshooting" maintenance guide, servicing guide, and preventive maintenance schedule and procedures.
 - 2. Field test reports and inspections, leak tests, operation tests and adjustments.
- D. Maintenance Materials: Furnish extra materials described below. Match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: One (1) set of filters for each indoor unit (where applicable).

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Store and handle units according to the manufacturer's recommendation.

1.09 WARRANTY

- A. Provide units covered by an extended manufacturer's limited warranty for a period of five (5) years from date of installation.
- B. During this period, if any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired by the manufacturer. Warranty does not include labor.

1.10 ELECTRICAL COORDINATION

- A. Refer to Division 26 Sections for the following:
 - 1. Power supply wiring from power source to power connection on variable refrigerant flow zoning systems.
- B. Provide the following electrical work as work of this section, complying with requirements of Division 26 Sections:
 - 1. Electrical disconnect switches.
- C. See Mechanical/Electrical Coordination Schedule on drawings for further clarification.

PART 2 PRODUCTS**2.01 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Daikin.
 - 2. LG.
 - 3. Mitsubishi Electronics America, Inc.
 - 4. Samsung.
 - 5. Trane.
 - 6. Or equal as approved by Owner.

2.02 AIR-SOURCE COMPRESSOR/HEAT EXCHANGER UNITS

- A. General: Units factory assembled, piped, wired and tested at the factory.
 - 1. Units designed for roof or garage mounting and outdoor weather conditions.
 - 2. Units equipped with multiple circuit boards that interface to the controls system and perform functions necessary for operation.
 - 3. Sound rating no higher than 60dB (A) as measured from all sides.
 - 4. Include accumulator with refrigerant level sensors and controls.
 - 5. Include high efficiency oil separator, retention, storage and logic controls to ensure compressor oil volume is maintained.
 - 6. The maximum allowable system combination ratio associated with the unit shall be 130%.
 - 7. Unit capable of performing continuous operation when an indoor fan/coil unit is being serviced or is disconnected.
 - 8. On heat recovery type systems, unit shall be capable of continuous operation in heating mode while exposed to an outdoor temperature range between -30°F and 61° F.
 - 9. On heat recovery type systems, unit shall be capable of continuous operation in cooling mode while exposed to an ambient (outdoor) temperature range between 40°F db and 122° F db.
- B. Unit Cabinet:
 - 1. Fabricated of galvanized steel G-90 sheet finished with powder coated baked enamel.

2. Removable inspection and service panels.
- C. Fan Assembly:
 1. Equipped with one or more direct-drive variable speed propeller fan(s).
 2. Fan blades stamped and formed aluminum.
 3. Motor BLDC type with inherent protection, permanently lubricate and sealed bearings, variable speed and maximum speed 1,100 RPM.
 4. Adjustable fan static pressure through dip switch and maximum 0.25" to 0.30" WG.
 5. Fan guard.
- D. Heat Exchanger Coil:
 1. Aluminum fins mechanically bonded on copper tubing, with factory-applied corrosion resistant coating.
 2. Minimum 3 rows.
 3. Include an integral coil guard.
 4. Include refrigerant circuits and bypass circuits for control of refrigerant pressures.
- E. Compressor:
 1. Equipped with one or more inverter driven scroll hermetic compressor(s) for linear capacity operation down to 10%.
 2. Include a crankcase heater factory mounted on the compressor.
 3. Compressor equipped with an internal thermal overload.
- F. Refrigerant System:
 1. Factory installed components including strainers check valves reversing valves, EEV's, charging ports, safety switches, service valves and solenoid valves.
- G. Controls:
 1. Unit controlled by integral microprocessors with adjustable setpoints and alarms.
 2. Low voltage control circuit between the indoor units, branch circuit controller and the heat exchanger units. Provide 2-conductor, non-polar twisted pair non-shielded 18 gauge cable.
 3. Provide BACnet compatible controls. VRF System shall operate independently and monitored from the facility control system.
 4. Provide unit with the following sensors:
 - a. Suction temperature.
 - b. Discharge temperature.
 - c. High pressure.
 - d. Low pressure.
 - e. Outdoor temperature.
 - f. Outdoor unit heat exchanger temperature.
- H. Options and Accessories:
 1. Field installed low ambient kit.
 - a. Galvanized G-90 steel sheet finished hood and deflector.
 - b. Hood for air discharge from vertical to horizontal.
 - c. Deflector for horizontal air intake protection from hail and wind.

2.03 BRANCH CIRCUIT CONTROLLERS (BCC)

- A. General:
 - 1. Includes equipment referred to as “heat recovery units” or “branch selector boxes”.
 - 2. Equipped with a circuit board that interfaces to the controls system and perform functions necessary for operation. Units factory assembled, piped, wired and tested.
 - 3. Refrigerant:
 - a. Minimum glass-fiber insulation liner minimum 1/2-inch thick.
 - b. Manufacturers Option: In lieu of line include condensate drain pan integral with cabinet bottom with connection projecting through cabinet.
- B. Unit Cabinet:
 - 1. The casing fabricated of galvanized steel.
 - 2. Capable of supplying the necessary refrigerant to each temperature zone.
 - 3. Insulate unit comply with Division 23 “HVAC Insulation”.
- C. Refrigerant: R410A with either water- or air-source VRF systems.
- D. Refrigerant Valves:
 - 1. Multiple two position refrigerant directional flow valves.
 - 2. Linear electronic expansion valves.
- E. Electrical Controls:
 - 1. BCC controlled by integral microprocessors.
- F. Options and Accessories:
 - 1. **Add options and Accessories here.**

2.04 INDOOR FAN COIL UNIT - CEILING CASSETTE

- A. General:
 - 1. Unit four-way discharge cassette style indoor unit that recesses into the ceiling with a ceiling grille.
 - 2. Units factory assembled, piped, wired and run tested.
 - 3. Include unit with factory assembled, piped, electronic modulating linear expansion device and control circuit board.
 - 4. Include a self-diagnostic function, time delay mechanism, and auto restart function, an emergency operation function and a test run switch.
 - 5. Unit refrigerant pipes charged and sealed with dehydrated air before shipment from the factory.
- B. Unit Cabinet:
 - 1. Cabinet shall fit within a standard 24-inch square suspended ceiling grid.
 - 2. Casing stamped and formed factory painted steel and panels formed off-white polymeric resin.
 - 3. Cabinet panel with provisions for a field installed filtered outside air intake. Access panels for maintenance of internal components.
 - 4. Surface exposed to cold temperatures covered with coated polystyrene insulation.
 - 5. Four-way molded ABS grille shall be fixed to bottom of cabinet allowing two, three, or four-way. Adjustable pattern air outlet with center portion of grille for return air.
 - 6. Condensate pan with drain plug under coil.

- C. Fan and Motor:
 - 1. Fan assembly with a direct driven single motor.
 - 2. Fan statically and dynamically balanced to run on a motor with permanently lubricated bearings.
 - 3. Two speeds; low and high.
- D. Filter:
 - 1. Return air filtered with removable, washable filter, 70 percent arrestance and MERV 3.
- E. Coil:
 - 1. Coil nonferrous construction with smooth mechanically bonded aluminum plate fins on copper tubing.
 - 2. Tubing with inner grooves for high efficiency heat exchange.
 - 3. Tube joints brazed with silver alloy.
 - 4. Coils pressure tested at the factory, including thermal expansion valve.
 - 5. Include an integral condensate drain pump lift mechanism.
- F. Controls: Unit controls provided by the manufacturer to perform functions necessary to operate the system. Controls shall be BACnet.
- G. Options and Accessories:
 - 1. Outside air connection kit.
 - 2. Auto supply air oscillating pattern controller.

2.05 INDOOR FAN COIL UNIT – WALL MOUNTED

- A. General:
 - 1. Unit wall-mounted indoor unit, top discharging and front return for vertical air flow.
 - 2. Factory assembled, piped, wired and tested.
 - 3. Include unit with factory assembled, piped electronic modulating linear expansion device and control circuit board.
 - 4. Include a self-diagnostic function, time delay mechanism, an auto restart function, an emergency operation function and a test run switch.
 - 5. Unit and refrigerant pipes charged and sealed with dehydrated air before shipment from the factory.
- B. Unit Cabinet:
 - 1. Casing stamped and formed factory painted steel and panels formed off-white polymeric resin.
 - 2. Formed polymeric return grilled and direction slot supply diffuser.
 - 3. Separate back plate for securing the unit to the wall.
 - 4. Access panels for maintenance of internal components.
 - 5. Glass-Fiber insulation liner minimum 1/2" thick for surfaces exposed to cold temperature or cover with coated polystyrene insulation.
- C. Fan and Motor:
 - 1. Fan assembly with one or two fan(s) with a direct driven single motor.
 - 2. Molded ABS fan statically and dynamically balanced to run on a motor with permanently lubricated and sealed bearings.
 - 3. Include a manual adjustable guide vane with the ability to change the airflow up and down.
 - 4. Multi-speed motor control minimum 3 speeds.

5. Fan/motor mounted on rubber grommets.
- D. Filter: Return air filtered with removable, permanent washable filter.
- E. Coil:
 1. Coil nonferrous construction with smooth mechanical bonded aluminum plate fins on copper tubing.
 2. Tubing with inner grooves for high efficiency heat exchange.
 3. Tube joints brazed with silver alloy.
 4. Coils pressure tested complying with AHRI 210/240 at the factory, include thermal expansion valve.
 5. A condensate pan with drain connection provided under the coil and projecting through cabinet.
 6. Fan high density polyethylene or stainless steel.
 7. Include an integral condensate lift mechanism.
- F. Controls: Controls provided by the manufacturer to perform functions necessary to operate the system. Controls shall be BACnet.
- G. Options and Accessories:
 1. Condensate drain pump and lift kit.
 2. Outside air connection kit.
 3. Include a motorized air sweep louver to automatically change airflow by directing the air up and down.

2.06 INDOOR FAN/COIL UNIT – CEILING SUSPENDED

- A. General:
 1. Unit ceiling-suspended indoor unit, front discharge and bottom return for horizontal air flow.
 2. Unit factory assembled, piped, wired and tested.
 3. Include unit factory assembled, piped electronic modulating linear expansion device and control circuit board.
 4. Include a self-diagnostic function, time delay mechanism, an auto restart function, with an emergency operation function and a test run switch.
 5. Unit and refrigerant pipes charged and sealed with dehydrated air before shipment from the factory.
- B. Unit Cabinet:
 1. Casing stamped and formed factory painted steel and panels formed off-white polymeric resin.
 2. Formed polymeric return grille and directional slot supply diffuser.
 3. Access panels for maintenance of internal components.
 4. Glass-fiber insulation liner minimum 1/2" thick for surfaces exposed to cold temperatures or cover with coated polystyrene insulation.
- C. Fan and Motor:
 1. Fan assembly with two, three, or four fan(s) direct driven single motor.
 2. Molded ABS Fan statically and dynamically balanced to run on a motor with permanently lubricated and sealed bearings.
 3. Include a manual adjustable guide vane with ability to change the airflow sided to side.
 4. Multi-speed motor control. Minimum 3 speeds.
 5. Fan/motor mounted on rubber grommets.

- D. Filter:
 - 1. Return air filtered with removable, permanent long-life washable filter, to prevent arresstance and MERV 3.
- E. Coil:
 - 1. Coil nonferrous construction with smooth mechanically bonded aluminum plate fins on copper tubing.
 - 2. Tubing with inner grooves for high efficiency heat exchange.
 - 3. Tube joints brazed with silver alloy.
 - 4. The coils pressure tested complying with AHRI 210/240 at the factory.
 - 5. Condensate pan with drain connection provided under the coil and projecting through cabinet pan high density polyethylene or stainless steel.
- F. Controls:
 - 1. Unit controls provided by the manufacturer to perform functions necessary to operate the system. Controls shall be BACnet.
- G. Options and Accessories:
 - 1. Condensate drain pump and lift kit.
 - 2. Outside air connection kit.
 - 3. Include a motorized air sweep louver to automatically change airflow by directing the airflow side to side.

2.07 LOCAL INDOOR CONTROLLERS/THERMOSTATS

- A. Equip each indoor unit, or group of units with a local controller/thermostat provided by the system manufacturer.
- B. The local controller/thermostat shall include indication for the following:
 - 1. Space temperature setpoint (locally adjustable, with ability to lock out at the system level).
 - 2. Space temperature.
 - 3. Unit heat/cool/fan status. Fan to run continuously with modulating heating/cooling capacity to meet setpoint.
 - 4. Include a touch screen controller.

2.08 VRF CONTROL SYSTEM (STAND-ALONE, OPEN PROTOCOL INTERFACE)

- A. Physical Characteristics:
 - 1. General: The VRF Controls Network shall be capable of supporting remote controllers, schedule timers, system controllers, centralized controllers, an integrated web based interface, graphical user workstation, and system integration to Building Management Systems via BACnet®.
 - 2. The Open Protocol Interface cabinet made from stainless steel. Include each interface with a battery backup and LED lights to display status/error.
- B. Electrical Characteristics:
 - 1. General:
 - a. Open Protocol Interface 24 VAC power supply.
 - b. Open Protocol Interface supplies 16 volts DC to the communication bus on the terminal of the outdoor unit.
 - 2. Wiring:
 - a. Open Protocol Interface communication wiring terminated in a daisy chain design at the outdoor unit, which is then daisy chained to branch selector, then daisy chained to each indoor unit and terminating at the farthest indoor unit.

- b. Remote control wiring run from indoor unit control terminal block to remote controller connected with that indoor unit.
 - c. Wiring size: Wiring shall be non-shielded, 2-conductor sheathed vinyl cord or cable and 18 AWG stranded copper wire.
- C. VRF Controls Network:
 - 1. The VRF Controls Network includes local remote controllers, multi-zone controllers, advanced multi-zone controllers, and open protocol network devices that transmit information via the communication bus.
 - 2. The VRF Controls Network with the ability to be accessed via a networked PC.
 - 3. The VRF Controls Network includes operation monitoring, scheduling, error e-mail distribution, general user software, tenant billing, maintenance support, and integration with Building Management Systems (BMS) using open protocol via BACnet® interfaces.
- D. Open Protocol Interfaces:
 - 1. Open Protocol Interfaces includes a translator between the DIII-Net communications and the protocols used in BACnet integration.
 - a. Open Protocol Interfaces wall-mounted and can be used in conjunction with a Building Management System (BMS).
 - b. System or unit errors displayed on, the VRF controllers and the BMS central monitoring system.
 - 2. Interface for use in BACnet: Include ability for a Building Management System (BMS) to control VRF indoor units.
 - 3. The Interface for use in BACnet to support operations superseding the centralized controller, local remote controller, system configuration, daily/weekly scheduling, monitoring of operation status, and malfunction monitoring.
 - 4. The Interface for use in BACnet to use standard open protocol based on ANSI/ASHRAE Standard 135. The BACnet Interface has been certified by the BACnet. The BACnet Interface is compatible with BACnet IP (ISO16484-5).
 - 5. Wall mounted interface for use in BACnet is used as a translator between the BACnet Building Management System (BMS) and the VRF communication bus to maintain the optimal operation of the indoor unit(s).
 - 6. Equip Interface for use in BACnet with one RJ-45 Ethernet port to support interconnection with a network PC via the Internet or Local Area Network (LAN).
 - 7. Provide interface for use in BACnet capable of communicating across BACnet Broadcast Management Devices (BBMD) in different subnet networks.
 - 8. Provide interface for use in BACnet capable of supporting Change of Value (COV) notification for available objects.
 - 9. Provide interface for use in BACnet building management system the capability to display the room temperature.
 - 10. Display error codes generated by the indoor units, water cooled units, branch selector boxes, and remote controllers on the BACnet building management system with a two digit error code as specified by the manufacturer.
 - a. Communication errors between the Interface for use in the BACnet building management system displayed with a red flashing LED.
- E. Basic Operation for Fan/Coils:
 - 1. The Interface for use in BACnet to provide up to 28 objects that can be monitored/controlled via the BACnet building management system.

2. The BMS shall control the following group operations and coordinated between the Mechanical Contractor and Temperature Control Contractor:
 - a. On/Off.
 - b. Operation Mode (Cool, Heat, Fan, Auto, and Dry).
 - c. Single setpoint setting for Cooling and Heating in the occupied mode.
 - d. Fan status.
 - e. Fan speed, with up to 3 speeds (dependent upon indoor unit type)
 - f. Vane direction (dependent upon indoor unit type).
 - g. Remote controller permit/prohibit of On/Off, Mode, and Setpoint.
 - h. Filter sign reset for indoor units.
 - i. Disable the Controller (local thermostat).
 - j. Forced off of indoor units.
 - k. Forced thermostat off of indoor units.
 - l. Energy saving offset of indoor unit setpoint (nighttime setback)
 - m. Compressor status.
 - n. Thermostat on/off status.
 - o. Heater status (where equipped).
 3. Capable of providing battery backup power for up to 3 years in total time for the clock. Settings stored in non-volatile memory.
- F. Programmability:
1. The BACnet building management system shall support weekly schedule settings through its programming. The schedule shall support at the indoor unit:
 - a. Each scheduled event shall specify time and target group.
 - b. Each scheduled event shall include On/Off, Operation Mode, Occupied Cooling Setpoint, Occupied Heating Setpoint, Setup (Cooling) setback setpoint, Setback (Heating) setback setpoint, Remote Controller On/Off Permit/Prohibit, Remote Controller Mode Permit/Prohibit, Remote Controller Setpoint Permit/Prohibit, and Timed Override Enable.
 - c. Setup (Cooling) and Setback (Heating) setpoints when unit is Off (unoccupied) by Group.
 - d. Provide an override for enabling indoor unit operation during the unoccupied period by the BACnet building management system programming.
 2. The BACnet building management system shall support auto-changeover through its programming.
 - a. Auto-change shall provide changeover for both Heat Pump and Heat Recovery systems based upon the group configurations.
 - b. Changeover shall change the operation mode of the indoor unit that is set as the Changeover Master. The Changeover Master indoor unit shall then change the operation mode of indoor unit groups daisy chained on the same DIII-Net communication bus to the same outdoor unit in the Heat Pump system or the same branch selector box in the Heat Recovery system.
 - c. Changeover to cooling mode to occur when the room temperature is great than or equal to the cooling setpoint. Differential to be determined by BACnet building management system programming.

- d. Changeover to heating mode to occur when room temperature is less than or equal to the heating setpoint. Differential to be determined by BACnet building management system programming.
 - e. Guard timer: Upon changeover, guard timer prevents another changeover during modes. Guard timer to be ignored by a change of setpoint manually from the BMS, Controller, Remote Controller, or by schedule. Guard timer to be configured by BACnet building management system programming.
 - 3. The Interface for use in BACnet shall support force shutdown of associated indoor unit groups.
- G. Fan/Coil Air Conditioner Monitoring and Control Points:
 - 1. Monitoring Points:
 - a. Start/stop status.
 - b. Alarm.
 - c. Malfunction code.
 - d. Air-conditioning mode.
 - e. Room temperature.
 - f. Filter sign.
 - g. Thermostat status.
 - h. Compressor status.
 - i. Indoor fan status.
 - j. Heater operation status (if equipped).
 - 2. Operating Points:
 - a. Start/stop operation.
 - b. Air-conditioning mode setting.
 - c. Room temperature setting.
 - d. Filter sign and reset.
 - e. Remote controller enable/disable.
 - f. Lower central device operation enable/disable.
 - g. Air flow rate setting.
 - h. Air direction setting.
 - i. Forced system stop.
 - j. Forced thermostat disable.
 - k. Energy saving.

PART 3 EXECUTION

3.01 GENERAL

- A. Install units according to manufacturer's written instructions.
- B. The system installation by a VRF manufacturer factory-trained contractor. Bidders required to submit training certification proof with bid documents. Bidder's installation price shall be based on the systems installation requirements. The Mechanical Contractor bids with complete knowledge of the HVAC system requirements.
- C. Install units level and plumb, maintaining manufacturer's recommended clearance.
- D. Install indoor unit components using manufacturer's standard mounting devices securely fastened to building structure.
- E. Install refrigerant piping to manufacturer's written instructions and best practices.

- F. Install new filters or clean foam type filters in each indoor unit within two (2) weeks after substantial completion.
- G. Comply with manufacturer's maximum piping length (and equivalent lengths), including maximum vertical heights and distances.
- H. Install piping to allow service and maintenance.
- I. Connect condensate drain pans using Type M tubing with streamline drainage fittings and soldered joints. Extend to nearest equipment drain or floor drain. Construct vented, deep trap at connection to drain pan and install cleanouts at changes in direction. Terminate to suit local code requirements, except where stricter methods are indicated.

3.02 COMMISSIONING

- A. Verify that installation is as indicated and specified.
- B. Complete manufacturer's installation and startup checks and perform the following:
 - 1. Inspect for visible damage to unit casing.
 - 2. Inspect for visible damage to compressor, condenser coil, and fans.
 - 3. Verify that clearances have been provided for servicing.
 - 4. Check that labels are clearly visible.
 - 5. Clean compressor-condenser unit and inspect for construction debris.
 - 6. Verify that controls are connected and operable.
 - 7. Remove shipping bolts, blocks, and tie-down straps.
 - 8. Verify that filters are installed.
- C. Start unit according to manufacturer's written instructions.
 - 1. Perform starting of refrigeration in summer only.
 - 2. Complete startup sheets and attach copy with Contractor's startup report.
- D. Check and record performance of interlocks and protection devices; verify sequences.
- E. Operate unit for an initial period as recommended or required by manufacturer.
- F. Simulate maximum cooling demand and check the following:
 - 1. Compressor refrigerant suction and hot-gas pressures.
 - 2. Short circuiting air through condenser.
- G. After starting and performance testing, vacuum cooling and condenser coils and lubricate bearings.

3.03 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test and adjust field-assembled components and equipment installation, including connections and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

3.04 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain units. Training shall be minimum three (3) eight (8) hour days. Comply with project closeout procedures.

END OF SECTION

SECTION 238239
ELECTRIC HEATING SYSTEMS**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. This section includes the followings:
 - 1. Cabinet unit heaters
 - 2. Baseboard Heaters
- B. Refer to Division 26 sections for the following work:
 - 1. Power supply wiring from power source to power connection on unit.
- C. Provide the following electrical work as work of this section, complying with requirements of Division 26 sections.
 - 1. Cabinet and Unit Heaters: Provide motor starting device and electrical disconnect means at each unit.

1.03 DEFINITIONS

- A. CWP: Cold working pressure.
- B. DDC: Direct digital control.
- C. PTFE: Polytetrafluoroethylene plastic.
- D. TFE: Tetrafluoroethylene plastic.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's specifications for electric heaters showing dimensions, weights, capacities, ratings, performance characteristics, gauges and finishes of materials and installation instructions.
- B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, weight loadings, construction details, required clearances and field connection details.
- C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to electric heaters. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- D. Maintenance Data: Submit maintenance instructions, "trouble-shooting" maintenance guide, motor and drive replacement and spare parts lists. Include this data, product data and shop drawings in maintenance manuals; in accordance with requirements of Division 23 Section 23 05 00.

1.05 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms who regularly engaged in manufacture of electric heaters, of types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than five (5) years.
- B. Codes and Standards:
 - 1. UL and NEMA Compliance: Provide electric motors and components which are listed and labeled by Underwriters Laboratories and comply with NEMA standards.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Handle electric heaters carefully to prevent damage, breaking, denting and scoring. Do not install damaged electric equipment or components; replace with new.
- B. Store electric heaters in clean, dry place. Protect from weather, dirt, fumes, water, construction debris and physical damage.
- C. Comply with manufacturer's rigging and installation instructions for unloading electric heaters and installing them to final location.

PART 2 PRODUCTS**2.01 MANUFACTURERS**

- A. Manufacturer: Subject to compliance with requirements, provide electric heaters of one (1) of the following:
 - 1. Berko
 - 2. Chromalux
 - 3. Indeeco
 - 4. King
 - 5. Markel
 - 6. Qmark
 - 7. Raywall
 - 8. Redd-i
 - 9. Warren
 - 10. Or equal as approved by Owner.

2.02 CABINET HEATERS

- A. General: Provide cabinet heaters in locations as indicated and of capacities, style and having accessories as scheduled. Include in basic unit chassis, coil, fan wheels, housing, motor and insulation.
- B. Fans: Provide centrifugal, forward curved double width fan wheels constructed of non-corrosive, molded, fiberglass-reinforced thermo-plastic material. Construct fan scrolls of galvanized steel.
- C. Electric Resistance Heating Elements: Steel fins shall be copper brazed to steel-sheath tubular heating elements. Element shall be finished with aluminized paint. Arrange fins and elements in uniform grid pattern mounted adjacent to discharge opening.
 - 1. Two-stage thermostat control.
- D. Motors: Provide two-speed motors with automatic overload protection.
- E. Cabinet: Die-formed 16 gauge furniture-grade steel. All metal surfaces of the cabinet shall be phosphatized and finished in baked enamel. Provide surface mounted unit with up-flow discharge air direction.

2.03 BASEBOARD HEATERS

- A. General: Provide electric baseboard heaters in locations as indicated and of capacities, style and having accessories as scheduled. Include in basic unit chassis, enclosure, built-in wireway, element area and terminal boxes.
- B. Enclosure: Steel construction, minimum 18 gauge, with removal front panel and extruded aluminum grilles, less than 1/4-inch openings. White epoxy powder-coat painted finish.
- C. Heating Element: Nickel chromium heating element wire in metal sheath, aluminum fins bonded to sheath enclosed.
 - 1. Overheating temperature protection with automatic reset.
 - 2. Thermostatic control, power relay, and integral disconnect.

PART 3 EXECUTION**3.01 EXAMINATION**

- A. Examine areas and conditions under which electric heaters are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Architect.

3.02 INSTALLATION OF ELECTRIC HEATERS

- A. General: Install units as indicated and in accordance with manufacturer's installation instructions.
- B. Uncrate units and inspect for damage. Verify that nameplate data corresponds with unit designation.
- C. Hang unit heaters from building substrate. Mount as high as possible to maintain greatest headroom possible unless otherwise indicated.
- D. Support units with mounting brackets anchored to building substrate.
- E. Mount baseboard heaters and cove heaters on building wall. Mount as indicated on the drawings.
- F. Coordinate with other trades to assure correct size for wall mounted units.
- G. Protect units with protective covers during balance of construction.

3.03 ADJUSTMENT AND CLEANING

- A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean coils and inside of unit.
- B. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

END OF SECTION

**SECTION 260500
GENERAL ELECTRICAL****PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 RESPONSIBILITIES

- A. The Bidding Requirements, Conditions of Contract, General Specifications and General Requirements, and this Division shall be binding on the Contractor and shall apply to all electrical work to be completed under this section.
- B. The Contractor shall be responsible for the work from the date of his Contract until its acceptance by the Owner and must make good all damages sustained from whatever cause. He shall use proper care and diligence in bracing and securing all parts of the work and shall in all cases judge as to the amount of protection required.

1.03 ORDINANCES, LAWS AND CODES

- A. All work shall conform to the rules and regulations of the National Electrical Code, Local Code, "Occupational Safety and Health Act" and the State Fire Marshall's Office. All certificates of approval shall be delivered to the Architect before final payment will be made.
- B. Should any change in the drawings and/or specifications be required to conform to the above mentioned laws and ordinances, the Architect shall be notified by the Bidder prior to the Bid Date, that the necessary changes may be completed. After the Bid Date, all work necessary to meet the requirements shall be at Contractor's expense, with no additional cost to the Owner.
- C. The Contractor shall pay all fees, permits or taxes for inspections, etc., in connection with the work under this Contract. Any costs, charges or connection fees which the Power Company assesses the Owner or Contractor in order to obtain permanent and temporary electrical service to the Project Facility will be paid by the Contractor as part of this Contract.

1.04 DATA AND MEASUREMENT

- A. The data given herein and on the drawings is as exact as could be secured insofar as building construction and existing conditions are concerned. Extreme accuracy is not guaranteed. The drawings and specifications are intended for the assistance of the Contractor in achieving the end result. Exact locations, measurements, distance, levels, etc., will be governed by conditions at the Job Site.
- B. The Contractor shall verify that the size of the equipment supplied by the selected manufacturers does not exceed the available mounting space.
- C. The Architect reserves the right to change location or size of conduits, outlets, luminaires or other pieces of equipment as may be necessary to avoid conflicts. No extra compensation will be allowed for such changes unless additional cost to the Contractor is caused.
- D. The Bidder shall visit the Project Site that he may have knowledge of conditions at the Job Site and adapt his work to such conditions.

1.05 DRAWINGS AND SPECIFICATIONS

- A. Anything mentioned in this specification and not shown on the drawings or vice versa shall be of like effect, as shown or mentioned in both. In any case of discrepancy or differences in the figures, drawings or specifications, the Bidder shall promptly report such discrepancies to the Architect who shall make a decision in writing. Any adjustment by the Contractor without this decision shall be at the expense of the Contractor.

1.06 QUALITY OF WORKMANSHIP

- A. The Contractor shall give his personal superintendence and direction to the work. He shall also keep a competent foreman or superintendent on the Project.
- B. All equipment, controls and junction boxes shall be located for ready access, operation, repair or maintenance.

- C. Any additional drawings necessary for the prosecution of the work will be furnished by the Architect as promptly as possible. The Contractor shall request any additional instructions needed and shall do no work without drawings and instructions.
- D. Any discrepancies between the Mechanical, Electrical and Architectural Drawings shall be reported to the Architect prior to the Bid Date.

1.07 GUARANTEE

- A. This Contractor shall guarantee all materials, workmanship and the successful operation of all apparatus furnished and installed by him for a period of one (1) year from the date of the final acceptance of the whole work, and shall guarantee to repair or replace at his own expense any part of the apparatus which may show defect during that time, provided such defect is, in the opinion of the Architect, due to imperfect material or workmanship and not to carelessness or improper operation. Guarantee period for the replacement shall begin with the date of replacement.
- B. The Owner shall notify the Contractor of any failure of any part or parts which occur during the guarantee period.
- C. The Contractor shall also guarantee the systems and the apparatus to be working properly to meet all conditions as specified.

1.08 SHOP DRAWINGS

- A. Shop Drawings shall be submitted in accordance with the requirements of Paragraph "Shop Drawings" of the General Conditions. The Contractor shall submit Shop Drawings of all fabricated work and equipment to be purchased. Data shall be sufficiently completed to permit evaluation and comparison with specified equipment and material. Each item shall be prepared as a separate submittal, not grouped or bound with other items.
- B. All drawings shall bear the Contractor's stamp of approval and must be dated.
- C. Shop Drawings shall include, but not be limited to the following:
 - 1. Luminaires.
 - 2. Switchboard.
 - 3. Panelboards.
 - 4. Circuit and Motor Disconnects.
 - 5. Emergency Engine Generator, Transfer Switch, Auxiliary Equipment.
 - 6. Fuses.
 - 7. Wiring Devices – Switches, Receptacles, Device Wallplates.
- D. A notation shall be made on each item submitted as to its specified use or description of specific location in the work.
- E. None of the preceding items shall be purchased, delivered to the site or installed until the item has been properly submitted in writing and reviewed by the Architect.
- F. Submittals shall be made even though the item is exactly as specified.
- G. Should the Contractor fail to comply with any of the requirements as stated, the Architect reserves the right to select a full line of materials, appliances and equipment, which shall be final and binding upon the Contractor.

1.09 SUBMITTAL DATA

- A. Review of submittal data is only for general conformance with the design concept of the Project and general compliance with the information given in the Contract Documents. Any action shown is subject to the requirements of the plans and specifications. Contractor is responsible for: Dimensions, which shall be confirmed and correlated at the job site; fabrication processes and techniques of construction; coordination of his work with that of all other trades and the satisfactory performance of his work.
- B. Contractor will be limited to one (1) review on a singular piece of equipment.

- C. The listing of a manufacturer as "acceptable" does not imply automatic compliance with Contract Documents. It is the sole responsibility of the Contractor to ensure that any price quotations received and submittals made are for equipment/systems, which meet or exceed the specifications included herein.

1.10 EQUAL MANUFACTURERS/EQUIPMENT

- A. Any requests for manufacturer/equipment to be considered as equal other than as specified herein shall be submitted to the Engineer not less than 10 days prior to Bid Date.
- B. Requests for review shall be sufficiently complete to permit evaluation and comparison with specified equipment and material.

1.11 AUTOCAD DRAWING FILE REQUESTS

- A. As an instrument of service to aid in Shop Drawing Submittals, Farris Engineering (FE) will provide AutoCAD drawing files upon request. The files will be sent upon return receipt of the "Request for Drawings" agreement signed by an Officer of the requesting firm. FE does not assure that the drawings represent all changes, addenda items, change orders or modifications that may have occurred. The drawings are simply a tool for use in producing shop drawing submittals.
- B. The drawing files will be "cleaned-up" by having the FE logo, Professional Engineer seal and all extraneous notes and details removed. FE must be compensated for this additional service by the requesting firm. A minimum fee of \$400.00 for up to eight (8) sheets and \$50.00 per sheet for each additional requested drawing will be invoiced to the requesting firm once the signed agreement is received.

PART 2 PRODUCTS

2.01 PROTECTION OF LUMINAIRES AND WARES

- A. This Contractor shall apply the necessary protective coverage to luminaires and other equipment to prevent scratches and mars to such equipment as a result of falling objects or work of other trades.

2.02 STORAGE

- A. This Contractor shall provide and be responsible for safe storage of his materials and such storage shall not interfere with the work of others or progress of the Project in any manner.

2.03 EQUIPMENT ENCLOSURES

- A. Provide enclosures, which mate properly with the equipment to be enclosed and are NEMA rated to suit the atmospheric conditions of the equipment surroundings.
- B. Equipment in corrosive atmosphere shall be rated NEMA 4X. All NEMA 4X equipment shall be fabricated from suitable non-metallic material or shall be stainless steel. Painted steel is not acceptable for NEMA 4X applications.

PART 3 EXECUTION

3.01 COORDINATION

- A. Before installing any work, this Contractor shall coordinate the electrical work with all other Contractors on the Project, with the Electric Utility Company and the City Code enforcing department.
- B. All electrical work shall be installed in proper sequence and so arranged with other trades that there will be no delay in the proper installation and completion of any part or parts of all piping systems and mechanical equipment.
- C. This Contractor shall carefully examine the drawings and shall be responsible for the proper fitting of equipment and conduit as indicated without major alteration. If alterations are required, a detailed drawing of the proposed departure due to actual field conditions or other causes shall be submitted to the Architect for approval.
- D. Whenever interferences might occur, before installing any of the work in question, the Electrical Contractor shall consult with other Contractors and shall come to an agreement with them as to the exact location and level of his conduit bus duct, luminaires and/or parts of his installation.

- E. Where recessed electrical devices (speakers, luminaires, etc.) are installed in fire-rated ceilings, Contractor shall provide an enclosure approved by authorities having jurisdiction to surround each device as required to maintain the fire integrity rating of the ceiling. Adequate clearance between device and enclosure shall be provided in accordance with device manufacturer's recommendations. Verify clearance requirements with device manufacturer prior to installation of luminaire.
- F. Multiwire branch circuits as defined by the National Electrical Code (circuits with common neutral) shall not be used. Exception: Where an equipment manufacturer requires a multiwire branch circuit for only one utilization equipment and where all ungrounded conductors of that circuit are opened simultaneously by the branch circuit overcurrent device.
- G. A cable raceway type wiring method, installed in exposed or concealed locations near metal-corrugated sheet roof decking, shall be installed and supported so the nearest outer surface of the cable raceway is not less than 6-inches from the nearest surface of the roof decking. Exception: Rigid metal conduit and intermediate metal conduit shall not be required to maintain this clearance.
- H. All changes in the work of this Contractor, caused by his neglect to follow these instructions, shall be made at this Contractor's expense.

3.02 DITCHING, EXCAVATION AND BACKFILLING

- A. Contractor shall do all excavation required to install conduits and equipment shown on drawings or required for proper operation. Excess excavation below the required level shall be backfilled with earth and thoroughly tamped.

3.03 CONNECTIONS FOR EQUIPMENT

- A. Coordinate the hook up of the following equipment with the Contractor required to furnish and install them. See the appropriate sections in the General Construction Work specifications for further information.
 - Mechanical Equipment
 - Cabinetry Equipment
 - Owner Furnished Equipment
- B. Verify fuse and/or circuit breaker requirements for electrical connections to equipment and provide overcurrent devices accordingly.
- C. The plans indicate the locations of system devices. The Contract shall include the wiring system required to interconnect the indicated devices to result in a complete, operating system. The interconnecting wiring shall be in conformity with the requirements of the manufacturer of the equipment as well as with other requirements set out herein. The basic wiring method to be employed is indicated herein. The Contractor's Shop Drawing submittal shall indicate the specific routing and type of wireway and the number and type of conductors to be installed.

3.04 WORK IN EXISTING BUILDING

- A. Inasmuch as work under this Contract includes adding to in the existing building, it shall be the responsibility of each Bidder to fully inform himself of any and all conditions which influence or are influenced by work contemplated by these specifications and accompanying drawings. The submission of a proposal by any Bidder will be construed as an admission by him that he has examined and is fully familiar with the premises and all conditions thereon and adjacent thereto, and has included in this proposal a proper and adequate amount to cover rearrangement of old work for the proper installation and operation of the new and existing equipment as shown on the drawings specified herein or as required. Such work shall be neatly and properly done.
- B. Maintain existing electrical service and feeders to occupied areas and operational facilities, unless otherwise indicated or when authorized otherwise in writing by Owner or Architect. Provide temporary service during interruptions to existing facilities. When necessary, schedule momentary outages for replacing existing wiring systems with new wiring systems. When that "cutting-over" has been successfully accomplished, remove, relocate or abandon existing wiring as indicated.

- C. The operation of all special systems within the building shall be maintained, including but not limited to fire alarm, telephone, data, security, etc. Provide temporary connections/equipment as necessary for required sequence of construction. Any necessary momentary outages shall be scheduled with the Owner prior to starting such work.

3.05 DEMOLITION AND REMOVAL OF EXISTING EQUIPMENT AND MATERIALS

- A. Existing conduits that are made spare by demolition work shall be removed unless concealed in existing construction.
- B. All conduits and conductors shown to be reused shall be thoroughly tested and checked for insulation breakdown and continuity.
- C. Electrical items must be removed where they interfere with or are not concealed by new construction such as new ceilings, walls, etc.
- D. Existing luminaires, outlets, receptacles and other equipment and material shall be relocated, removed, reconnected or left in place as indicated on the drawings. Where an existing device is shown removed from an existing circuit, new wiring shall be provided as required to ensure continuity of existing circuit. If existing devices or other electrical items, such as electrically operated equipment interfere with the location of a new partition, relocation of existing equipment, new equipment, etc., the existing items including electrical components of electrically operated equipment shall be disconnected and removed or satisfactorily relocated and reconnected even though not specifically indicated on the drawings. All material removed which is considered salvageable by the Owner and is not specifically designated to be reused on the drawings or not practical to be reused shall remain in the property of the Owner and shall be neatly stockpiled in a specially designated location.

3.06 TEMPORARY WIRING (Existing Electrical Service)

- A. This Contractor shall provide temporary power.
- B. Temporary power may be derived from the existing electrical service.
- C. All materials for the temporary service and wiring may be used and remains the property of the Electrical Contractor.
- D. Temporary wiring materials are not to be installed as part of the permanent wiring system.
- E. Wiring need not be installed in conduit, but must be adequately installed and protected from mechanical injury to prevent shock.
- F. Permanent wiring including feeders, panels, receptacles, etc., may be used as soon as installed.
- G. The Electrical Contractor shall bear all installation costs necessary to connect and disconnect the temporary service.

3.07 CLEANING

- A. This Contractor shall at all times keep the premises free of all waste or surplus materials, rubbish and debris which is caused by his employees or resulting from his work.
- B. After all equipment and luminaires have been installed and building is ready for occupancy, the Electrical Contractor shall remove all stickers, rust stains, labels, temporary covers, plaster marks, paint spots, etc. All foreign matter shall be vacuumed out of all conduits, panels, motors, devices, switches, luminaires, etc.
- C. Identification plates and trims on all equipment shall be free of paint and polished.
- D. The Contractor shall leave the electrical portion of the work in a safe clean and very neat condition ready for operation.

3.08 REBATES

- A. The Contractor shall assist the Owner with filing of applicable forms to obtain rebates. This shall include but not be limited to determination of qualifying materials and furnishing invoices for materials with corresponding quantities.

3.09 RECORD DRAWINGS

- A. The Contractor shall maintain an up-to-date set of plans and specifications on the Job Site. He shall mark all Addendum Items and any field changes on this set and see that a copy of all changes is furnished to the Architect at the end of the Project.
- B. The drawings shall also include as-built conditions such as equipment locations, routing of service entrance and major feeders, etc.

3.10 INSTRUCTION IN OPERATION BOOKS AND SPARE PARTS

- A. After all tests and adjustments have been made, the Contractor shall furnish the necessary qualified personnel to place the special systems in continuous operation, during which time he shall provide complete Operating and Maintenance Instructions to the Owner's representative with an outline of instructions in written form. These personnel shall reserve adequate time to instruct an Owner's representative on proper operation (including all phases of the system and each of its component parts).
- B. Contractor shall furnish Owner with two (2) sets of all operating instructions, maintenance instruction and spare parts lists of all equipment furnished under this Contract. Lists shall include current unit prices and source of supply for each item of operable equipment.

3.11 FIRESTOPPING

- A. Openings around electrical penetrations through fire-resistant rated walls, partitions, floors or ceilings shall be firestopped using listed materials to maintain the fire rating. Installation shall be done in accordance with manufacturer's recommendations. Materials shall be UL Listed and labeled and FM approved for fire ratings consistent with penetrated barriers.
 - 1. Foamed-in-place type firestopping shall only be permitted in concealed-from-view locations. Sealant type firestopping shall be used in exposed-to-view locations.
 - 2. Cable tray, conduit sleeves (2-inch and larger) and similar penetrations of fire-rated walls, floors or ceilings shall be sealed by a method that permits cables to be easily added or removed without damage to the firestopping materials. Products similar to Grace Construction Products Flamesafe Bags, Specified Technologies, Inc. EZ Path Fire Rated Pathway and Wiremold Flamestopper FS Series are acceptable when rated for the application. Coordinate requirements with product manufacturer and authority having jurisdiction. Foamed in place or sealant type firestopping are not acceptable at these locations.

3.12 TESTS AND ADJUSTMENTS

- A. Upon completion of installation of electrical connections, and after circuitry has been energized with rated power source test connections to demonstrate capability and compliance with requirements. Ensure that direction of rotation of each motor fulfills requirement. Correct malfunctioning units at site, then retest to demonstrate compliance.
- B. During the progress and after completion of the work included under this specification, the Contractor shall make all required tests at his own expense in the presence of the Architect as required hereinafter and by local ordinances, codes, laws and regulations. Such tests shall be in accordance with other sections of this division. The Architect shall be notified five (5) days in advance as to the time when such tests are to be performed that a representative of the Architect may be present.

END OF SECTION

SECTION 260519
WIRES AND CABLES**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Extent of electrical wire and cable work is indicated by drawings and schedules. Wires and cables shall be single, insulated conductors, field-installed in continuous raceways unless specified otherwise.
- B. Types of electrical wire, cable and connectors specified in this section include the following:
1. Copper conductors.
 2. Tap type connectors.
 3. Wirenut connectors.

PART 2 PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products of one (1) of the following (for each type of wire, cable and connector):
1. Wire and Cable:
 - a. Apex Wire and Cable Corp.
 - b. American Insulated Wire Corp.
 - c. American Wire and Cable Co.
 - d. Belden Div; Cooper Industries.
 - e. Brand-Rex Div; Pyle National Co.
 - f. Cerro Wire and Cable Corp.
 - g. Cleveland Insulated Wire Co.
 - h. General Cable Corporation.
 - i. Helix Wire Corporation.
 - j. Houston Wire
 - k. Indiana Insulated Wire Inc.
 - l. Larabee Wire Manufacturing Co., Inc.
 - m. Madison Wire and Cable Corp.
 - n. Okonite Co.
 - o. Pirelli Cable Corp.
 - p. Radix Wire Co.
 - q. Rome Cable Corp.
 - r. Southwire Company.
 - s. Triangle PWC, Inc.
 - t. Or equal as approved by Owner.
 2. Connectors:
 - a. AMP, Inc.
 - b. Appleton Electric Co; Emerson Electric Co.

- c. Buchanan Co.
- d. Burndy Corporation.
- e. Brand-Rex Div. Pyle National Co.
- f. Electrical Products Div; Midland-Ross Corp.
- g. General Electric Co.
- h. Gould, Inc.
- i. Ideal Industries, Inc.
- j. Leviton Mfg Company.
- k. 3M Company
- l. O-Z/Gedney Co.
- m. Southport Industries Inc.
- n. Square D Company.
- o. Thomas and Betts Corp.
- p. Or equal as approved by Owner.

2.02 WIRES, CABLES AND CONNECTORS

- A. General: All reference to size in these specifications or on drawings is for copper conductors. Provide electrical wires, cables and connectors of manufacturer's standard materials, as indicated by published product information; designed and constructed as recommended by manufacturer, for a complete installation and for application indicated. Except as otherwise indicated, provide copper conductors with conductivity of not less than 98% at 20°C (68°F).
- B. Building Wires: Provide factory-fabricated wires of sizes, ampacity rating, and materials for applications and services indicated. Where not indicated, provide proper wire selection as determined by Installer to comply with project's installation requirements, NEC and NEMA Standards.
- C. Cables: Provide UL-type factory-fabricated cables of sizes, ampacity ratings, and materials and jacketing/sheathing as indicated for services indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements, NEC and NEMA Standards.
- D. Connectors: Provide UL-type factory-fabricated, metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Where not indicated, provide proper selection as determined by Installer to comply with project's installation requirements, NEC and NEMA Standards.

PART 3 EXECUTION

3.01 INSTALLATION OF WIRES AND CABLES

- A. General: Install electrical cables, wires and wiring connectors as indicated, in compliance with applicable requirements of NEC, NEMA, UL and NECA's "Standard of Installation" and in accordance with recognized industry practices.
- B. The normal minimum size shall be 12 AWG. All wire No. 10 and smaller to be solid, all No. 8 and larger shall be stranded.
- C. All service entrance and below grade feeders size #1 AWG and larger shall be type XHHW-2.
- D. All exposed exterior and below grade feeders and branch circuits size #2 AWG and smaller shall be type THWN-2
- E. All above grade interior wiring shall be type THHN.
- F. Pull conductors simultaneously where more than one (1) is being installed in same raceway.
- G. Use polywater Dyna Blue water based pulling lubricant or equal where necessary.

- H. Insulation on conductors shall be permanently marked with wire size, insulation type, voltage range and manufacturer's name. The insulation on conductors shall be color coded as follows:
 - 1. 120/208-volt circuit: Phase A - Black; Phase B - Red; Phase C - Blue.
 - 2. 277/480-volt circuit: Phase A - Brown; Phase B - Orange; Phase C - Yellow.
- I. The phase conductors shall be tagged and shall remain the same throughout the circuit.
- J. Switch legs shall be color coded to distinguish them from Hot or Phase Conductors.
- K. Switch legs occurring in the same box or enclosure shall be color coded separately.
- L. Exceptions to the color coding as listed above shall be as follows:
 - 1. Wiring for special systems shall be color coded or labeled as required by the manufacturer.
- M. Use pulling means including, fish tape, cable, rope and basket weave wire/cable grips which will not damage cables or raceway.
- N. Install exposed cable, parallel and perpendicular to surfaces, or exposed structural members and follow surface contours, where possible.
- O. Keep conductor splices to minimum.
- P. Install splices and taps which possess equivalent-or-better mechanical strength and insulation ratings than conductors being spliced.
- Q. Use splice and tap connectors which are compatible with conductor material.
- R. All splices and taps shall be made in outlet, junction and pull boxes. Splices on circuit wiring shall be of the pigtail type using solderless connectors. Larger sizes of conductors requiring uninsulated connectors of the bolt type shall be taped with pressure sensitive vinyl tape.
- S. For branch circuit wiring, conductor fill per conduit run shall not contain more than eight (8) current carrying wires, provided the wire size is derated as required by the National Electrical Code. Conduits containing both circuit switch legs and/or traveler wires may contain more than the number stated above, providing the conduit is of adequate size and the wire size is derated as required by the National Electrical Code. Whenever a 120-volt, single phase branch circuit is over 70-feet in length or a 277-volt, single phase branch circuit is over 150-feet, and the load is in excess of 50% of the branch circuit protective device, the conductors shall be increased one (1) size to the first outlet box unless specifically noted otherwise. For special systems conductor fill of conduit is per manufacturers specifications furnished with each system, noted on the drawings or shall be as required by code.
- T. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486A and B.

3.02 FIELD QUALITY CONTROL

- A. Prior to energization of circuitry, check installed wires and cables with megohm meter to determine insulation resistance levels to ensure requirements are fulfilled.
- B. Prior to energization, test wires and cables for electrical continuity and for short-circuits.
- C. Subsequent to wire and cable hook-ups, energize circuitry and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units and then retest to demonstrate compliance.

END OF SECTION

SECTION 260526
GROUNDING**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Extent of grounding work is indicated by drawings, schedules and as specified herein.
- B. Types of grounding specified in this section include the following:
 - 1. Solid grounding.
- C. Requirements of this section apply to electrical grounding work specified elsewhere in these specifications.

PART 2 PRODUCTS**2.01 GROUNDING SYSTEMS**

- A. Materials and Components:
 - 1. General: Except as otherwise indicated, provide electrical grounding systems indicated; with assembly of materials, including, but not limited to, cables/wires, connectors, terminals (solderless lugs), grounding rods/electrodes and plate electrodes, bonding jumper braid and additional accessories needed for complete installation. Where more than one type unit meets indicated requirements, selection is Installer's option. Where materials or components are not indicated, provide products complying with NEC, UL, IEEE and established industry standards for applications indicated.
- B. Conductors: Provide copper electrical grounding conductors for grounding connections matching power supply wiring materials and sized according to NEC. All conduits shall contain a minimum of one (1) separate equipment grounding conductor identified and sized according to NEC.
- C. Bonding Jumper Braid: Copper braided tape, constructed of 30-gage bare copper wires and properly sized for indicated applications.
- D. Flexible Jumper Strap: Flexible flat conductor, 480 strands of 30-gage bare copper wire; 3/4-inch wide, 9-1/2-inches long; 48,250cm. Protect braid with copper bolt hole ends with holes sized for 3/8-inch dia. bolts.
- E. Bonding Plates, Connectors, Terminals and Clamps: Provide electrical bonding plates, connectors, terminals, lugs and clamps as recommended by bonding plate, connector, terminal and clamp manufacturers for indicated applications.
- F. Ground Rods:
 - 1. Ground Rods: Steel with copper welded exterior, 5/8-inch dia. x 8-feet (Unless otherwise noted).
- G. Electrical Grounding Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, bonding straps, as recommended by accessories manufacturers for type services indicated.
- H. Exothermic Welded Connections: Comply with AWS Code for procedures, appearance, and quality of welds; and methods used in correcting welding work. Provide welded connections where grounding conductors connect to underground grounding rods/electrodes.

PART 3 EXECUTION**3.01 INSPECTION**

- A. Installer must examine areas and conditions under which electrical grounding connections are to be made and notify Contractor in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.02 INSTALLATION OF ELECTRICAL GROUNDING

- A. General: Install electrical grounding systems where shown, in accordance with applicable portions of NEC, with NECA's "Standard of Installation" and in accordance with recognized industry practices to ensure that products comply with requirements and serve intended functions.
- B. The equipment grounding conductor shall be connected directly to the equipment grounding screw provided on receptacles.
- C. At switch outlets, where self-grounding type switches are installed in metal boxes, the equipment grounding conductor shall be connected directly to the metal box.
- D. Where switches installed in non-metallic boxes have metallic cover plates or screws, provide switches with green hexagonal equipment ground screw and connect to the equipment grounding conductor.
- E. Coordinate with other electrical work as necessary to interface installation of electrical grounding system with other work.
- F. Weld grounding conductors to underground grounding rods/electrodes. (Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable).
- G. Install bonding jumpers with ground clamps on water meter piping to electrically bypass water meters.
- H. Install clamp-on connectors only on thoroughly cleaned metal contact surfaces, to ensure electrical conductivity and circuit integrity.

3.03 FIELD QUALITY CONTROL

- A. Upon completion of installation of electrical grounding systems, test ground resistance with ground resistance tester. Where tests show resistance to ground is over 5 ohms, take appropriate action to reduce resistance to 5 ohms or less, by driving additional ground rods; then retest to demonstrate compliance.

END OF SECTION

SECTION 260529
SUPPORTING DEVICES**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals and associated fastenings.
1. Refer to other Division 26 Sections for additional specific support requirements that may be applicable to specific items.

PART 2 PRODUCTS**2.01 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Slotted Metal Angle and U-Channel Systems:
 - a. Allied Tube & Conduit.
 - b. American Electric.
 - c. B-Line Systems, Inc.
 - d. Cinch Clamp Co., Inc.
 - e. GS Metals Corp.
 - f. Haydon Corp.
 - g. Kin-Line, Inc.
 - h. Unistrut Diversified Products.
 - i. Or equal as approved by Owner.
 2. Conduit Sealing Bushings:
 - a. Bridgeport Fittings, Inc.
 - b. Cooper Industries, Inc.
 - c. Elliott Electric Mfg. Corp.
 - d. GS Metals Corp.
 - e. Killark Electric Mfg. Co.
 - f. Madison Equipment Co.
 - g. L.E. Mason Co.
 - h. O-Z/Gedney.
 - i. Producto Electric Corp.
 - j. Racor, Inc.
 - k. Red Seal Electric Corp.
 - l. Spring City Electrical Mfg. Co.
 - m. Thomas & Betts Corp.
 - n. Or equal as approved by Owner.

2.02 COATINGS

- A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

2.03 MANUFACTURED SUPPORTING DEVICES

- A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets and spring steel clamps.
- B. Fasteners: Types, materials and construction features as follows:
 - 1. Expansion Anchors: Carbon steel wedge or sleeve type. Plastic expansion anchors (for conduit 1-inch and smaller only).
 - 2. Toggle Bolts: All steel springhead type.
 - 3. Powder-Driven Threaded Studs: Heat-treated steel, designed specifically for the intended service.
- C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps and cap screws.
- D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.
- E. U-Channel Systems: 16-gage steel channels, with 9/16-inch diameter holes, at a minimum of 8-inches on center, in top surface. Provide fittings and accessories that mate and match the U-channel and are of the same manufacturer.

2.04 FABRICATED SUPPORTING DEVICES

- A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.
- B. Steel Brackets: Fabricated of angles, channels and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.
- C. Pipe Sleeves: Provide pipe sleeves of one (1) of the following:
 - 1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams or welded longitudinal joint. Fabricate sleeves from the following gage metal for sleeve diameter noted:
 - a. 3-inches and smaller: 20-gage.
 - b. 4-inch to 6-inches: 16-gage.
 - c. Over 6-inches: 14-gage.
 - 2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
 - 3. Plastic Pipe: Fabricate from Schedule 80 PVC plastic pipe.

PART 3 EXECUTION**3.01 INSTALLATION**

- A. Install supporting devices to fasten electrical components securely and permanently in accordance with NEC requirements.
- B. Coordinate with the building structural system and with other electrical installation.
- C. Raceway Supports: Comply with the NEC and the following requirements:
 - 1. Conform to manufacturer's recommendations for selection and installation of supports.

2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four (4). Where this determination results in a safety allowance of less than 200 lbs, provide additional strength until there is a minimum of 200 lbs safety allowance in the strength of each support.
 3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
 4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
 5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4-inch diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
 6. Support exposed and concealed raceway within 1-foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
 7. In vertical runs, arrange support so that load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.
- D. Vertical Conductor Supports: Install simultaneously with installation of conductors.
- E. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers and other devices.
- F. Support sheet metal boxes directly from the building structure or by bar hangers.
- G. Sleeves: Install in concrete slabs and walls and all other fire-rated floors and walls for raceways and cable installations. For sleeves through fire-rated wall or floor construction, apply UL Listed firestopping sealant in gaps between sleeves and enclosed conduits and cables.
- H. Conduit Seals: Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.
- I. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, busways, cabinets, panelboards, transformers, boxes, disconnect switches and control components in accordance with the following:
1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.
 2. Holes cut to depth of more than 1-1/2-inch in reinforced concrete beams or to depth of more than 3/4-inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
 3. Ensure that the load applied to any fastener does not exceed 25% of the proof test load. Use vibration- and shock-resistant fasteners for attachments to concrete slabs.

END OF SECTION

**SECTION 260533
RACEWAYS****PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. All wiring shall be installed in continuous raceways as specified herein except where specifically noted otherwise.
1. When in conformance with the National Electrical Code and other applicable codes and listed for use in return air plenums, low voltage wiring (30-volt or less) may be installed without conduit above accessible ceilings unless noted otherwise. All low voltage wiring at other locations (concealed in walls, above non-accessible ceilings, exposed areas without ceilings, etc.) shall be installed in conduit. All fire alarm system wiring shall be installed in conduit. All cable installed without conduit shall be neatly placed within joist space above ceilings and properly supported. Cable shall not be placed on or supported by ceiling system.
- B. Types of raceways in this section include the following:
1. Electrical metallic tubing.
 2. Flexible metal conduit.
 3. Liquid-tight flexible metal conduit.
 4. Rigid metal conduit.
 5. Rigid nonmetallic conduit.
 6. Surface metal raceways.

PART 2 PRODUCTS**2.01 METAL CONDUIT AND TUBING**

- A. General: Provide metal conduit, tubing and fittings of types, grades, sizes and weights (wall thicknesses) for each service indicated. Where types and grades are not indicated, provide proper selection determined by Installer to fulfill wiring requirements and comply with applicable portions of NEC for raceways.
- B. Rigid Steel Conduit: Provide rigid steel, zinc-coated, threaded type conforming to ANSI C80.1 and UL 6. Provide zinc coating fused to inside and outside walls.
1. Rigid Metal Conduit Fittings: Rigid metal conduits shall have threaded couplings when installed in concrete or direct burial in the ground. Other installations in dry locations may be threadless rigid fittings.
- C. Flexible Metal Conduit: Provide flexible metal conduit conforming to UL 1. Formed from continuous length of spirally wound, interlocked zinc-coated strip steel.
1. Flexible Metal Conduit Fittings: Provide conduit fittings for use with flexible steel conduit of threadless hinged clamp type.
 - a. Straight Terminal Connectors: One-piece body, female end with clamp and deep slotted machine screw for securing conduit and male threaded end provided with locknut.
 - b. 45° or 90° Terminal Angle Connectors: Two-piece body construction with removable upper section, female end with clamp and deep slotted machine screw for securing conduit and male threaded end provided with locknut.

- D. Liquid-Tight Flexible Metal Conduit: Provide liquid-tight flexible metal conduit conforming to UL 360; construct of single strip, flexible, continuous, interlocked and double-wrapped steel; galvanized inside and outside; coat with liquid-tight jacket of flexible polyvinyl chloride (PVC).
 - 1. Liquid-Tight Flexible Metal Conduit Fittings: Provide cadmium plated, malleable iron fittings with compression type steel ferrule and neoprene gasket sealing rings, with insulated throat.
- E. Electrical Metallic Tubing (EMT): Provide electrical metallic tubing conforming to ANSI C80.3 and UL 797.
 - 1. EMT Fittings: Fittings for EMT shall be steel and may be of the screw or compression type except that in poured concrete the screw type is not acceptable. All EMT connectors shall be of the insulated throat type. Cast or indenter fittings are not acceptable. EMT connectors shall be fastened to box or enclosure with locknuts. Snap-in fittings are not acceptable.
 - 2. Steel EMT connectors with male threads on the locknut and female threads on the connector equal to Cooper Crouse-Hinds Space-Saver connectors may be used in lieu of insulated throat type connectors.
- F. Conduit Bodies: Provide galvanized cast-metal conduit bodies of types, shapes and sizes as required to fulfill job requirements and NEC requirements. Construct conduit bodies with threaded-conduit-entrance ends, removable covers, either cast or of galvanized steel and corrosion-resistant screws.

2.02 NONMETALLIC CONDUIT

- A. General: Provide nonmetallic conduit and fittings of types, sizes and weights as specified.
- B. Rigid Nonmetallic Conduit:
 - 1. Heavy Wall Conduit: Schedule 40, 90 C, UL Rated, construct of polyvinyl chloride and conforming to NEMA TC-2, for direct burial, or normal above ground use, UL Listed.
- C. Conduit and Tubing Accessories: Provide conduit and tubing duct accessories of types, sizes, and materials, complying with manufacturers published product information, which mate and match conduit and tubing.

2.03 SURFACE METAL RACEWAYS

- A. Boxes for Surface Raceways: Designed, manufactured and supplied by raceway manufacturer for use with specified raceway.
- B. Manufacturers: Subject to compliance with requirements, provide surface metal raceways of the following:
 - 1. Wiremold Company.
 - 2. Hubbell Wiring Systems.
 - 3. Or equal as approved by Owner.

PART 3 EXECUTION

3.01 INSTALLATION OF RACEWAYS

- A. General: Install raceways as indicated; in accordance with manufacturer's written installation instructions, and in compliance with NEC and NECA's "Standards of Installation". Install units plumb and level and maintain manufacturer's recommended clearances.
- B. Coordinate with other work including wires/cables, boxes and panel work, as necessary to interface installation of electrical raceways and components with other work.

3.02 INSTALLATION OF CONDUITS

- A. General: All conduits shall be concealed unless noted otherwise. Install concealed conduits either in walls, slabs or above hung ceilings. In existing work where conduits can not be concealed in finished areas, surface metal raceways shall be used.
1. Mechanically fasten together metal conduits, enclosures, and raceways for conductors to form continuous electrical conductor. Connect to electrical boxes, fittings and cabinets to provide electrical continuity and firm mechanical assembly.
 2. Avoid use of dissimilar metals throughout system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, coat surfaces with corrosion inhibiting compound before assembling.
 3. Install miscellaneous fittings such as reducers, chase nipples, 3-piece unions, split couplings, and plugs that have been specifically designed and manufactured for their particular application. Install expansion fittings in raceways every 200-feet linear run or wherever structural expansion joints are crossed.
 4. Use roughing-in dimensions of electrically operated unit furnished by supplier. Set conduit and boxes for connection to units only after receiving review of dimensions and after checking location with other trades.
- B. Conduit Installation: Provide rigid (non-flexible) conduit where embedded in concrete on or below grade, in direct contact with earth or fill below slab, wet locations, in sizes larger than 2-inches or installed outdoors. Follow minimum requirements in other areas as follows:
1. Use rigid steel zinc-coated conduit in spaces where exposed below 4-feet-0-inch height in Mechanical Equipment Rooms, Electrical Equipment Rooms, Penthouses and in locations subject to mechanical injury.
 2. Where acceptable to all authorities having jurisdiction, intermediate metal conduit may be used in lieu of rigid steel conduit in non-hazardous locations when in compliance with NEC.
 3. Use PVC coated rigid steel conduit and fittings where installed in corrosive atmosphere. Patch all nicks and scrapes in PVC coating after installing conduit.
 4. Use steel zinc-coated EMT for raceway systems except as specifically specified previously, where not allowed by NEC or noted on drawings. Additionally EMT shall not be acceptable below grade, in or under slabs on grade, in wet locations or in sizes larger than 2-inches.
 5. Use flexible conduit in movable partitions and from outlet boxes to recessed lighting fixtures in accessible ceilings, and final 24-inches of connection to motors, or control items subject to movement or vibration, and in cells of precast concrete panels. The maximum length for flexible conduit shall not exceed 6-feet.
 6. Use liquid-tight flexible conduit where subjected to one (1) or more of the following conditions:
 - a. Exterior location.
 - b. Moist or humid atmosphere where condensate can be expected to accumulate.
 - c. Pump motors.
 - d. Corrosive atmosphere.
 - e. Subjected to water spray or dripping oil, water or grease.
 7. Rigid Non-Metallic Conduits:
 - a. Rigid non-metallic conduits may be used below grade or embedded in concrete on or below grade only.
 - b. Rigid non-metallic conduits shall not be used for exposed stub-ups above floor. Where acceptable to authority having jurisdiction, rigid non-metallic conduits may be stubbed-up 6-inches above floor where concealed within walls. In masonry walls, non-metallic conduits may be extended to a maximum of 48-inches above floor.
 - c. Make solvent cemented joints in accordance with recommendations of manufacturer.

- d. Install rigid non-metallic conduits in compliance with NEC, local utility practices, and all other authorities having jurisdiction.
- C. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment with an adjustable top or coupling thread inside the plugs and set flush with the finished floor. Extend conductors to equipment with rigid steel conduit; flexible metal conduit may be used 6-inches above the floor. Where equipment connections are not made under this Contract, install screwdriver-operated threaded flush plugs flush with floor.
- D. Protect stub-ups from damage where conduits rise from floor slabs. Arrange so curved portion of bends is not visible above the finished slab.
- E. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200 lb tensile strength. Leave not less than 12-inches of slack at each end of the pull wire.
- F. Cut conduits straight, properly ream, and cut threads for heavy wall conduit deep and clean. Use temporary closures to prevent foreign matter from entering raceways.
- G. Field-bend conduit with benders designed for purpose so as not to distort nor vary internal diameter.
- H. Size conduits to meet NEC requirements and as shown on drawings or specified herein, except no conduit smaller than 3/4-inch shall be embedded in or below concrete or in masonry walls.
- I. Fasten rigid conduit terminations in sheet metal enclosures with locknuts inside and outside enclosure or with threadless rigid box connectors and terminate with bushing.
- J. Where conduit is installed exposed in unfinished areas, conduit shall be installed in such a manner that it does not impede access around equipment or create a tripping hazard.
- K. Conduit terminations in wet locations shall be of the threaded hub type or other sealing type fittings UL Listed for use in wet locations.
- L. Conduits are not to cross vertical or horizontal openings such as pipe shafts, elevator shafts, ventilating duct openings, etc.
- M. Keep conduits a minimum distance of 6-inches from parallel runs of flues, hot water pipes or other sources of heat. Wherever possible, install horizontal raceway runs above water and steam piping.
- N. Conduit shall be properly supported as specified herein and as required by NEC.
- O. Support riser conduit at each floor level with clamp hangers.
- P. Use of running threads at conduit joints and terminations is prohibited. Where required, use 3-piece union or split coupling.
- Q. Complete installation of electrical raceways before starting installation of cables/wires within raceways.
- R. Install raceway sealing fittings in accordance with the manufacturer's written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL Listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points and elsewhere as indicated:
 - 1. Where conduits enter or leave hazardous locations.
 - 2. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces and air-conditioned spaces.
 - 3. Where required by the NEC.
- S. Openings around electrical penetrations through fire-resistant-rated walls, partitions, floors or ceilings shall be firestopped using approved methods to maintain the fire resistance rating.
- T. Provide sleeves for conduits passing through foundation or other load bearing walls.

- U. Conduits installed underground which extend through the foundation walls shall be sealed to prevent the entrance of moisture through the foundation walls. All conduits extending through the exterior walls of a building in areas below grade shall be provided with a hydrostatic seal such as Link Seal or equal.
- V. Concealed Conduits:
 - 1. Conduits in finished areas shall be installed concealed.
 - 2. Metallic raceways installed underground or in floors below grade, or outside are to have conduit threads painted with corrosion inhibiting compound before couplings are assembled. Draw up coupling and conduit sufficiently tight to ensure watertightness.
 - 3. For floors-on-grade, install conduits under concrete slabs.
 - 4. Install underground conduits minimum of 24-inches below finished grade.
 - 5. Rigid steel conduit buried in direct contact with the earth shall be coated with an asphaltum base paint prior to installation and all scratches shall be repainted after installation before backfilling.
- W. Conduits in Concrete Slabs:
 - 1. Conduits shall not be installed in concrete slabs without prior approval/direction from the Structural Engineer regarding maximum conduit sizes, minimum cover, locations, etc.
- X. Install conduits as not to damage or run through structural members. Avoid horizontal or cross runs in building partitions or side walls.
- Y. Exposed Conduits:
 - 1. In unfinished areas such as Janitor Closets, Storage, Mechanical Equipment Rooms, etc., conduit may be run exposed. Prior permission shall be first obtained from the Architect. All exposed conduit shall be installed in a neat manner following the building lines. Horizontal runs shall be close to the ceiling and shall be installed above mechanical piping as much as possible. Single hung conduits shall be supported with strap or rod hangers, wire is not an acceptable hanger. Multiple hung conduits shall be strapped to the channel to hold it in place.
 - 2. Install exposed conduits and extensions from concealed conduit systems neatly, parallel with or at right angles to walls of building.
 - 3. Install exposed conduit work as not to interfere with ceiling inserts, lights or ventilation ducts or outlets.
 - 4. Support exposed conduits by use of hangers, clamps or clips. Support conduits on each side of bends and on spacing not to exceed following: Up to 1-inch: 6-feet-0-inch; 1-1/4-inch and over: 8-feet-0-inch.
 - 5. Run conduits for outlets on waterproof walls exposed. Set anchors for supporting conduit on waterproof wall in waterproof cement.
 - 6. Above requirements for exposed conduits also apply to conduits installed in space above hung ceilings, and in crawl spaces except that spacing of supports for conduits up to 1-inch shall not exceed 8-feet-0-inch.
- Z. Conduit Fittings:
 - 1. Construct locknuts for securing conduit to metal enclosure with sharp edge for digging into metal, and ridged outside circumference for proper fastening.
 - 2. Plastic insulating bushings for terminating rigid conduits smaller than 1-1/4-inch are to have ribbed sides, with smooth upper edges to prevent injury to cable insulation.
 - 3. Install metallic insulated type bushings for terminating rigid conduits 1-1/4-inch and larger. Bushings are to have flared bottom and ribbed sides. Upper edge to have phenolic insulating ring molded into bushing.
 - 4. Miscellaneous fittings such as reducers, chase nipples, 3-piece unions, split couplings and plugs to be specifically designed for their particular application.

3.03 INSTALLATION OF SURFACE RACEWAYS AND WIREWAYS

- A. General: Mechanically assemble metal enclosures, and raceways for conductors to form continuous electrical conductor, and connect to electrical boxes, fittings and cabinets as to provide effective electrical continuity and rigid mechanical assembly.
1. Avoid use of dissimilar metals throughout system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, coat all surfaces with corrosion inhibiting compound before assembling.
 2. Install expansion fittings in all raceways wherever structural expansion joints are crossed.
 3. Make changes in direction of raceway run with proper fittings, supplied by raceway manufacturer. No field bends of two-piece type raceway sections will be permitted.
 4. Field bends of single piece raceway shall be permitted for small offsets only where the use of fittings supplied by the manufacturer is not possible. Field-bend raceway with benders designed for purpose so as not to distort nor vary internal diameter of raceway. Raceway shall be installed so as to avoid field bends wherever possible.
 5. Properly support and anchor raceways for their entire length by structural materials. Raceways are not to span any space unsupported.
 6. Use boxes as supplied by raceway manufacturer wherever junction, pull or device boxes are required. Standard electrical "handy" boxes, etc. shall not be permitted for use with surface raceway installations.

END OF SECTION

SECTION 260534
ELECTRICAL BOXES AND FITTINGS**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Extent of electrical box and associated fitting work is indicated by drawings and schedules.
- B. Types of electrical boxes and fittings in this section include the following:
 - 1. Outlet boxes.
 - 2. Junction boxes.
 - 3. Pull boxes.
 - 4. Bushings.
 - 5. Locknuts.
 - 6. Knockout closures.

PART 2 PRODUCTS**2.01 FABRICATED MATERIALS**

- A. Outlet Boxes: Conform to UL 514A, "Metallic Outlet Boxes, Electrical," and UL 514B, "Fittings for Conduit and Outlet Boxes." Boxes shall be of type, shape, size and depth to suit each location and application.
 - 1. Conform to NEMA OS 1, "Sheet Steel Outlet Boxes, Device Boxes, Covers and Box Supports." Boxes shall be sheet steel with stamped knockouts, threaded screw holes and accessories suitable for each location including mounting brackets and straps, cable clamps, exterior rings and fixture studs.
- B. Raintight Outlet Boxes: Provide corrosion-resistant cast-metal raintight outlet wiring boxes, of types, shapes and sizes, including depth of boxes, with threaded conduit holes for fastening electrical conduit, cast-metal face plates with spring-hinged watertight caps suitably configured for each application, including face plate gaskets and corrosion-resistant plugs and fasteners.
- C. Junction and Pull Boxes: Provide galvanized code-gage sheet steel junction and pull boxes, with screw-on covers; of types, shapes and sizes, to suit each respective location and installation; with welded seams and equipped with steel nuts, bolts, screws and washers.
- D. Bushings, Knockout Closures and Locknuts: Provide corrosion-resistant box knockout closures, conduit locknuts and conduit bushings, offset connectors, of types and sizes, to suit respective installation requirements and applications.

PART 3 EXECUTION**3.01 INSTALLATION OF ELECTRICAL BOXES AND FITTINGS**

- A. General: Install electrical boxes and fittings as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation" and in accordance with recognized industry practices to fulfill project requirements.
- B. Surface-mounted device boxes in unfinished areas shall be a minimum of 4-inch square knockout type. Surface-mounted boxes in finished and exterior areas, shall be cast metal, threaded hub similar to Crouse Hinds "FS" or "FD" conduit box.
- C. Coordinate installation of electrical boxes and fittings with wire/cable, wiring devices and raceway installation work.
- D. Provide weathertight outlets for interior and exterior locations exposed to weather or moisture.
- E. Provide knockout closures to cap unused knockout holes where blanks have been removed.

- F. Install electrical boxes in those locations, which ensure ready accessibility to enclosed electrical wiring. Junction boxes shall not be installed above non-accessible ceilings.
- G. Avoid installing boxes back-to-back in walls. Provide not less than 24-inch separation.
- H. Avoid installing aluminum products in concrete.
- I. Position recessed outlet boxes accurately to allow for surface finish thickness.
- J. Avoid using round boxes where conduit must enter box through side of box, which would result in difficult and insecure connections when fastened with locknut or bushing on rounded surfaces.
- K. Fasten electrical boxes firmly and rigidly to substrates or structural surfaces to which attached or solidly embed electrical boxes in concrete or masonry. Box support shall be independent of conduit.
- L. Provide electrical connections for installed boxes.
- M. Subsequent to installation of boxes, protect boxes from construction debris and damage.

3.02 POSITION OF OUTLETS

- A. The Electrical Contractor shall consult with Mechanical and General Contractor prior to rough-in outlets and shall set boxes to avoid interference with equipment installation in walls or ceilings.
- B. Outlets shall be centered with respect to paneling, trim, furring, etc. Outlets improperly located shall be corrected at Contractor's expenses. Outlets shall be set plumb, secured firmly in place with face of box or plaster ring extending to finished surface or wall, ceiling or floor as the case may be.
- C. Washers or bushings shall be installed between recessed box and device strap to make a flush rigid installation of the device installed.
- D. The following mounting height schedule is included to assist the Contractor in estimating. All device locations shall be coordinated with Architectural details and elevations. Exact heights shall be obtained from the Project Superintendent at the time of installation or taken from drawings as shown thereon. Heights of device outlets are noted in inches from the finished floor.

Switches	48-inch Top
Receptacles	
In Janitor Closet	
Equipment Room,	
Storage Room,	
Shop Toilets and	
Unfinished Areas	48-inch Top
Weatherproof (Exterior)	24-inch Bottom
Others	16-inch Bottom
At Counters and Desk	Bottom 2-inches above
(Unless otherwise indicated)	backsplash
Fire Alarm Visual Notification	Bottom of unit 80-inches above
Units or Combination Audible/Visible	finished floor
Fire Alarm Audible Notification	Top of unit 6-inches below
Units, Clocks, Speakers, Etc.	ceiling or 96- inches
(Unless otherwise indicated)	(Whichever is lower)
Thermostats, Starters, Speaker Controls,	48-inch Top
Fire Alarm Manual Stations, Wall	
Phones, Etc.	

3.03 GROUNDING

- A. Upon completion of installation work, ground electrical boxes as required by NEC and other Division 26 Sections.

END OF SECTION

SECTION 260553
ELECTRICAL IDENTIFICATION**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Extent of electrical identification is indicated by drawings and schedules.
- B. Types of electrical identification specified in this section include the following:
 - 1. Buried cable warnings.
 - 2. Electrical power, control and communication conductors.
 - 3. Operational instructions and warnings.
 - 4. Danger signs.
 - 5. Equipment/system identification signs.
- C. Refer to Division 01 General Requirements Section, Identification Systems, for equipment and system nameplates and performance data; not work of this section.

PART 2 PRODUCTS**2.01 ELECTRICAL IDENTIFICATION MATERIALS**

- A. General: Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than one (1) single type is specified for an application, selection is Installer's option, but provide single selection for each application.
- B. Plasticized Tags:
 - 1. General: Manufacturer's standard pre-printed or partially pre-printed accident-prevention and operational tags, of plasticized card stock with matte finish suitable for writing, approximately 3-1/4-inch x 5-5/8-inch, with brass grommets and wire fasteners, and with appropriate pre-printed wording including large-size primary working, e.g., DANGER, CAUTION, DO NOT OPERATE.
- C. Self-Adhesive Plastic Signs:
 - 1. General: Provide manufacturer's standard, self-adhesive or pressure-sensitive, pre-printed, flexible vinyl signs for operational instructions or warnings; of sizes suitable for application areas and adequate for visibility, with proper wording for each application, e.g., 208V, EXHAUST FAN, RECTIFIER.
 - a. Colors: Unless otherwise indicated or required by governing regulations, provide orange signs with black lettering.
- D. Baked Enamel Danger Signs:
 - 1. General: Provide manufacturer's standard "DANGER" signs of baked enamel finish on 20-gage steel; of standard red, black and white graphics; 14-inch x 10-inch size except where 10-inches x 7-inches is the largest size which can be applied where needed, and except where larger size is needed for adequate vision; with recognized standard explanation wording, e.g., HIGH VOLTAGE, KEEP AWAY, BURIED CABLE, DO NOT TOUCH SWITCH.

E. Engraved Plastic-Laminate Signs:

1. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in sizes and thicknesses indicated, engraved with engraver's standard letter style of sizes and wording indicated, black face and white core (letter color) except as otherwise indicated, punched for mechanical fastening except where adhesive mounting is necessary because of substrate.
 - a. Thickness: 1/16-inch, for units up to 20 sq. in. or 8-inch length; 1/8-inch for larger units.
 - b. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate substrate.

F. Underground-Type Plastic Line Marker:

1. General: Manufacturer's standard permanent, bright-colored, continuous-printed plastic tape, intended for direct-burial service; not less than 6-inch wide x 4 MILS thick. Provide tape with printing which most accurately indicates type of service or buried cable.

G. Color-Coded Conduit Markers:

1. General: Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, plastic-sheet conduit markers, extending 360° degrees around conduits; designed for attachment to conduit by adhesive, adhesive lap joint of marker or matching adhesive plastic tape at each end of marker, or pretensioned snap-on. Except as otherwise indicated, provide lettering which indicates voltage of conductor(s) in conduit. Provide 8-inch minimum length for 2-inch and smaller conduit, 12-inch length for larger conduit.
 - a. Colors: Unless otherwise indicated or required by governing regulations, provide orange markers with black letters.

H. Marker Tapes:

1. Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.02 LETTERING AND GRAPHICS

- A. General: Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of electrical systems and equipment. Comply with ANSI A13.1 pertaining to minimum sizes for letters and numbers.

PART 3 EXECUTION**3.01 APPLICATION AND INSTALLATION****A. General Installation Requirements:**

1. Install electrical identification products as indicated, in accordance with manufacturer's written instructions and requirements of NEC.
2. Coordination: Where identification is to be applied to surfaces, which require finish, install identification after completion of painting.
3. Regulations: Comply with governing regulations and requests of governing authorities for identification of electrical work.

B. Operational Identification and Warnings:

1. General: Wherever reasonably required to ensure safe and efficient operation and maintenance of electrical systems, and electrically connected mechanical systems and general systems and equipment, including prevention of misuse of electrical facilities by unauthorized personnel, install self-adhesive plastic signs or similar equivalent identification, instruction or warnings on switches, outlets and other controls, devices and covers of electrical enclosures. Where detailed instructions or explanations are needed, provide plasticized tags with clearly written messages adequate for intended purposes.

C. Danger Signs:

1. General: In addition to installation of danger signs required by Governing regulations and authorities, install appropriate danger signs at locations indicated and at locations subsequently identified by Installer of electrical work as constituting similar dangers for persons in or about Project.
 - a. High Voltage: Install danger signs wherever it is possible, under any circumstances, for persons to come into contact with electrical power of voltages higher than 250-volts.
 - b. Critical Switches/Controls: Install danger signs on switches and similar controls, regardless of whether concealed or locked up, where untimely or inadvertent operation (by anyone) could result in significant danger to persons, or damage to or loss of property where instructed by Architect.

D. Equipment/System Identification:

1. General: Install engraved plastic-laminate sign on each major unit of electrical equipment in building; including central or master unit of each electrical system including communication/control/signal systems, unless unit is specified with its own self-explanatory identification or signal system. Signs for disconnect switches, motor starters, contactors and similar equipment shall indicate the load served. Except as otherwise indicated, provide single line of text, 1/2-inch high lettering on 1-1/2-inch high sign (2-inch high where two (2) lines are required), white lettering in black field. Lettering for emergency power system components shall be white lettering in red field. Provide text matching terminology and numbering of the Contract Documents and shop drawings. Provide signs for each unit of the following categories of electrical work.
 - a. Panelboards, electrical cabinets and enclosures.
 - b. Access panel/doors to electrical facilities.
 - c. Major electrical switchgear.
 - d. Disconnect switches.
 - e. Power transfer equipment.
 - f. Transformers.
2. Provide engraved sign indicating location of transformer disconnecting means.
3. Service Equipment shall be legibly marked with engraved sign stating the following:
 - a. Available Fault Current.
 - b. ____ Amperes.
 - c. Date Calculated.
 - d. Month/Day/Year.
 - e. Example:

Available Fault Current
49,058 Amperes
Dated Calculated
08/01/08
 - f. Fault current values shall be calculated by the Contractor per specification section 26 05 73.13.
4. Arc Flash values shall be calculated by the Contractor per specification 26 05 73.13.
5. All panelboards, motor control centers, switchboards, fused and unfused safety switches, transfer switches, combination starters and transformers shall be provided with an engraved sign stating the following:
 - a. Name of Equipment.

- b. Voltage.
- c. Power Source.
- d. Example:

Panel A
480Y/277 Volt
Fed from MSB1
Circuit 3

- 6. Install signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with fasteners, except use adhesive where fasteners should not or cannot penetrate substrate.
- E. Underground Cable Identification:
 - 1. General: During back-filling/top-soiling of each exterior underground electrical, signal or communication cable, install continuous underground-type plastic line marker, located directly over buried line at 6-inch to 8-inch below finished grade. Where multiple small lines are buried in a common trench and do not exceed an overall width of 16-inch, install a single line marker.
 - 2. Install line marker for every buried cable, regardless of whether direct buried or protected in conduit.
- F. Control Wiring and Cable Identification:
 - 1. All wiring and cabling, including that within factory-fabricated panels and field installed shall be labeled at each end within 2-inches of termination with a cable identifier and other descriptive information. All wiring and cables shall have additional identifiers within 2-inches of exit from the associated raceway.
 - 2. Permanently label or code each point of field terminal strips to show the instrument or item served.
 - 3. Identify all other control components with permanent labels. Identifiers shall match record documents. All plug-in components shall be labeled such that removal of components does not remove label.
- G. Cable/Conductor Identification:
 - 1. General: Apply cable/conductor identification in each box/enclosure/cabinet, except where another form of identification (such as color-coded conductors) is provided. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar previously established identification for project electrical work.
- H. Conduit Identification:
 - 1. General: Where electrical conduit is exposed in spaces with exposed mechanical piping, which is identified by a color-coded method, apply color-coded identification on electrical conduit in a manner similar to piping identification. Except as otherwise indicated, use orange as coded color for conduit.

END OF SECTION

SECTION 260573.13
SHORT-CIRCUIT STUDIES**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.03 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals may be in digital form.
 - 1. Short-circuit study input data, including completed computer program input data sheets.
 - 2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
 - b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.05 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

- C. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.01 COMPUTER SOFTWARE

- A. Comply with IEEE 399 and IEEE 551.
- B. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.02 SHORT-CIRCUIT STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Cable size and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
- D. Comments and recommendations for system improvements, where needed.
- E. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 - 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
 - 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 - 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
 - 5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
- F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.
- G. Short-Circuit Study Output:
 - 1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated fault-current magnitude and angle.

- c. Fault-point X/R ratio.
- d. Equivalent impedance.
- 2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Calculated asymmetrical fault currents:
 - (1) Based on fault-point X/R ratio.
 - (2) Based on calculated symmetrical value multiplied by 1.6.
 - (3) Based on calculated symmetrical value multiplied by 2.7.
- 3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Obtain all data necessary for the conduct of the study.
 - 1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
 - 2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
 - 3. For relocated equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E (2021).
- B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
 - 1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 - 2. Obtain electrical power utility impedance at the service.
 - 3. Power sources and ties.
 - 4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.

5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.02 SHORT-CIRCUIT STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system to be studied is indicated on Drawings.
- E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
 1. To normal system low-voltage load buses where fault current is 10 kA or less.
 2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
 1. Electric utility's supply termination point.
 2. Low-voltage switchgear.
 3. Control panels.
 4. Standby generators and automatic transfer switches.
 5. Branch circuit panelboards.
 6. Disconnect switches.

3.03 ADJUSTING

- A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

END OF SECTION

SECTION 260573.19
ARC-FLASH HAZARD ANALYSIS**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.03 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the **affected portion from the system**.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals may be in digital form.
 - 1. Arc-flash study input data, including completed computer program input data sheets.
 - 2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.05 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations and licensed. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 PRODUCTS**2.01 COMPUTER SOFTWARE DEVELOPERS**

- A. Comply with IEEE 1584 and NFPA 70E (2021).
- B. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.02 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Cable size and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchboard and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Short-Circuit Study Output: As specified in "Short Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
- F. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."
- G. Arc-Flash Study Output:
 - 1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
- H. Incident Energy and Flash Protection Boundary Calculations:
 - 1. Arcing fault magnitude.
 - 2. Protective device clearing time.
 - 3. Duration of arc.
 - 4. Arc-flash boundary.
 - 5. Working distance.
 - 6. Incident energy.
 - 7. Hazard risk category.
 - 8. Recommendations for arc-flash energy reduction.
- I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.03 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis.
- B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
 - 1. Location designation.
 - 2. Nominal voltage.
 - 3. Flash protection boundary.
 - 4. Hazard risk category.
 - 5. Incident energy.
 - 6. Working distance.
 - 7. Engineering report number, revision number, and issue date.
- C. Labels shall be machine printed, with no field-applied markings.

PART 3 EXECUTION**3.01 EXAMINATION**

- A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.02 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E (2021) and its Annex D for hazard analysis study.
- B. Preparatory Studies:
 - 1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
 - 2. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."
- C. Calculate maximum and minimum contributions of fault-current size.
 - 1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
 - 2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
- D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
- E. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.
- F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
- G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
 - 1. Fault contribution from induction motors should not be considered beyond three to five cycles.

2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).
- H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
 1. When the circuit breaker is in a separate enclosure.
 2. When the line terminals of the circuit breaker are separate from the work location.
- I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.03 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
 1. Verify completeness of data supplied on the one-line diagram on Drawings and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article. Call discrepancies to the attention of Architect.
 2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
 3. For existing equipment, whether or not relocated, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers.
- B. Electrical Survey Data: Gather and tabulate the following input data to support study. Comply with recommendations in IEEE 1584 and NFPA 70E (2021) as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.
 1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Obtain electrical power utility impedance at the service.
 3. Power sources and ties.
 4. Short-circuit current at each system bus, three phase and line-to-ground.
 5. Full-load current of all loads.
 6. Voltage level at each bus.
 7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in per cent, and phase shift.
 8. For reactors, provide manufacturer and model designation, voltage rating and impedance.
 9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
 10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
 11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
 12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
 13. Motor horsepower and NEMA MG 1 code letter designation.

14. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
15. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

3.04 LABELING

- A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:
 1. Switchgear.
 2. Control panel.
 3. Branch circuit panelboards.

3.05 APPLICATION OF WARNING LABELS

- A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.06 DEMONSTRATION

- A. Engage the Arc-Flash Study Specialist to train Owner's maintenance personnel in the potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION

**SECTION 262413
SWITCHBOARDS****PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Extent of switchboard work is indicated by drawings and schedules.
- B. Types of switchboards specified in this section include the following:
 - 1. Circuit Breaker Type Switchboard

PART 2 PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide switchboards of one (1) of the following:
 - 1. ABB.
 - 2. Siemens.
 - 3. Square D Co.
 - 4. Cutler-Hammer.
 - 5. Or equal as approved by Owner.
- B. All switchboards and panelboards shall be of the same manufacturer. The Contractor shall verify that the size of equipment supplied by the selected manufacturer does not exceed the available mounting space.

2.02 EQUIPMENT SECTIONS AND COMPONENTS

- A. General: Except as otherwise indicated, provide switchboards and ancillary components of types, sizes, characteristics and ratings indicated, which comply with manufacturer's standard design, materials, components and construction in accordance with published product information and as required for complete installation.
- B. Switchboards: Provide factory- assembled, dead-front, metal-enclosed, self-supporting secondary power switchboards, of types, sizes and electrical ratings and characteristics indicated; consisting of panel (vertical) units, and containing circuit breakers of quantities, ratings and types indicated. Provide tin plated aluminum main bus and connections to switching devices and circuit- breaker branches, with main bus and tap connections bolted tightly according to manufacturer's torquing requirements for maximum conductivity. The current density of the bus shall not exceed 750-amperes per square inch cross-section for aluminum or 1000-amperes per square inch cross-section for copper. Brace bus for short-circuit stresses up to 100,000 - amperes symmetrical. Provide accessibility of line and load terminations from front of switchboard. Prime and coat switchboard with manufacturer's standard finish and color. Equip units with built-in lifting eyes and yokes; and provide individual panel (vertical) units, suitable for bolting together at Project Site. Construct switchboard units for the following environment:
 - 1. Installation: Indoors, NEMA Type 1.
- C. Enclosures: Construct dead-front switchboards, suitable for floor-mounting, with front cabling/wiring accessibility, and conduit accessibility as indicated. Provide welded steel channel framework; hinge wireway front covers to permit ready access to branch circuit load side terminals. Coat enclosures with manufacturer's standard corrosive-resistant finish. Minimum depth shall be 24-inches.
 - 1. A ground bus shall be furnished secured to each vertical section structure and shall extend the entire length of the switchboard.

- D. Feeder circuit breaker(s) shall be thermal-magnetic molded-case circuit breakers conforming to NEMA AB1 with interrupting capacity to meet the available fault. Circuit breaker frame sizes of 250-amp and larger shall have adjustable magnetic trip settings.
- E. Feeder circuit breaker(s) shall be electronic trip circuit breakers conforming to NEMA AB 1 with interrupting capacity to meet the available fault. The electronic trip circuit breakers shall be RMS sensing, with replaceable rating plugs and have the following field-adjustable settings:
 - 1. Instantaneous trip.
 - 2. Long and short time pickup levels.
 - 3. Long and short time adjustments.
 - 4. Ground-fault pickup level with time delay I₂t response.
- F. Identification: Each switch shall be equipped with engraved plastic nameplates identifying its load.
- G. Branch circuits for feeders and power loads shall consist of circuit breaker of type, size and rating as indicated on the drawings.
 - 1. All main and branch circuit breakers shall be fully rated and have a minimum interrupting rating of 65,000-amperes symmetrical at 208 -volts.
- H. Provide switchboard with a multifunction digital meter. The meter shall be a microprocessor based unit suitable for 3- or 4-wire systems and have as a minimum the following features:
 - 1. Switch-selectable digital display of the following:
 - a. Phase Currents, Each Phase: Plus or minus 1%.
 - b. Phase-to-Phase Voltages, 3-Phase: Plus or minus 1%.
 - c. Phase-to-Neutral Voltages, 3-Phase: Plus or minus 1%.
 - d. Three-Phase Real Power: Plus or minus 2%.
 - e. Three-Phase Reactive Power: Plus or minus 2%.
 - f. Power Factor: Plus or minus 2%.
 - g. Frequency: Plus or minus 0.5%.
 - h. Integrated Demand, (KWD or KVAD) with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2%, user resettable.
 - i. Accumulated energy, in megawatt hours (joules), plus or minus 2%; stored values unaffected by power outage for up to 72 hours.
 - 2. Mounting: Display and control unit flush or semi-flush mounted in switchboard.
- I. Switchboard/ Main breaker shall have maintenance switch for one energy reduction per NEC 240.87.

2.03 GROUND FAULT PROTECTION

- A. Ground fault protection shall be provided integral with the main electronic trip circuit breaker. Provide all accessories as required.

PART 3 EXECUTION

3.01 INSPECTION

- A. Installer must examine areas and conditions under which switchboards and components are to be installed and notify Contractor in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.02 INSTALLATION

- A. Install switchboards as indicated, in accordance with manufacturer's written instructions, with recognized industry practices; complying with applicable requirements of NEC, NEMA's Standard PB 2.1 and NECA's "Standard of Installation".
- B. Coordinate with other work including electrical cabling/wiring work, as necessary to interface installation of switchboards with other work.
- C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486A.
- D. Install fuses in switchboards, if any.

3.03 ADJUSTING AND CLEANING

- A. Adjust operating mechanisms for free mechanical movement.
- B. Touch-up scratched or marred surfaces to match original finishes.

3.04 GROUNDING

- A. Provide equipment grounding connections for switchboards as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective ground. Provide ground bus of ampacity equal to at least 30% of main bus rating.

3.05 FIELD QUALITY CONTROL

- A. Prior to energization of circuitry, check all accessible connections to manufacturer's tightening torque specifications.
- B. Prior to energization of switchboards, check with ground resistance tester phase-to-phase and phase-to-ground insulation resistance levels to ensure requirements are fulfilled.
- C. Prior to energization, check switchboards for electrical continuity of circuits and for short-circuits.
- D. Subsequent to wire and cable hook-ups, energize switchboards and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units and then retest to demonstrate compliance.

END OF SECTION

SECTION 262416
PANELBOARDS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. Extent of panelboard and enclosure work, including cabinets and cutout boxes is indicated by drawings and schedules.
- B. Types of panelboards and enclosures in this section include the following:
 - 1. Power-distribution panelboards.
 - 2. Lighting and appliance panelboards.
- C. Refer to other Division 26 Sections for cable/wire, connectors and electrical raceway work required in conjunction with panelboards and enclosures; not work of this section.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide panelboard products of one (1) of the following:
 - 1. ABB.
 - 2. Siemens.
 - 3. Square D Company.
 - 4. Cutler-Hammer.
 - 5. Or equal as approved by Owner.

2.02 PANELBOARDS

- A. General: Except as otherwise indicated, provide panelboards, enclosures and auxiliary components, of types, sizes and ratings indicated, which comply with manufacturer's standard materials; design and construction in accordance with published product information; equip with proper number of unit panelboard devices as required for complete installation. Where types, sizes or ratings are not indicated, comply with NEC, UL and established industry standards for those applications indicated.
- B. Lighting and Appliance Panelboards: Provide dead-front safety type lighting and appliance panelboards as indicated, with switching and protective devices in quantities, ratings, types and arrangements shown; with anti-turn solderless pressure type lug connectors approved for copper or aluminum conductors; equip with tin-plated aluminum bus bars, full-sized neutral bar, with bolt-on type heavy-duty, quick-make, quick-break, single-pole or multi-pole circuit- breakers, as indicated, with toggle handles that indicate when tripped. Multipole breakers shall be provided with a common trip. Provide suitable lugs on neutral bus for each outgoing feeder required; provide bare uninsulated grounding bars suitable for bolting to enclosures.
 - 1. Lighting and Appliance Panelboards shall be type:

480V

ABB	Bolt-on	Bolt-on
Siemens	AQ	AD, AE
Square D	S1	S2
Cutler-Hammer	NQOD	NF
	PRL1, PRL2	PRL2, PRL3

2. Breakers in 240-volt panelboards shall be fully rated and shall have an interrupting capacity as indicated on drawings.
- C. Lighting and Appliance Panelboard Enclosures: Provide galvanized sheet steel cabinet type enclosures, minimum 20-inches wide and 5-3/4-inches deep, code-gage, minimum 16-gage thickness. Construct with multiple knockouts and wiring gutters. Provide fronts with adjustable trim clamps, and doors with flush metal locks and keys, all panelboard enclosures keyed alike. Equip with interior circuit-directory frame, and card with clear plastic covering. Provide baked gray enamel finish over a rust inhibitor coating. Design enclosures for recessed or surface-mounting as indicated. Provide enclosures which are fabricated by same manufacturer as panelboards, which mate properly with panelboards to be enclosed and are NEMA rated to suit the atmospheric conditions of the equipment surroundings.
 1. Furnish six (6) spare keys for each type of panelboard cabinet lock.
- D. Panelboard Accessories: Provide panelboard accessories and devices including, but not necessarily limited to, cartridge and plug time-delay type fuses, circuit-breakers, ground-fault protection units, etc., as recommended by manufacturer for ratings and applications indicated.

PART 3 EXECUTION

3.01 INSPECTION

- A. Installer must examine areas and conditions under which panelboards and enclosures are to be installed and notify Contractor in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Installer.

3.02 INSTALLATION OF PANELBOARDS

- A. General: Install panelboards and enclosures as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC Standards and NECA's "Standard of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.
- B. Coordinate installation of panelboards and enclosures with cable and raceway installation work.
- C. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B or manufacturer's torque requirements when more stringent.
- D. Anchor enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically secure.
- E. Provide properly wired electrical connections within enclosures.
- F. Provide factory panelboard circuit directory cards upon completion of installation work. Circuit directory cards shall be arranged with even numbered circuits separated by group or card from odd numbered circuits. All circuits, including spares and spaces, shall be labeled. All identification shall be at a minimum typewritten. Hand lettering is not acceptable.
- G. Provide four (4) 3/4-inch empty conduits for future from each flush-mounted panelboard to an accessible space above the ceiling in finished rooms or in joist space of unfinished rooms.
- H. All wiring within panelboards shall be arranged in a neat and organized manner.

3.03 GROUNDING

- A. Provide equipment grounding connections for panelboards as required by NEC and other Division 26 Sections. Tighten connections to comply with tightening torques specified in UL Standards 486A and B to assure permanent and effective grounds.

3.04 FIELD QUALITY CONTROL

- A. Prior to energization of circuitry, check all accessible connections to manufacturer's tightening torque specifications.

- B. Prior to energization of panelboards, check with ground resistance tester phase-to-phase and phase-to-ground insulation resistance levels to ensure requirements are fulfilled.
- C. Prior to energization, check panelboards for electrical continuity of circuits and for short-circuits.
- D. Subsequent to wire and cable hook-ups, energize panelboards and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units and then retest to demonstrate compliance.

END OF SECTION

**SECTION 262726
WIRING DEVICES****PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. The extent of wiring device work is indicated by drawings and schedules. Wiring devices are defined as single discrete units of electrical distribution systems, which are intended to carry but not utilize electric energy.
- B. Types of electrical wiring devices in this section include the following:
 - 1. Receptacles.
 - 2. Ground-fault circuit interrupters.
 - 3. Switches.
 - 4. Wallplates.
 - 5. Plugs and connectors.

PART 2 PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide wiring devices of one (1) of the following (for each type and rating of wiring device):
 - 1. Arrow Hart
 - 2. Bryant Electric Co.
 - 3. Cooper Wiring Devices
 - 4. Daniel Woodhead Co.
 - 5. Eagle Electric Mfg. Co.
 - 6. General Electric Co.
 - 7. Hubbell Inc.
 - 8. Leviton Mfg Co.
 - 9. Pass and Seymour Inc.
 - 10. Or equal as approved by Owner.

2.02 FABRICATED WIRING DEVICES

- A. General: Provide factory-fabricated wiring devices, in types, colors and electrical ratings for applications indicated and which comply with NEMA Standards Pub/No. WD 1. Provide ivory color devices except as otherwise indicated; color selection to be verified by Contractor with Architect/Engineer and color of existing devices. All devices shall be specification grade.
 - 1. Devices on emergency circuits shall be red.
 - a. Wallplates for emergency devices shall be as specified in "WIRING DEVICE ACCESSORIES" paragraph(s) of this section [and shall have engraved red-filled letters "EMERGENCY" on each wallplate].
 - b. Wallplates for emergency devices shall be red.

B. Receptacles:

1. Heavy-Duty Simplex: Provide single heavy-duty self-grounding type receptacles, 2-pole, 3-wire, with green hexagonal equipment ground screw, 20-amperes, 125-volts, with metal plaster ears; design for side and back wiring with spring loaded, screw activated pressure plate, with NEMA configuration 5-20R unless otherwise indicated.
2. Heavy-Duty Duplex: Provide heavy-duty self-grounding type duplex receptacles, 2-pole, 3-wire, 20-amperes, 125-volts, with green hexagonal equipment ground screw, metal plaster ears, finger groove, design for side and back wiring with spring loaded, screw activated pressure plate, with NEMA configuration 5-20R unless otherwise indicated.
 - a. P & S Plug Tail receptacles with connector built into back of device and separate polycarbonate connector housing with connector leads are acceptable.
 - b. Provide orange isolated ground type receptacles where indicated on associated drawings.
 - c. Provide hospital grade devices where required per NEC and Local Codes.
3. Ground-Fault Interrupters: Provide "feed-thru" type ground-fault circuit interrupters, with heavy-duty duplex receptacles, capable of protecting connected downstream receptacles on single circuit, and of being installed in a 2-3/4-inch deep outlet box without adapter, grounding type UL Rated Class A, Group 1, rated 20-amperes, 120-volts, 60 Hz; with solid-state ground-fault sensing and signaling; with 5-milliamperes ground-fault trip level; equip with NEMA configuration 5-20R.

C. Plugs and Connectors:

1. Plugs and Connectors: Provide plugs and connectors with required amperage ratings, voltage ratings and NEMA configurations, which are designed to suit the atmospheric conditions of the equipment surroundings. All plugs and connectors shall be manufactured by Daniel Woodhead Company or approved equal by one (1) of the following manufacturers:
 - a. Hubbell Inc.
 - b. Pass and Seymour Inc.
 - c. Or equal as approved by Owner.

D. Switches:

1. General: Switches shall be provided as specified in this section. Additional features such, as key operator, rocker and lighted toggle shall be provided where indicated on the drawings.
2. Single-Pole: Provide heavy-duty flush single-pole AC quiet, self-grounding type switches, 20-amperes, 120/277-volts, with mounting yoke insulated from mechanism, equip with plaster ears, toggle switch handle, and side-wired screw terminals.
3. Double Pole: Provide heavy-duty flush double-pole AC quiet, self-grounding type switches, 20-amperes, 120/277-volts, with mounting yoke insulated from mechanism, equip with plaster ears, toggle switch handles and side-wired screw terminals.
4. Three-Way: Provide heavy-duty flush 3-way AC quiet, self-grounding type switches, 20-amperes, 120/277-volts, with mounting yoke insulated from mechanism, equip with plaster ears, toggle switch handles and side-wired screw terminals.
5. Four-Way: Provide heavy-duty flush 4-way AC quiet, self-grounding type switches, 20-amperes, 120/277-volts, with mounting yoke insulated from mechanism, equip with plaster ears, toggle switch handles and side-wired screw terminals.

2.03 WIRING DEVICE ACCESSORIES

- A. Wallplates: Provide wallplates for single and combination wiring devices, of types, sizes and with ganging and cutouts as indicated. Select plates which mate and match wiring devices to which attached. Construct with metal screws for securing plates to devices; screw heads colored to match finish of plates; wallplates colored to match wiring devices except as noted below. Provide plates possessing the following additional construction features:
1. Finished Areas:

Material and Finish:	0.04-inch thick, type 302 satin finished stainless steel
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 2. Unfinished Areas:

Material and Finish:	Steel plate, galvanized.
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 3. Surface-mounted boxes in unfinished areas shall be furnished with 4-inch square raised covers, with openings to fit device or devices to be installed.
- B. Furnish metallic weatherproof covers for receptacle installed outdoors, in wet locations or shown as weatherproof. Provide in-use weatherproof covers where required per NEC.
- C. Finish plates provided for switches controlling exhaust fans shall be stainless steel and engraved as follows "EXH FAN" in 1/4-inch high black filled letters.

PART 3 EXECUTION**3.01 INSTALLATION OF WIRING DEVICES**

- A. Install wiring devices as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation" and in accordance with recognized industry practices to fulfill project requirements.
- B. Coordinate with other work, including painting, electrical boxes and wiring work, as necessary to interface installation of wiring devices with other work.
- C. Install wiring devices only in electrical boxes, which are clean; free from excess building materials, dirt and debris.
- D. Install wallplates after painting work is completed.
- E. The continuity of branch circuit conductors shall not depend on device connections such as lampholders, receptacles, etc. where the removal of the device would interrupt the continuity. Branch circuit conductors shall be spliced with jumpers to connect the device.
- F. Connections of wire to devices shall be screw tightened (except devices with built-in connector/leads). Connections using only spring pressure are not acceptable.
- G. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B. Use properly scaled torque indicating hand tool.
- H. All switches and receptacles with exposed terminals shall be wrapped with insulating tape equal to Scotch No. 33 such that no live parts are left exposed.

3.02 PROTECTION OF WALLPLATES AND RECEPTACLES

- A. Upon installation of wallplates and receptacles, advise Contractor regarding proper and cautious use of convenience outlets. At time of Substantial Completion, replace those items, which have been damaged, including those burned and scored by faulty plugs and those, which are not clean and free from paint, dirt and debris.

3.03 GROUNDING

- A. Provide equipment grounding connections for wiring devices, unless otherwise indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.

3.04 TESTING

- A. Prior to energizing circuitry, test wiring for electrical continuity, and for short-circuits. Ensure proper polarity of connections is maintained. Subsequent to energization, test wiring devices to demonstrate compliance with requirements.

END OF SECTION

SECTION 262813**FUSES****PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Extent of fuse work is indicated by drawings and schedules.
- B. Types of fuses specified in this section include the following:
 - 1. Class L time-delay.
 - 2. Class RK1 time-delay.
 - 3. Class RK5 time-delay.
 - 4. Plug fuses.

PART 2 PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS**

- A. Manufacturer: Subject to compliance with requirements, provide products of one (1) of the following:
 - 1. Bussman Div; McGraw-Edison Co.
 - 2. Littelfuse Co.
 - 3. Gould Shawmut.
 - 4. Or equal as approved by Owner.
- B. Fuse types listed below are for Bussman Co. Fuses by Littelfuse Co. or Gould Shawmut shall be equal to types indicated.

2.02 FUSES

- A. General: Except as otherwise indicated, provide fuses of types, sizes, ratings, and average time/current and peak let-through current characteristics indicated, which comply with manufacturer's standard design, materials and construction in accordance with published product information, and with industry standards and configurations.
- B. Class L Time-Delay Fuses: Provide UL Class L time-delay fuses rated 600V (Type KRP-C), 60 Hz, with 200,000 RMS symmetrical interrupting current rating for sizes 601-amperes and larger.
- C. Class RK1 Time-Delay Fuses: Provide UL Class RK1 time-delay fuses rated 250V (Type LPN-RK) for voltages under 250V and 600V (Type LPS-RK) for voltages 250-600V, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for sizes 100- through 600-amperes.
- D. Class RK5 Time-Delay Fuses: Provide UL Class RK5 time-delay fuses rated 250V (Type FRN-R) for voltages under 250V and 600V (Type FRS-R) for voltages 250-600V, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for sizes .1- through 90-amperes.
- E. Plug fuses shall be permitted only for single-pole fuseholder with switch units. Plug fuses shall be dual-element Type S fuses.

PART 3 EXECUTION**3.01 INSTALLATION OF FUSES**

- A. Install fuses as indicated, in accordance with the manufacturer's written instructions and with recognized industry practices to ensure that protective devices comply with requirements. Comply with NEC and NEMA Standards for installation of fuses.
- B. Coordinate with other work, including electrical wiring work, as necessary to interface installation of fuses with other work.

- C. Install fuses in fused switches, if any.
- D. Short-circuit protection dual-element fuses installed in individual motor circuits with separate overload protection shall be sized at 150% of motor nameplate current rating or the next standard fuse size. Where excessive ambient temperature, high inertia motor loads or frequent "on-off" cycling requires larger fuses, consult the electrical engineer. Use fuse reducers where fuse gaps are larger than fuse dimension.
- E. All fuse sizes shall be coordinated with manufacturer's requirements for each unit of equipment to be connected.

3.02 FIELD QUALITY CONTROL

- A. Prior to energization of fusible devices, test devices for continuity of circuitry and for short-circuits. Correct malfunctioning units and then demonstrate compliance with requirements.

END OF SECTION

SECTION 262816
CIRCUIT AND MOTOR DISCONNECTS**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Extent of circuit and motor disconnect switch work is indicated on drawings and schedules.
- B. Types of circuit and motor disconnect switches in this section include the following:
 - 1. Equipment disconnects.
 - 2. Appliance disconnects.
 - 3. Motor-circuit disconnects.
- C. Wires/cables, raceways and electrical boxes and fittings required in connection with circuit and motor disconnect work are specified in other Division 26 Sections.

PART 2 PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS**

- A. Manufacturer: Subject to compliance with requirements, provide circuit and motor disconnects of one (1) of the following:
 - 1. ABB.
 - 2. Siemens.
 - 3. Square D Company.
 - 4. Cutler-Hammer.
 - 5. Or equal as approved by Owner.

2.02 DISCONNECT SWITCHES

- A. General-Duty Disconnect Switches: For switches rated less than 100-amps provide surface-mounted, general-duty type, sheet-steel enclosed switches, of types, sizes and electrical characteristics indicated; rated for system voltage, 60 Hz, with required number of poles and solid neutral incorporating spring assisted, quick-make, quick-break switches. Equip with operating handle which is integral part of enclosure base and whose operating position is easily recognizable and is capable of being padlocked in OFF position. Construct current carrying parts of high-conductivity copper, with silver-tungsten type switch contacts and positive pressure type reinforced fuse clips where fusing is required. The enclosure shall be NEMA rated to suit the atmospheric conditions of the equipment surroundings and of the manufacturer's standard finish. When used as service disconnect, provide with UL markings indicating "suitable for use as service equipment".
- B. Heavy-Duty Disconnect Switches: For switches rated 100-amps or greater provide surface-mounted, heavy-duty type, sheet-steel enclosed switches, of types, sizes and electrical characteristics indicated; rated for system voltage 60 Hz, with required number of poles and solid neutral incorporating quick-make, quick-break type switches. Equip with operating handle which is integral part of enclosure base and whose position is easily recognizable, and is padlockable in OFF position; construct current carrying parts of high-conductivity copper, with silver-tungsten type switch contacts, and positive pressure type reinforced fuse clips where fusing is required. The enclosure shall be NEMA rated to suit the atmospheric conditions of the equipment surroundings and of the manufacturer's standard finish. When used as service disconnect, provide with UL markings indicating "suitable for use as service equipment".
- C. Motor-circuit disconnect switches must be HP rated.

- D. Fuses: Provide fuses for disconnect switches, as recommended by switch manufacturer, of classes, types and ratings needed to fulfill electrical requirements for service indicated.

PART 3 EXECUTION

3.01 INSTALLATION OF MOTOR AND CIRCUIT DISCONNECT SWITCHES

- A. Install circuit and motor disconnect switches where indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NEMA and NECA's "Standard of Installation" and in accordance with recognized industry practices.
- B. Coordinate motor and circuit disconnect switch installation work with electrical raceway work, location of equipment and as necessary for proper interface. Provide U-channel supports from floor and/or structure where required to mount disconnects at free-standing equipment.
- C. Install disconnect switches used with motor-driven appliances, and motors and controllers within sight of controller position for motors greater than 1/8 HP.

3.02 GROUNDING

- A. Provide equipment grounding connections, sufficiently tight to assure a permanent and effective ground as required by NEC and in Grounding Section of Division 26.

3.03 FIELD QUALITY CONTROL

- A. Subsequent to completion of installation of electrical disconnect switches, energize circuitry and demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at Project Site, then retest to demonstrate compliance; otherwise remove and replace with new units and retest.

END OF SECTION

SECTION 265113
LUMINAIRES**PART 1 GENERAL****1.01 RELATED DOCUMENTS**

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

1.02 SUMMARY

- A. Extent of luminaires work is indicated by drawings and schedules.
- B. Materials covered in this section include the following:
 - 1. Luminaires.
 - 2. Emergency lighting units.
 - 3. Exit signs with battery backup.
 - 4. LED

1.03 SUBMITTALS

- A. For each luminaires type listed on the "Luminaire Schedule" on the drawings, submit the following information for review:
 - 1. A cut sheet for each luminaires with type designation listed at the top of the sheet. Clearly identify full luminaires part number and all included options. Cut sheet shall contain photometrics and list luminaires efficiency.
 - 2. Driver cut sheet from an acceptable manufacturer with specific model number identified. Indicate on the cut sheet each luminaires type utilizing the driver.
 - 3. Include warranty information that meets or exceeds requirements indicated in the specifications or on plans.

1.04 WARRANTY

- A. Provide material manufacturer's written warranties, as follows:
 - 1. LED Luminaires: Five (5) years.
 - 2. Emergency lighting units: Five (5) years
 - 3. Exit signs with battery backup: Five (5) years

PART 2 PRODUCTS**2.01 LUMINAIRES - GENERAL**

- A. Letters (A, B, C, etc.) near each luminaires symbol shown on the drawings correspond to the "Luminaire Schedule", also on the drawings.
- B. The type and acceptable manufacturers of all luminaires shall be as indicated on the luminaires schedule and drawings.
 - 1. Additional products from manufacturers not listed on the schedule or drawings may be submitted for review and pre-approval by the Architect and Engineer.
 - 2. Prior approvals must be submitted 10 days prior to Bid or prior to last addendum.
- C. All recessed luminaires shall be provided with rubber or fiberglass gaskets or of equivalent material to prevent light leaks around flush trim. Luminaires shall be provided with proper thermal protection as required for surrounding environment. Exterior luminaires shall be furnished with weatherproof, neoprene gaskets suitable for outdoor installations.

- D. All acrylic lenses shall be prismatic and not less than 0.125-inches thick nominal. Lensed luminaires installed in kitchens and other areas indicated on the drawings shall have prisms inverted to provide smooth cleaning surface.
- E. No labels on the luminaires shall be visible from a floor-standing position.
- F. All components of all luminaires shall be UL listed.
- G. All luminaire finishes shall be factory applied unless specifically noted otherwise. Refer to schedule on drawings for finish color.
- H. Provide factory installed integral disconnecting means for fluorescent luminaires per 2020 NEC article 410.130 (G). Note that exception No. 4 and exception No. 5 will not be accepted.
- I. All luminaires shall be painted after fabrication. Housings for recessed fluorescent luminaires shall have a minimum depth of 4". Provide extruded aluminum type door frames where luminaires are specified with aluminum door frames.
- J. LED downlights shall have matte Alzak finish self-trimming reflectors. LED downlights with shall have hardware mounting for reflector, spring clips are not acceptable.
- K. Contractor shall field verify voltage of all luminaires prior to ordering.
- L. Where luminaires are shown with lamps switched separately, provide quantity of ballasts accordingly. Provide inside lamp(s) switched separate from outside lamps unless noted otherwise.

2.02 EMERGENCY LIGHTING UNITS

- A. Acceptable Manufacturers: Refer to Luminaire Schedule on plans.
- B. Description: Sealed emergency unit with maintenance-free batteries and lamp types as specified in the Luminaires Schedule on plans plus appropriately sized battery charger and electronic control circuitry, UL 924 and NFPA 101 (2018) compliant. Luminaire housing shall be impact-resistant thermoplastic die-cast aluminum with adjustable fixed lights.
- C. Provide with self-test and self-diagnostic feature. Unit shall automatically perform monthly tests for 30 seconds every 30 days and a full discharge test of 90 minutes one time per year. Upon component failure, the unit shall emit an audible alarm and provide a visual signal. Unit shall be capable of 90 minutes of continuous illumination upon loss of AC power.
- D. Emergency lighting unit layout shown on plans is based upon manufacturer and model specified on the Luminaire Schedule. If an alternative emergency lighting unit manufacturer is selected by the Contractor from the acceptable manufacturers list in the Luminaire Schedule, the selected manufacturer shall review luminaire layout on plans and confirm NFPA 101 (2018) compliance for light levels in the paths of egress identified on the architectural plans. Additional lighting units shall be provided by the Contractor, as needed, to maintain NFPA 101 (2018) egress lighting compliance. The cost of the additional luminaires shall be included in the Contractor's bid amount.
- E. For cold environment applications, the unit shall be rated for a minimum of 0°F temperatures using integral strip heater(s) or other proven method.
- F. All exterior units and remote heads shall have die-cast aluminum housing and be UL wet location listed.
- G. Units subject to physical damage (in gymnasiums, etc.) shall be provided with steel wire guard of suitable size and strength.

2.03 EXIT SIGNS WITH BATTERY BACKUP

- A. Acceptable Manufacturers: Refer to Luminaire Schedule on plans.

- B. Description: Emergency luminaires with maintenance-free batteries and integral LED light source plus appropriately sized battery charger and electronic control circuitry, UL 924 and NFPA 101 (2018) compliant. Luminaires housing shall be impact-resistant thermoplastic with red 'EXIT' lettering and chevrons as shown on plans.
- C. Provide with self-test and self-diagnostic feature. Unit shall automatically perform monthly tests for 30 seconds every 30 days and a full discharge test of 90 minutes one time per year. Upon component failure, the unit shall emit an audible alarm and provide a visual signal. Unit shall be capable of 90 minutes of continuous illumination upon loss of AC power.
- D. For cold environment applications, the unit shall be rated for a minimum of 0°F temperatures using integral strip heater(s) or other proven method.

2.04 LIGHT EMITTING DIODES (LED) SYSTEMS

- A. Acceptable manufacturers: Refer to Luminaire Schedule on plans.
 - 1. The manufacturer and model listed on the Luminaire Schedule is the basis of design and represents the quality level and required options. Any proposed equal luminaires submitted for review and pre-approval by the Engineer shall meet or exceed the performance of the basis of design.
- B. Each LED-containing luminaires shall be tested as a complete lighting system under the requirements of IESNA LM-79, LM-80 and utilize absolute photometry.
- C. Provide each luminaires with an LED driver that has been tested and approved for use with the LED array in the luminaires. Luminaires installed in low ambient temperature areas shall have LED drivers specifically designed for low temperature starting. Luminaires installed in high ambient temperature areas shall have LED drivers specifically designed for high temperature starting.
- D. Correlated Color Temperature (CCT) shall be as noted on the Luminaire Schedule on plans.

PART 3 EXECUTION

3.01 INSPECTION

- A. Examine areas and conditions under which luminaires are to be installed and substrate which will support luminaires. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF LUMINAIRES

- A. Install luminaires at locations and heights as indicated, in accordance with luminaires manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation", NEMA Standards and with recognized industry practices to ensure that luminaires fulfill requirements.
- B. Coordinate with other electrical work as appropriate to properly interface installation of luminaires with other work.
- C. Where recessed luminaires are specified, Contractor shall provide plaster frames or other framing devices to the Ceiling Contractor prior to the installation of the luminaires and shall be responsible to see that the proper luminaires are furnished for the specific ceiling used.
- D. Independently support each lay-in luminaires installed in an acoustical ceiling using 2 #12 steel wires connected to opposite ends of the luminaires housing and anchored to structure (floor deck, metal truss, etc.) above. All other luminaires installed in a ceiling grid shall be supported by minimum 1 #12 steel wire connected to luminaires housing and anchored to structure (floor deck, metal truss, etc.). In no case shall any luminaires be hung from plaster, plasterboard, acoustic or insulating materials or supported solely by an acoustical ceiling grid.

- E. Where recessed luminaires are installed in fire-rated ceilings or walls, Contractor shall provide an enclosure approved by authorities having jurisdiction to surround each luminaire as required to maintain the fire integrity rating of the ceiling. Adequate clearance between luminaires and enclosure shall be provided in accordance with luminaire manufacturers recommendations. Verify clearance requirements with luminaire manufacturer prior to installation of luminaires.

3.03 ADJUSTING AND CLEANING

- A. Clean luminaires of dirt and debris upon completion of installation.
- B. Protect installed luminaires from damage during construction period.

3.04 FIELD QUALITY CONTROL

- A. Upon completion of installation of luminaires, and after building circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units and proceed with retesting.
- B. Contractor shall perform 'burn-in' period for all fluorescent, compact fluorescent and HID lamps per lamp manufacturer's recommendations. Lamps shall not be dimmed during this period.

3.05 GROUNDING

- A. Provide equipment grounding connections for luminaires as required by NEC and other Division 26 Sections. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.

END OF SECTION