National Park Service
U.S. Department of the Interior

Northeast Region

Replace HVAC System Units

PMIS No.: 313918

PROJECT MANUAL

RICHMOND NATIONAL BATTLEFIELD PARK

3215 East Broad Street
Richmond, Virginia 23223

April 18, 2025

FRONT COVER:

Chimborazo Visitor Center

Mailing Address:

Richmond National Battlefield Park
3215 East Broad Street
Richmond, Virginia 23223

To review general information about

Richmond National Battlefield Park

please visit:

www.NPS.gov/RICH

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SECTION 00 60 00 - NPS PROJECT FORMS

PART 1 - GENERAL

1.1 SUMMARY

A. Below is the listing of National Park Service (NPS), Project Forms included in this Project Manual. The Project Forms, included in Divisions 00, shall be utilized to perform and complete the necessary tasks, as applicable, to the Project.

B. Project is:
Update HVAC System Units in Richmond Buildings
Richmond National Battlefield Park
3215 East Broad Street, Richmond, VA 23223
PMIS Number: RICH 313918

C. Location: Richmond Metropolitan Statistical Area; VA01 & VA04 Congressional District

1.2 RELATED SECTIONS

A. All Divisions and Sections of the Project Manual, in its entirety, particularly those that specify submissions and/or transmittals of information, qualifications, and other materials, between the Contractor and Government are related to this Document, including, but not limited to:

1. Division 01, all Sections
2. Division 02 through 49 all Material Sections
3. Project Drawings

1.3 LIST OF PROJECT FORMS

A. Included with the Project Manual are NPS Project Forms that shall be utilized in performing the required tasks and duties of the Project. The NPS forms are:

1. Document 006211 – SUBMITTAL TRANSMITTAL FORM [CM-16]
2. Document 006241 – CONTRACTOR QUALITY CONTROL DAILY REPORT FORM
3. Document 006273 – SCHEDULE OF VALUES FORM [SOV]
4. Document 006313 – REQUEST FOR INFORMATION FORM [RFI]
5. Document 006411 – EMERGENCY CONTACT LIST

B. Should a listed Project Form not be present in the Project Manual, notify the Government immediately in a timely manner, in writing, directed to the Contracting Officer and Contract Specialist. Submit said notification no later than 10 days prior to Pre-construction Conference.

PART 2 - PRODUCTS Not Applicable to this Document

PART 3 - EXECUTION

3.1 SUBMITTING FORMS

A. All Project Forms submitted to the Government shall be completed in type-face or neatly printed.

1. Completed forms shall be e-mailed to the Government.
2. Once a month submit original documents bearing an original authorized agent signature to the Government.

END OF SECTION 00 60 00

DOCUMENT 006211 - SUBMITTAL TRANSMITTAL FORM

CM-16
r11/10

Date:	Transmittal No.: Sheet: of:

Park RICH	PMIS No.: 313918	Project: **Replace HVAC System Units**	Contract No.:

Contractor:	Subcontractor / Supplier:

A = Action / **I** = Informational	Item No.	Specification Section No.	Paragraph No.	Description of Item (Size, Type, Name, Manufacturer, Use, Etc.)	Alternate Materials Proposed	NPS ACTION				
						A			I	
						Approved	Approved with Notations	Disapproved - Resubmit	Accept	Reject

Date:	Contractor's Signature / Title:	Review Comments
I hereby certify that this submittal has been reviewed for accuracy, completeness, and compliance with contract requirements.		
Date:	Recommended by / Title:	
Date:	Action by / Title:	
Date Received:	Distribution 1 copy each: CO, CS, COR, A/E, NERO.	Date To Contractor:

Approval of this submittal is subject to the provisions of the contract drawings and specifications. This action is for general concurrence only and the government is not responsible for errors or omissions.

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DOCUMENT 006241
CONTRACTOR'S QUALITY CONTROL
DAILY REPORT

CQC

This is a National Park Service Northeast Region Form.

PROJECT: Rehabilitate Structures for Leasing			REPORT NUMBER:	SHT. OF
RICH – PMIS No. 313918			CONTRACT NO.:	DATE:
PARK: Richmond National Battlefield Park			CONTRACTOR'S REPRESENTATIVE ON THE JOB	
WEATHER (Rain, Snow, Cloudy, Windy, etc.)	RAINFALL (Inches)	TEMPERATURE MAX. / MIN.	GROUND CONDITIONS (Dry, Damp, Wet, Frozen, etc.)	

1. PRIME CONTRACTOR

NO. EMPLOYEES BY JOB CATEGORIES	Hours	HEAVY EQUIPMENT ON JOB	NO. UNITS	HRS. WORKING		
				YES	NO	Comments

WORK PERFORMED BY PRIME CONTRACTOR:

2. MATERIALS DELIVERED

OFFICIAL VISITORS TO SITE

2A. SUBCONTRACTOR,_____: (If more than one subcontractor use copies of following page.)

NO. EMPLOYEES BY JOB CATEGORIES	Hours	HEAVY EQUIPMENT ON JOB	NO. UNITS	HRS. WORKING		
				YES	NO	Comments

WORK PERFORMED BY SUBCONTRACTOR:

3. SPECIFIC INSPECTIONS: (Inspections performed, results, and corrective actions)

4. TESTING: ☐1 Check if any testing was performed today. (Complete and attach Test Report Information Sheets.)

Type and Location of Testing:

5. VERBAL INSTRUCTION RECEIVED FROM GOVERNMENT ON CONSTRUCTION DEFICIENCIES OR RE-TESTING REQUIRED:

6. REMARKS:

7. CERTIFICATION:

I, the undersigned, certify that the above report is complete and correct and that I, or my authorized representative, have inspected all work performed this day by the Prime Contractor and each subcontractor and determined that all materials, equipment, and workmanship are in strict compliance with the plans and specifications except as may be noted above.

_____

Contractor's Quality Control Representative DATE:

SUBCONTRACTOR WORK CONTINUED:	CONTRACT NO.	REPORT NO. _____ SHEET_____OF _____

2B SUBCONTRACTOR,

NO. EMPLOYEES BY JOB CATEGORIES	Hours	EQUIPMENT ON JOB	NO. UNITS	HRS. WORKING		
				YES	NO	Comments

WORK PERFORMED BY SUBCONTRACTOR:

2C SUBCONTRACTOR,

NO. EMPLOYEES BY JOB CATEGORIES	Hours	EQUIPMENT ON JOB	NO. UNITS	HRS. WORKING		
				YES	NO	Comments

WORK PERFORMED BY SUBCONTRACTOR:

2D SUBCONTRACTOR,

NO. EMPLOYEES BY JOB CATEGORIES	Hours	EQUIPMENT ON JOB	NO. UNITS	HRS. WORKING		
				YES	NO	Comments

WORK PERFORMED BY SUBCONTRACTOR:

2E SUBCONTRACTOR,

NO. EMPLOYEES BY JOB CATEGORIES	Hours	EQUIPMENT ON JOB	NO. UNITS	HRS. WORKING		
				YES	NO	COMMENTS

WORK PERFORMED BY SUBCONTRACTOR:

DOCUMENT 006273
SCHEDULE OF VALUES FORM

This is a National Park Northeast Region form.
See Instructions on page 2.

SOV

Project: Replace HVAC System Units
Park: RICH – Richmond National Battlefield Park

PMIS No: 313918
Solicitation No: _____

Contractor: _____

Trade: _____
CAP No.: _____
Date: _____
Page:: _____

SPEC SECTION	DESCRIPTION	BID	UM	QTY	Labor	Material	SCHEDULED VALUE
							$

SOV

GENERAL INSTRUCTIONS

1. Complete all items on the opposite side of this Document.
2. Deliver document clearly typed or written to the Government with a return e-mail address, in order for the Government to communicate if required.
3. Should additional space be required, copy first page. Utilize as many copies as appropriate to Project

COLUMN BY COLUMN INSTRUCTIONS for SCHEDULE OF VALUES (SOV)

1. Complete the project information section.
2. Enter the required information in the following cells:
   a. **Spec Section** - Select relevant specification section per the Project Manual.
   b. **Description** - Maximum of 27 characters, use standard abbreviations. Do not use punctuation such as periods, appostrophies or quotations. (feet = FT, inches = IN) (example: 3/4 IN copper DHW)
   c. **BID -** Insert "**B**" for a base bid item, "**G**" for a general requirement item, or "**O**" for an optional item. Must be CAPS**.**
   d. **UM** (Unit Measure) - Select relevant unit from UM list (UM Codes) Must be CAPS.
   e. **Quantity** - Whole number, no decimals (do not use truncation to hide decimal portion of value. Round value to nearest dollar.)
   f. **Labor** - Whole number, no decimals (do not use truncation to hide decimal portion of value. Round value to nearest dollar.)
   g. **Material** - Whole number, no decimals (do not use truncation to hide decimal portion of value. Round value to nearest dollar.)
   h. **Scheduled Value**- Enter total Government cost.
3. As necessary copy first page / spreadsheet as many times as required to provide Government with Project information.
4. Utilize Unit of Measure Legend below as appropriate to material.
5. Properly completed Schedule of Values (SOV) spreadsheet will facilitate Government processing of Certified Application for Payment (CAP) and issuance of benefits as applicable to Contract. Attach completed form to CAP.

Unit of Measure Legend - Imperial Units

Line No.	UM	UM Description	Line No.	UM	UM Description	Line No.	UM	UM Description
1	AC	Acres	11	HR	Hour	21	MO	Months
2	BF	Board Feet	12	IN	Inches	22	NT	Not to Exceed
3	CF	Cubic Feet	13	LB	Pounds	23	PC	Pieces
4	CI	Cubic Inches	14	LF	Linear Feet	24	SF	Square Feet
5	CS	Hundred Square Feet	15	LS	Lump Sum	25	SI	Square Inch
6	CY	Cubic Yard	16	LY	Linear Yard	26	SQ	Square
7	EA	Each	17	MB	Thousand Board Feet	27	SY	Square Yard
8	FC	Hundred Feet	18	MF	Thousand Feet	28	TN	Tons
9	FT	Feet	19	MH	Man Hour	29	WK	Weeks
10	GA	Gallons	20	MI	Miles	30	YD	Yards

DOCUMENT 006313
REQUEST FOR INFORMATION

This is a Northeast Region form.

See Instructions on page 2.

RFI

PROJECT:	Rehabilitate Structures for Leasing			RFI No.:			
Park:	RICH – Richmond National Battlefield			From:			
	Park PMIS No. 313918			e-mail:			
To:				Date:			
e-mail:							
RE:				Project No.:			
Specification Div. & Sec:		Part, Article, Paragraph:		Drawing Reference:		Detail & Drawing No.:	

REQUEST:

Response Requested by Date:

Signed by: Date:

GOVERNMENT RESPONSE:

Response From: *(Select all that apply.)*

Contracting Officer ☐	Contract Specialist ☐	Contracting Officer's ☐ Representative	Park ☐	NER NPS Arch/Eng ☐	A/E ☐	Date Rec'd:	Date Ret'd:

Signed by: Date:

Response Copies to other Parties: *(Select other parties of the Project sent a copy, other than Requestor / Contractor.)*

Contracting Officer ☐	Contract Specialist ☐	Contracting Officer's ☐ Representative	Park ☐	NER - NPS Arch / Eng ☐	A/E ☐	Other ☐	File

PRIORITY : *(Explanation by Requestor as to claim of Priority.)*

GENERAL INFORMATION

This Document is a form utilized in the Northeast Region of the National Park Service for Construction Contracts. Use of this Document in other NPS regions, or with Denver Service Center, will require permission.

This Document shall be executed should an entity have a question about the Project after Notice of Award.

INSTRUCTIONS

1. Please complete items one through twelve on the opposite side of this document.
2. Deliver document clearly typed or written to the Government with a return e-mail address, in order for the Government to respond in a timely manner.

DOCUMENT 006411
EMERGENCY CONTACT LIST

This is a National Park Service Interior Region 1 form.
See Instructions on page 2 before completing.

ECL

PROJECT:	Replace HVAC System Units	ECL No.	
	PMIS No. 313918	From:	
Park:	Richmond National Battlefield Park (RICH)		
		E-mail:	
To:		Date:	
		Contract No.:	

Per the requirements of the Contract, below is a list of emergency contact numbers for those entities involved in the execution of the Project.

This ECL is being issued by the Prime Contractor to the National Park Service for the Project, and shall be updated monthly, submitted with Document 006276 - CERTIFIED APPLICATION FOR PAYMENT. (CAP) and distributed to the appropriate parties of the Project.

_____ NO CHANGES TO ECL since last submission _____ ECL HAS BEEN UPDATED with new contact information

Line No.	Contractor / Sub / Agency	Firm Name	Name and Address of Contact	Land Line	Cellular Line:
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					

14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

INSTRUCTIONS

PURPOSE: This form is designed to provide the National Park Service with the names, addresses and telephone numbers of key persons of the Contract, who are to be contacted in emergencies to cope with civil disturbances, fires, utility failures, and other types of emergency conditions.

PREPARATION: In cases where ECL is lengthy, consider preparing more than one list (i.e., a list for fire, police, FBI, U.S. Attorney, U.S. Marshall, Bomb Squad, a list of numbers for Field or Regional Office Personnel, etc.). List to be updated periodically as required. Check box in Item 1 when applicable on date of preparation.

DISTRIBUTION. This form is designed to be kept at the Project Site; however it should be beneficial for key persons such as Building Managers to have an individual copy of the form. The offices which receive listings and the distribution should be made according to requirements of the Contract.

SECTION 01 00 00 - GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 INTENT AND ARRANGEMENT OF DOCUMENTS

A. The specifications and drawings are intended to include everything necessary to perform the entire work properly. Every item necessarily required may not be specifically mentioned or shown. Unless expressly stated, all systems and equipment shall be complete and operable.

B. Titles and headings to divisions, sections and paragraphs in these contract documents are introduced for convenience and shall not be taken as a correct or complete segregation of the several units of materials and labor. No responsibility either direct or implied is assumed by the government for omissions or duplications by the contractor or the contractor's lower-tier contractors, due to real or alleged error in arrangement of matter in the subcontract documents.

C. The terms of the contract, general provisions, and general requirements apply to each division of these specifications as fully as if repeated within that division.

D. Items listed under scope of work for each division of the specifications are not necessarily all inclusive. The contractor shall be responsible for the complete job.

E. Portions of these specifications are of the abbreviated, simplified type and may include incomplete sentences.

1. Omissions of words or phrases such as: the contractor shall, in conformity with, shall be, as noted on the drawings, in accordance with details, a, the, and all are intentional. Omitted words or phrases shall be supplied by inference in the same manner as they are when a note occurs on the drawings.

2. Such terms as: approved, reviewed, equal, as directed, as required, as permitted, acceptable, and satisfactory mean by or to the government.

1.2 DEFINITIONS AND STATUS OF INDIVIDUALS

A. The terms defined in the contract, general conditions, and general provisions shall apply throughout. Certain additional terms and refinements shall apply as specified below.

B. Owner: the term “Owner” or “government” shall mean the United State Government, Department of the Interior, National Park Service.

C. Government: the term “government” shall mean the person duly authorized by the Owner to act as the Contracting Officer; and person or persons duly authorized by the Contracting Officer.

D. Contracting Officer (CO) shall mean the official Government Representative for the Project. The CO shall be assigned by the Government and made known to the Contractor at the time of Award. The CO's contact information shall be issued at that time.
1. The designation of Contracting Officer (CO) may include:
a. Contracting Officer's Representative (COR).
b. Any other designated person as selected by the Government.
2. Lines of communication between the Government, the CO and the Contractor will be covered at the Preconstruction Meeting.

E. Contracting Officer’s Representative (COR): the term “contracting officer’s representative” shall mean the person designated by the contracting officer to be a liaison between the government and the contractor. During the construction phase, all submittals and

communications with the government. The COR will administer the technical requirements of the subcontract and will coordinate the inspection of the work.

F. Contractor shall mean the company or individual that holds the Contract for the Work of this Project with the Government.

1. Where the word Contractor is used throughout these documents it shall mean the Contractor and all applicable subcontractors.
2. The Contractor shall be responsible for ensuring that all subcontractors receive all pertinent information and perform the Work in compliance with the Project Documents.

G. Period-of-Performance (Construction Period) shall mean the period designated in the Project Documents as the time frame, in calendar days, during which the Work of the Project will be performed.

1. See Division 01 Section "Project Schedule" for communication and coordination requirements.

H. See Division 01, section "Definition of Contract Price Schedule Line Items" for definitions of line items to be included on the Contract Price Schedule.

1.3 CODES

A. Applicable provisions of the Massachusetts State Uniform Construction Code (UCC) and the codes and regulations of the Department of Energy are hereby referred to and made a part of this contract. All work performed shall be in accordance with such laws, codes, and regulations. The latest edition or supplement or amendment thereto in effect at the time of submittal of bid shall be the issue in effect (unless shown otherwise) of all applicable laws, codes, and regulations including, but not limited to:

1. Virginia Uniform Statewide Building Code
2. NFPA 70 National Electrical Code
3. NFPA 72 National Fire Alarm and Signaling Code
4. Energy Conservation Performance Standards, 10 Code of Federal Regulations (CFR), Part 435 (mandatory for federal buildings)

B. Where codes or standard specifications other than those listed in this paragraph are referred to in the different Divisions of these Specifications, it is understood that they apply as fully as if cited here.

C. Where differences exist between codes affecting this work, the code affording the greatest protection to the government shall govern.

D. If the contractor observes that these drawings and specifications are at variance with the codes, the contractor shall notify the project manager in writing at once for resolution.

E. Pursuant to labor codes contractor shall include in its base bid all costs for provision of adequate sheeting, shoring, bracing, or equivalent method for the protection of life or limb, in conformance with applicable federal and state safety orders.

F. Maintenance clearances shall be maintained around equipment as required by the plans and specifications and/or codes and standards, and as recommended by the equipment manufacturers. The maintenance envelope and equipment access shall be kept clear of any permanent obstruction. It is the contractor's responsibility to enforce these requirements with all lower-tier subcontractors. The contractor and lower-tier subcontractors shall be responsible for correcting any infringement on this requirement at no cost to the government.

1.4 CONSTRUCTION LIMITS

A. The area to be set aside for the work under this contract is shown on the drawings, and the contractor shall confine the construction to the immediate area within the construction limits.

1.5 PARKING—THE USE OF ROADS—SITE ACCESS

A. Parking: parking for private vehicles is limited. Parking for contractors, sub-tier contractors and their workers will be limited to the construction limits and as agreed with the government.

B. Site access: The site is open daily at 8:00 A.M. and closes at 4:00 P.M. Access at other times must be coordinated with the government.

C. Permission for access to the site may be revoked for any and all persons who violate the university traffic regulations including speed limits, parking restrictions, and directions of the university police. All of the contractor's personnel, operating forces, and delivery personnel shall be made aware of and shall comply with traffic regulations at all times.

1.6 COORDINATION OF WORK

A. The contractor shall coordinate and schedule the work of all its lower-tier subcontractors, and shall furnish all information required by them for proper scheduling and execution of the work.

B. In the same manner, the contractor shall coordinate the work with that of the government including reasonable adjustments of schedule in order for other government operations to be conducted.

1.7 INFORMATION TRANSMITTAL

A. Schedule of Values: See Section 01 29 73.

B. Materials and Equipment:

1. The contractor shall submit a complete list of all materials and equipment to be incorporated in the work. Unless a specific time limit for this submittal is established within the provisions of these specifications, this shall be done with such promptness as not to cause delay to the work.

2. All materials and equipment shall be new and within one year of manufacture. No rebuilt, refurbished, remanufactured, or used equipment and materials shall be installed under this project.

3. All project materials shall be furnished in accordance with the Buy American Act, FAR Clause 52.225-9. Requests for waivers per this clause should be submitted with the bid documents.

C. Record drawings

1. The contractor shall maintain at the site a complete, precise, accurate, dimensioned record of actual locations of the work, including concealed and embedded work, size and type of equipment, and every change or deviation from original subcontract drawings. The contractor shall keep this record legible and correct weekly as the job progresses on black or blue line prints. The contractor shall keep record drawings available for inspection at all times. Record drawings will be inspected before approval of requests for payment.

2. It shall be the responsibility of the contractor to submit to the project manager within ten (10) days after final inspection, one (1) complete marked-up set of subcontract drawings

fully illustrating all revisions made by all the crafts in the course of the work. This shall include all field changes, adjustments, variances, substitutions and deletions, whether covered by change order or not. Underground utility installations must be located precisely as constructed on the marked-up drawings.

1.8 WORK RESTRICTIONS – USE OF PREMISES

A. Contractor's Use of Premises: During construction, Contractor will have limited use of site as indicated on drawings and as confirmed by the Government. Contractor's use of premises is limited only by Government's right to perform work, maintain public access and/or employ other contractors on portions of Project and as follows:

1. The Site will be occupied by Government employees throughout the course of the work.
2. Government employees, park visitors and the public will occupy and use the area surrounding the Project Site throughout the Construction Period.
3. Limits: Throughout the entire duration of the Project, including all Phases of the Work, confine all operations to the limits shown on the Construction Documents.
   a. No site, land or earth disturbance shall occur for this Project without written approval of the Government.
4. Driveways, Walkways, and Entrances: Entrances serving premises, driveways pathways, pedestrian areas, sidewalks, parking areas and loading areas shall be kept clear and available to the Government, the public, park visitors and emergency vehicles at all times, unless otherwise agreed to in advance by the Government. Do not use these areas for staging, parking of vehicles or equipment, or storage of materials.
5. Storage of materials and products: Confine to immediate worksite as directed by the Government. Contractor is allowed a storage container on the Project Site at a location mutually agreeable between Contractor and the Government.
6. Preservation of Adjacent Finishes, Contents and Grounds: Prevent damages to adjacent finishes and grounds. Restore all damages, repairing and/or replacing damaged elements to their original condition prior to damage, with no additional costs to the Government.
7. Existing Utilities and Utility Interruption: Notify the Government and utility company in writing of any proposed disturbances or planned interruptions of existing utilities. Contractor shall submit a Plan of Operations for utility disturbance.
   a. Contractor shall be responsible for locating and preventing damage to known utilities. If any damage occurs, contractor shall take action relative thereto and repair utility at no additional expense to the Government. No additional time shall be added to Contract for repairs from damages. Repairs shall commence immediately and be carried out expeditiously and in a professional manner pursuant to and compliant with all federal, state and local codes and regulations, as applicable.
   b. If damage occurs to an unknown utility, Contractor shall repair and reconnect utility immediately. An equitable adjustment shall be made in accordance with the Changes clause of the Contract.
   c. Interruption of Existing Utility Service: Contractor shall notify the Government forty-eight (48) hours in advance of utility interruption, and interruption shall be permitted with prior consent of the Government. Two (2) hours is the maximum time allowed for planned utility disruptions unless otherwise approved by the Government in writing.
8. Hauling Restrictions: Contractor shall comply with all US DOT, State DOT and local legal load restrictions in the transport of all materials and products for the Project. The Government reserves the right to impose additional hauling restrictions within Park Boundaries.

a. Contractor is responsible for obtaining any and all permits, special or otherwise, required by authorities having jurisdiction that may be necessary for utilization of adjacent roads for construction operations.
b. Possession of a Permit by Contractor shall not relieve Contractor of liability for damage which may result from construction operations in utilization of said streets and sidewalks.

9. Contractor at all times shall conduct his operations to ensure the safety for all and minimize any inconveniences to the public. All operations shall be compliant with OSHA and other authorities' regulations, including state and local bodies, having jurisdiction.

B. On-Site Work Hours: Limit work hours to normal business working hours of 8:00 a.m. to 4:00 p.m., Monday through Friday, unless otherwise indicated.
1. Weekend Hours: Weekend work may be permitted with written authorization of the Government.
2. Early Morning Hours: Early morning work may be permitted, with written authorization of the Government.

C. Non-smoking Building/Premises: Smoking is not permitted within the limits of the Project Site and Park grounds.

D. The following items are prohibited on the premises, including the Project Site and Park grounds:
1. Firearms
2. Ammunition
3. Alcohol
4. Pets

E. All Contractor's commercial vehicles, including material and product delivery vehicles, shall be equipped with fire extinguishing equipment and first aid supplies as required by U.S. DOT and state DOT.

F. Parking: Contractor shall park all commercial and personal vehicles in areas designated by the Government. Contractor is responsible for managing and coordinating parking for personnel, subcontractors and their personnel and deliveries in a legal manner that does not conflict with site usage by the Government.

1.9 HISTORIC NATURE OF PROJECT, PROJECT SITE AND SURROUNDS

A. The Contractor shall note and respect the historical significance of the Project, Project Site and surrounds where the work will be performed. Due to this, certain aspects of the Work of this Project may not be performed in a manner and/or with methods commonplace in the current construction industry of today. It shall be incumbent upon the Contractor to furnish mechanics capable of executing first-class workmanship in the materials and methods specified, and who have the knowledge and experience to take any and all necessary precautions to protect elements of historic significance, structural and decorative, not scheduled to receive work.

B. See Division 01, Sections "Historic Preservation Treatment" and "Photo Documentation for Historic Projects" for further requirements.

1.10 ARCHEOLOGICAL FINDINGS

A. While this project requires only minimal ground disturbance, the Contractor is advised that there may be archeological remains in the area surrounding the site. In the unlikely event that archeological objects are observed or encountered during the project, the Contractor will notify park staff and the park archeologist immediately. Artifacts, structural features, domestic and/or archeological objects of nature, historic or prehistoric, above or sub-surface, found within the construction work area or otherwise on the premises, are and shall remain the property of the government.

B. In the unlikely event that archeological objects are observed or encountered during the project, the Contractor will notify park staff and the park archeologist immediately.

C. See Division 01 Section "Archeological Findings" for further requirements.

1.11 HAZARDOUS MATERIALS

A. If any additional Hazardous Material is encountered, all work shall stop in the area of the encounter and Contractor shall notify the Government immediately of discovery and its extent as known. Contractor shall not work in the encounter area until a resolution is established.
   1. Contractor shall continue work in all other areas of the Project without interruption or delay, or
   2. Contractor shall adjust work and/or begin other work on the Project that is not dependent upon the encounter area.

B. Should the temporary suspension of work at the site due to the discovery result in delays, re-mobilization or in additional work, Contractor will be compensated by an equitable adjustment under the Changes clause of the Contract.

1.12 FINAL ACCEPTANCE

A. Notice that the work is ready for final inspection and acceptance shall consist of a written notice issued to the COR by the contractor stating that the contractor has carefully inspected all portions of the work, has reviewed in detail the drawings and specifications, and that to the best of the contractor's knowledge all requirements and conditions of the contract documents have been fulfilled.

B. Upon receipt of this notice, the COR and the contractor shall make a joint inspection of the work. After deficiencies, if any, have been corrected or accounted for, and after all work is satisfactorily complete, the government will accept the work; and a notice of completion will be filed by the government.

C. Prior to final acceptance, filing of the notice of completion or processing of final payment, the following documents shall be submitted, reviewed, and accepted by the government:

   1. Certificates of compliance and performance guarantees and manufacturers' warranties required under various sections.

   2. Record drawings: per paragraph 1.8.g.

   3. Operating and maintenance manuals.

   4. Instruction of government personnel, as required.

   5. All required operations tests.

PART 2 - PRODUCTS

2.1 GENERAL

A. See Division 1 Section "Product Requirements" and individual Specifications Sections for requirements.

PART 3 - EXECUTION

3.1 GENERAL

A. The Project shall be executed, and all construction activities completed by the Contractor as required by the Contract Documents.

B. See individual Specification Sections for specific Execution requirements.

3.2 HOUSEKEEPING

A. The Contractor shall maintain the site in a neat, orderly, and safe condition at all times.

3.3 FINAL CLEANING

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

B. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a portion of Project:

1. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
2. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
3. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
4. Remove tools, construction equipment, machinery, and surplus material from Project site.
5. Waste Disposal: Remove all project generated waste from site and dispose of it in a legal manner.

END OF SECTION 01 00 00

SECTION 01 11 00 – SUMMARY OF WORK

1.1 SECTION INCLUDES

A. The Work of this Section includes the following:
1. Project Information
2. Summary of Work
3. Definitions
4. Site Examination
5. Field Verification
6. Intent and Arrangement of Documents
7. Work covered by the Project Documents, including this Project Manual and Drawings
8. Work under separate contracts,
9. Work Restrictions / Use of Premises
10. Governments and the public's occupancy requirements
11. Historic Nature of Project
12. Archeological Findings
13. Hazardous Materials

1.2 PROJECT INFORMATION

A. Project Name: Update HVAC System Units in Richmond Buildings

1. Park Alpha Code: RICH
2. PMIS Nos: 313918
3. Owner: United States Department of the Interior, National Park Service
4. Park Address: 3215 East Broad Street, Richmond, VA 23223
5. Project Location: Cold harbor Visitor Center, Chimborazo Visitor Center, Fort Harrison Visitor Center, Garthright House, Watt House, Ranger Office, Housing Quarters 13, Maintenance Building, and Auto Shop.

B. Any Project Information, including that requested through a Request for Information (RFI), shall be transmitted by e-mail in the appropriate format per the type of document being transmitted. Pending the size of the electronic data file(s), the Government may elect to utilize its FTP site where the receiver must be invited by the Government to access and retrieve the information and the receiver must accept all conditions and regulations relating to such.

1.3 SUMMARY OF WORK

A. The implied intent of the Project is to ensure the life safety, health and well-being of all users and preserve the historic fabric of the Project components.

B. The Work of the Project consists of furnishing all materials, labor, equipment, and supervision as required for the Project by the Project Documents; as required by applicable codes and regulations; and as required by site conditions.

C. The work includes, but may not be limited to, the following:

1. Base Project: Chimborazo Visitor Center
   a. Replace heat pump.
   b. Replace AHU.

c. Install VAV boxes.
d. Clean ductwork existing and commission systems.
e. Install new controls.

2. Base Project: Cold Harbor Visitor Center
   a. Replace heat pump.
   b. Replace exhaust fans.
   c. Clean ductwork existing and commission systems.
   d. Install new controls
3. Base Project: Watt House
   a. Replace heat pump.
   b. Clean ductwork existing and commission systems.
   c. Install new controls.
4. Base Project: Ranger Office, 1900 Maintenance Way
   a. Replace heat pump.
   b. Clean ductwork existing and commission systems.
   c. Install new controls.
5. Base Project: Maintenance Building
   a. Replace heat pump.
   b. Install new mini-split
   c. Install new attic fans.
   d. Clean ductwork existing and commission systems.
   e. Install new controls.
6. Base Project: Auto Shop.
   a. Remove PTAC and install new mini-split
   b. Replace boiler
   c. Clean ductwork existing and commission systems.
   d. Install new controls.
7. Option 1: Garthright House
   a. Replace heat pump.
   b. Clean ductwork existing and commission systems.
   c. Install new controls.
8. Option 2: Housing Quarters 13, 1910 Maintenance Way
   a. Replace heat pump.
   b. Clean ductwork existing and commission systems.
   c. Install new controls.
9. Option 3: Fort Harrison Visitor Center
   a. Replace AHU.
   b. Replace exhaust fans
   c. Replace heat pump
   d. Install new ERV
   e. Replace ductwork and commission systems.
   f. Install new controls.

D. Work shall be completed as required by all applicable prevailing codes, including but not limited to the International Building Code, latest edition including all state and local amendments and other codes, as applicable.

E. Weather protection shall mean the temporary protection of that work adversely affected by moisture, wind, heat, and cold by covering, patching, sealing, enclosing, ventilating, cooling and/or heating. This protection shall be provided for all work areas, the building, and its

contents, trafficked adjacent areas, and all construction materials and accessories. Each trade will be responsible for his/her own weather protection as it relates to the work scope.

F. The Contractor shall perform the work in a manner as to minimize interference with the operation of the facility. The Contractor shall provide a Method-of-Procedure (MOP), for each building that clearly explains the method(s) proposed to implement the work within the limits of the Contract.

G. Throughout the duration of the Work of this Project the Contractor shall be fully responsible for maintaining the climate, within the structure, required to preserve the historic fabric and characteristics of the structure.

H. Contractor shall provide safe OSHA compliant access to the work areas for all personnel, for the moving of equipment and materials and to allow for Government Inspections.

I. Throughout the duration of the Work of this Project the Contractor shall be fully responsible for maintaining the weather-tightness of all portions of the structure.

1. Contractor or his authorized representative shall be available on two hours' notice, twenty-four hours a day for the duration of this Project, to repair and prevent any and all leaks related to the Work.

2. The Contractor shall furnish the Government with the name (s) and personal telephone number(s) of person(s) that will respond in the event of an emergency.

J. Contractor shall provide safe OSHA compliant access to the work areas for all personnel, for the moving of equipment and materials and to allow for Government Inspections.

1.4 PROJECT DOCUMENTS

A. In the event of a discrepancy between the requirements of the Specifications and/or Drawings and the Federal Acquisition Regulations (FAR), the FAR shall govern. The FAR can be accessed on the internet:

1. https://www.acquisition.gov/far

B. In case of a discrepancy either in the figures, in the Drawings, or in the Technical Specifications, the matter shall be promptly submitted to the Government, who will decide in writing. Any adjustment by the Contractor without such a determination will be at their own risk and expense.

1.5 INTENT AND ARRANGEMENT OF DOCUMENTS

A. The specifications and drawings are intended to include everything necessary to perform the entire work properly. Every item necessarily required may not be specifically mentioned or shown. Unless expressly stated, all systems and equipment shall be complete and operable.

B. Titles and headings to divisions, sections and paragraphs in these contract documents are introduced for convenience and shall not be taken as a correct or complete segregation of the several units of materials and labor. No responsibility either direct or implied is assumed by the government for omissions or duplications by the contractor or the contractor's lower-tier contractors, due to real or alleged error in arrangement of matter in the subcontract documents.

C. The terms of the contract, general provisions, and general requirements apply to each division of these specifications as fully as if repeated within that division.

D. Items listed under scope of work for each division of the specifications are not necessarily all inclusive. The contractor shall be responsible for the complete job.

E. Portions of these specifications are of the abbreviated, simplified type and may include incomplete sentences.

1. Omissions of words or phrases such as: the contractor shall, in conformity with, shall be, as noted on the drawings, in accordance with details, a, the, and all are intentional. Omitted words or phrases shall be supplied by inference in the same manner as they are when a note occurs on the drawings.

2. Such terms as: approved, reviewed, equal, as directed, as required, as permitted, acceptable, and satisfactory mean by or to the government.

1.6 SITE EXAMINATION

A. The Contractor and the Subcontractors, as appropriate, are strongly encouraged to visit and examine the existing conditions of the Project Site prior to submission of offer for the Contractor to better understand the Work, and aid in forming any questions the Contractor may have prior to the submission of offer.

B. If the Contractor wishes to perform additional site examinations after the pre-proposal meeting, Contractor shall contact the park Contracting Officer's Representative to coordinate a time. The Park representative is, and may be contacted at:

1.7 FIELD VERIFICATION

A. The Contractor shall verify all existing conditions and new and existing dimensions prior to the commencement of work and/or ordering of products and materials that may affect the Work of this Project. Any and all discrepancies shall be forwarded to the Government in writing for clarification prior to the commencement of work. Any work performed prior to clarification, particularly and including that which may require correction shall be corrected by the Contractor at no additional costs to the Project and the Government.

1.8 WORK RESTRICTIONS – USE OF PREMISES

A. Contractor's Use of Premises: During construction, Contractor will have limited use of site as indicated on drawings and as confirmed by the Government. Contractor's use of premises is limited only by Government's right to perform work, maintain public access and/or employ other contractors on portions of Project and as follows:

1. Buildings will be occupied by Government employees throughout the course of the work.

2. Government employees, park visitors and the public will occupy and use the area surrounding the Project Site throughout the Construction Period.

3. Limits: Throughout the entire duration of the Project, including all Phases of the Work, confine all operations to the limits shown on the Construction Documents.

a. No site, land or earth disturbance shall occur for this Project without written approval of the Government.

4. Driveways, Walkways, and Entrances: Entrances serving premises, driveways pathways, pedestrian areas, sidewalks, parking areas and loading areas shall be kept clear and available to the Government, the public, park visitors and emergency vehicles at all times, unless otherwise agreed to in advance by the Government. Do not use these areas for staging, parking of vehicles or equipment, or storage of materials.

5. Storage of materials and products: Confine to immediate worksite as directed by the Government. Contractor is allowed a storage container on the Project Site at a location mutually agreeable between Contractor and the Government.

6. Preservation of Adjacent Finishes, Contents and Grounds: Prevent damages to adjacent finishes and grounds. Restore all damages, repairing and/or replacing damaged elements to their original condition prior to damage, with no additional costs to the Government.

7. Existing Utilities and Utility Interruption: Notify the Government and utility company in writing of any proposed disturbances or planned interruptions of existing utilities. Contractor shall submit a Plan of Operations for utility disturbance.

   a. Contractor shall be responsible for locating and preventing damage to known utilities. If any damage occurs, contractor shall take action relative thereto and repair utility at no additional expense to the Government. No additional time shall be added to Contract for repairs from damages. Repairs shall commence immediately and be carried out expeditiously and in a professional manner pursuant to and compliant with all federal, state and local codes and regulations, as applicable.

   b. If damage occurs to an unknown utility, Contractor shall repair and reconnect utility immediately. An equitable adjustment shall be made in accordance with the Changes clause of the Contract.

   c. Interruption of Existing Utility Service: Contractor shall notify the Government forty-eight (48) hours in advance of utility interruption, and interruption shall be permitted with prior consent of the Government. Two (2) hours is the maximum time allowed for planned utility disruptions unless otherwise approved by the Government in writing.

8. Hauling Restrictions: Contractor shall comply with all US DOT, State DOT and local legal load restrictions in the transport of all materials and products for the Project. The Government reserves the right to impose additional hauling restrictions within Park Boundaries.

   a. Contractor is responsible for obtaining any and all permits, special or otherwise, required by authorities having jurisdiction that may be necessary for utilization of adjacent roads for construction operations.

   b. Possession of a Permit by Contractor shall not relieve Contractor of liability for damage which may result from construction operations in utilization of said streets and sidewalks.

9. Contractor at all times shall conduct his operations to ensure the safety for all and minimize any inconveniences to the public. All operations shall be compliant with OSHA and other authorities' regulations, including state and local bodies, having jurisdiction.

B. On-Site Work Hours: Limit work hours to normal business working hours of 8:00 a.m. to 4:00 p.m., Monday through Friday, unless otherwise indicated.

   1. Weekend Hours: Weekend work may be permitted with written authorization of the Government.

   2. Early Morning Hours: Early morning work may be permitted, with written authorization of the Government.

C. Non-smoking Building/Premises: Smoking is not permitted within the limits of the Project Site and Park grounds.

D. The following items are prohibited on the premises, including the Project Site and Park grounds:

1. Firearms
2. Ammunition
3. Alcohol
4. Pets

E. All Contractor's commercial vehicles, including material and product delivery vehicles, shall be equipped with fire extinguishing equipment and first aid supplies as required by U.S. DOT and state DOT.

F. Parking: Contractor shall park all commercial and personal vehicles in areas designated by the Government. Contractor is responsible for managing and coordinating parking for personnel, subcontractors and their personnel and deliveries in a legal manner that does not conflict with site usage by the Government.

G. Permission for access to the site may be revoked for any and all persons who violate the university traffic regulations including speed limits, parking restrictions, and directions of the university police. All of the contractor's personnel, operating forces, and delivery personnel shall be made aware of and shall comply with traffic regulations at all times.

1.9 HISTORIC NATURE OF PROJECT, PROJECT SITE AND SURROUNDS

A. The Contractor shall note and respect the historical significance of the Project, Project Site and surrounds where the work will be performed. Due to this, certain aspects of the Work of this Project may not be performed in a manner and/or with methods commonplace in the current construction industry of today. It shall be incumbent upon the Contractor to furnish mechanics capable of executing first-class workmanship in the materials and methods specified, and who have the knowledge and experience to take any and all necessary precautions to protect elements of historic significance, structural and decorative, not scheduled to receive work.

B. See Division 01, Sections "Historic Preservation Treatment" and "Photo Documentation for Historic Projects" for further requirements.

1.10 ARCHEOLOGICAL FINDINGS

A. The Contractor is advised that there may be archeological remains in the area surrounding the site. Artifacts, structural features, domestic and /or archeological objects of nature, historic or prehistoric, above or sub-surface, found within the construction work area or otherwise on the premises, are and shall remain the property of the Government.

B. See Division 01 Section "Archeological Protection" for further requirements.

1.11 HAZARDOUS MATERIALS

A. If any additional Hazardous Material is encountered, all work shall stop in the area of the encounter and Contractor shall notify the Government immediately of discovery and its extent as known. Contractor shall not work in the encounter area until a resolution is established.

1. Contractor shall continue work in all other areas of the Project without interruption or delay, or
2. Contractor shall adjust work and/or begin other work on the Project that is not dependent upon the encounter area.

B. Should the temporary suspension of work at the site due to the discovery result in delays, re-mobilization or in additional work, Contractor will be compensated by an equitable adjustment under the Changes clause of the Contract.

PART 2 PRODUCTS

2.1 GENERAL

A. See Division 1 Section "Product Requirements" and individual Specifications Sections for requirements.

PART 3 EXECUTION

3.1 GENERAL

A. The Project shall be executed, and all construction activities completed by the Contractor as required by the Contract Documents.

B. See individual Specification Sections for specific Execution requirements.

3.2 HOUSEKEEPING

A. The Contractor shall maintain the site in a neat, orderly, and safe condition at all times.

3.3 FINAL CLEANING

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

B. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a portion of Project:

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

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

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

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

5. Waste Disposal: Remove all project generated waste from site and dispose of it in a legal manner.

END OF SECTION 01 11 00

SECTION 01 27 00 – DEFINITION OF CONTRACT PRICE SCHEDULE LINE ITEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Included in the Solicitation Package is a Contract Price Schedule.

B. The intent of this section is to explain, in general, what is and what is not included in the contract line items on the Contract Price Schedule and the limits or cut-off points where one item ends and another begins.

C. For Lump Sum line items, provide the total price, including all costs for general conditions, overhead and profit.

D. For all Unit Priced line items, provide the total price to complete the work for each unit, including all costs for general conditions, overhead and profit. In addition, provide an Extended Unit Price derived from multiplying the Unit Price by the number of units specified. The Extended Unit Price shall be included in the Total Base Bid (or Option, where applicable).

E. If no contract line item exists for a portion of the work, include the costs in a related item.

PART 2 - (Not Used)

PART 3 - EXECUTION.

3.1 LIST OF CONTRACT LINE ITEMS

A. Contract Line Item No.1: Base Bid - Chimborazo Visitor Center
   1. This item consists of replaced HVAC system as indicated on the drawings and as specified herein.
   2. Work will not be measured for payment.
   3. Payment will be made at the contract price per lump sum price.

B. Contract Line Item No.2: Base Bid - Cold Harbor Visitor Center
   1. This item consists of replaced HVAC system as indicated on the drawings and as specified herein.
   2. Work will not be measured for payment.
   3. Payment will be made at the contract price per lump sum price.

C. Contract Line Item No.3: Base Bid - Watt House
   1. This item consists of replaced HVAC system as indicated on the drawings and as specified herein.
   2. Work will not be measured for payment.
   3. Payment will be made at the contract price per lump sum price.

D. Contract Line Item No.4: Base Bid - Ranger Office, 1900 Maintenance Way
   1. This item consists of replaced HVAC system as indicated on the drawings and as specified herein.
   2. Work will not be measured for payment.
   3. Payment will be made at the contract price per lump sum price.

E. Contract Line Item No.5: Base Bid - Ranger Office, Maintenance Building
   1. This item consists of replaced HVAC system as indicated on the drawings and as specified herein.
   2. Work will not be measured for payment.
   3. Payment will be made at the contract price per lump sum price.

F. Contract Line Item No.6: Base Bid - Ranger Office, Auto Shop.
   1. This item consists of replaced HVAC system as indicated on the drawings and as specified herein.
   2. Work will not be measured for payment.
   3. Payment will be made at the contract price per lump sum price.

G. Contract Line Item No.7: Option 1 - Garthright House.
   1. This item consists of replaced HVAC system as indicated on the drawings and as specified herein.
   2. Work will not be measured for payment.
   3. Payment will be made at the contract price per lump sum price.

H. Contract Line Item No.8: Option 2 - Housing Quarters 13, 1910 Maintenance Way
   1. This item consists of replaced HVAC system as indicated on the drawings and as specified herein.
   2. Work will not be measured for payment.
   3. Payment will be made at the contract price per lump sum price.

I. Contract Line Item No.9: Option 3 - Fort Harrison Visitor Center
   1. This item consists of replaced HVAC system as indicated on the drawings and as specified herein.
   2. Work will not be measured for payment.
   3. Payment will be made at the contract price per lump sum price.

SECTION 013100 - PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.1 SUMMARY

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

1. Coordination drawings.
2. Requests for Information (RFIs).
3. Project meetings.

B. Related Requirements:

1. Section 017300 "Execution" for procedures for coordinating general installation and field-engineering services, including establishment of benchmarks and control points.

1.2 DEFINITIONS

A. RFI: Request from Offeror or Contractor seeking information from the government required for clarifications of the Contract Documents.

1.3 INFORMATIONAL SUBMITTALS

A. Schedule of Values: See Section 01 29 73.

B. Materials and Equipment:

1. The contractor shall submit a complete list of all materials and equipment to be incorporated in the work. Unless a specific time limit for this submittal is established within the provisions of these specifications, this shall be done with such promptness as not to cause delay to the work.
2. All materials and equipment shall be new and within one year of manufacture. No rebuilt, refurbished, remanufactured, or used equipment and materials shall be installed under this project.
3. All project materials shall be furnished in accordance with the Buy American Act, FAR Clause 52.225-9. Requests for waivers per this clause should be submitted with the bid documents.

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

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

D. Record drawings

1. The contractor shall maintain at the site a complete, precise, accurate, dimensioned record of actual locations of the work, including concealed and embedded work, size and type of equipment, and every change or deviation from original subcontract drawings. The contractor shall keep this record legible and correct weekly as the job progresses on black or blue line prints. The contractor shall keep record drawings available for inspection at all times. Record drawings will be inspected before approval of requests for payment.

2. It shall be the responsibility of the contractor to submit to the project manager within ten (10) days after final inspection, one (1) complete marked-up set of subcontract drawings fully illustrating all revisions made by all the crafts in the course of the work. This shall include all field changes, adjustments, variances, substitutions and deletions, whether covered by change order or not. Underground utility installations must be located precisely as constructed on the marked-up drawings.

1.4 GENERAL COORDINATION PROCEDURES

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

1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.

2. Coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair.

3. Make adequate provisions to accommodate items scheduled for later installation.

B. Prepare memoranda for distribution to each party involved, outlining special procedures required for coordination. Include such items as required notices, reports, and list of attendees at meetings.

1. Prepare similar memoranda for Owner and separate contractors if coordination of their Work is required.

C. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities, **and activities of other contractors,** to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:

1. Preparation of Contractor's construction schedule.

2. Preparation of the schedule of values.

3. Installation and removal of temporary facilities and controls.

4. Delivery and processing of submittals.

5. Progress meetings.

6. Pre-Installation conferences.

7. Project closeout activities.

8. Startup and adjustment of systems.

1.5 COORDINATION DRAWINGS

A. Coordination Drawings, General: Prepare coordination drawings according to requirements in individual Sections, where installation is not completely shown on Shop Drawings, where limited space availability necessitates coordination, or if coordination is required to facilitate integration of products and materials fabricated or installed by more than one entity.

1. Content: Project-specific information, drawn accurately to a scale large enough to indicate and resolve conflicts. Do not base coordination drawings on standard printed data. Include the following information, as applicable:

a. Indicate functional and spatial relationships of components of Governmental, structural, civil, mechanical, and electrical systems.

b. Indicate dimensions shown on the Drawings. Specifically note dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Government indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.

B. Coordination Drawing Organization: Organize coordination drawings as follows:

1. Structural Penetrations: Indicate penetrations and openings required for all disciplines.

2. Slab Edge and Embedded Items: Indicate slab edge locations and sizes and locations of embedded items for metal fabrications, sleeves, anchor bolts, bearing plates, angles, door floor closers, slab depressions for floor finishes, curbs and housekeeping pads, and similar items.

3. Review: Government will review coordination drawings to confirm that the Work is being coordinated, but not for the details of the coordination, which are Contractor's responsibility.

1.6 REQUESTS FOR INFORMATION (RFIs)

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

1. Government will return RFIs submitted to Government by other entities controlled by Contractor with no response.

2. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.

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

1. Project name.

2. Project number.

3. Date.

4. Name of Contractor.

5. Name of Contracting Officer, Contracting Officer’s Representative **and Construction Manager**.

6. RFI number, numbered sequentially.

7. RFI subject.
8. Specification Section number and title and related paragraphs, as appropriate.
9. Drawing number and detail references, as appropriate.
10. Field dimensions and conditions, as appropriate.
11. Contractor's suggested resolution. If Contractor's solution(s) impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
12. Contractor's signature.
13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.

C. RFI Forms: Form bound in Project Manual or Software-generated form with substantially the same content as indicated above, acceptable to Government.

D. Government's **and Construction Manager's** Action: Government **and Construction Manager** will review each RFI, determine action required, and respond. Allow ten working days for Government's response for each RFI. RFIs received by Government after 1:00 p.m. will be considered as received the following working day.

1. The following RFIs will be returned without action:
   a. Requests for approval of submittals.
   b. Requests for approval of substitutions.
   c. Requests for coordination information already indicated in the Contract Documents.
   d. Requests for adjustments in the Contract Time or the Contract Sum.
   e. Requests for interpretation of Government's actions on submittals.
   f. Incomplete RFIs or inaccurately prepared RFIs.
2. Government's action may include a request for additional information, in which case Government's time for response will date from time of receipt of additional information.
3. Government's action on RFIs that may result in a change to the Contract Time or the Contract Sum may be eligible for Contractor to submit Change Proposal according to Section 012600 "Contract Modification Procedures."
   a. If Contractor believes the RFI response warrants change in the Contract Time or the Contract Sum, notify Government **and Construction Manager** in writing within **10** days of receipt of the RFI response.

E. RFI Log: Prepare, maintain, and submit a tabular log of RFIs organized by the RFI number. Submit log **weekly. Include the following:**

1. Project name.
2. Name and address of Contractor.
3. Project name and address.
4. RFI number including RFIs that were dropped and not submitted.
5. RFI description.
6. Date the RFI was submitted.

7. Date Government's response was received.

F. On receipt of Government's action, update the RFI log and immediately distribute the RFI response to affected parties. Review response and notify COR within **seven calendar** days if Contractor disagrees with response.

1. Identification of related Contract Modification.

1.7 PROJECT MEETINGS

A. General: **COR will schedule and conduct** meetings and conferences at Project site unless otherwise indicated.

1. Attendees: Inform participants and others involved, and individuals whose presence is required, of date and time of each meeting. Notify Owner and Government of scheduled meeting dates and times.

2. Agenda: Prepare the meeting agenda. Distribute the agenda to all invited attendees.

3. Minutes: Entity responsible for conducting meeting will record significant discussions and agreements achieved. Distribute the meeting minutes to everyone concerned within **three** days of the meeting.

B. Preconstruction Conference: **Government will schedule and conduct** a preconstruction conference before starting construction, at a time convenient to the Government.

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

2. Agenda: Discuss items of significance that could affect progress, including the following:

a. Tentative construction schedule.

b. Phasing.

c. Critical work sequencing and long-lead items.

d. Designation of key personnel and their duties.

e. Procedures for processing field decisions and Change Orders.

f. Procedures for RFIs.

g. Procedures for testing and inspecting.

h. Procedures for processing Applications for Payment.

i. Distribution of the Contract Documents.

j. Submittal procedures.

k. Preparation of record documents.

l. Use of the premises **and existing building**.

m. Work restrictions.

n. Working hours.

o. Owner's occupancy requirements.

p. Responsibility for temporary facilities and controls.

q. Procedures for moisture and mold control.

r. Procedures for disruptions and shutdowns.

s. Construction waste management and recycling.

t. Parking availability.

u. Office, work, and storage areas.

v. Equipment deliveries and priorities.

w. First aid.

x. Security.

y. Progress cleaning.

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

C. Pre-installation Conferences: Conduct a pre-installation conference at Project site before each construction activity that requires coordination with other construction.

1. Attendees: Installer and representatives of manufacturers and fabricators involved in or affected by the installation and its coordination or integration with other materials and installations that have preceded or will follow, shall attend the meeting. Advise Government **and Construction Manager** of scheduled meeting dates.

2. Agenda: Review progress of other construction activities and preparations for the particular activity under consideration, including requirements for the following:

a. Contract Documents.

b. Options.

c. Related RFIs.

d. Related Change Orders.

e. Purchases.

f. Deliveries.

g. Submittals.

h. Review of mockups.

i. Possible conflicts.

j. Compatibility problems.

k. Time schedules.

l. Weather limitations.

m. Manufacturer's written instructions.

n. Warranty requirements.

o. Compatibility of materials.

p. Acceptability of substrates.

q. Temporary facilities and controls.

r. Space and access limitations.

s. Regulations of authorities having jurisdiction.

t. Testing and inspecting requirements.

u. Installation procedures.

v. Coordination with other work.

w. Required performance results.

x. Protection of adjacent work.

y. Protection of construction and personnel.

3. Record significant conference discussions, agreements, and disagreements, including required corrective measures and actions.

4. Reporting: Distribute minutes of the meeting to each party present and to other parties requiring information.

5. Do not proceed with installation if the conference cannot be successfully concluded. Initiate whatever actions are necessary to resolve impediments to performance of the Work and reconvene the conference at earliest feasible date.

6. Attendees: In addition to representatives of **Construction Manager,** and Government, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the meeting shall be familiar with Project and authorized to conclude matters relating to the Work.

7. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.

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

      1) Review schedule for next period.

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

      1) Interface requirements.

      2) Sequence of operations.

      3) Status of submittals.

      4) Deliveries.

      5) Off-site fabrication.

      6) Access.

      7) Site utilization.

      8) Temporary facilities and controls.

9) Progress cleaning.

10) Quality and work standards.

11) Status of correction of deficient items.

12) Field observations.

13) Status of RFIs.

14) Status of proposal requests.

15) Pending changes.

16) Status of Change Orders.

17) Pending claims and disputes.

18) Documentation of information for payment requests.

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

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

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 013100

SECTION 01 33 00 - SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

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

B. Related Requirements:

1. Section 013200 "Construction Progress Documentation" for submitting schedules and reports, including Contractor's construction schedule.
2. Section 017823 "Operation and Maintenance Data" for submitting operation and maintenance manuals.
3. Section 017839 "Project Record Documents" for submitting record Drawings, record Specifications, and record Product Data.

1.2 DEFINITIONS

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

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

1.3 ACTION SUBMITTALS

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

1.4 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

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

1. Government will furnish Contractor one set of digital data drawing files of the Contract Drawings for use in preparing Shop Drawings and Project record drawings.

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

b. Contractor shall execute a data licensing agreement in the form acceptable to the Government.

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

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.

a. Government and Construction Manager reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

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

1. Initial Review: Allow 15 days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required.by Government. The Government will advise Contractor when a submittal being processed must be delayed for coordination.
2. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.
3. Resubmittal Review: Allow 15 days for review of each resubmittal.

D. Paper Submittals: Place a permanent label or title block on each submittal item for identification.

1. Indicate name of firm or entity that prepared each submittal on label or title block.
2. Include the following information for processing and recording action taken:

a. Project name.
b. Date.
c. Name of Architect.
d. Name of Construction Manager.
e. Name of Contractor.
f. Name of subcontractor.
g. Name of supplier.
h. Name of manufacturer.
i. Submittal number or other unique identifier, including revision identifier.

j. Number and title of appropriate Specification Section.
k. Drawing number and detail references, as appropriate.
l. Location(s) where product is to be installed, as appropriate.
m. Other necessary identification.

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

a. Submit one copy of submittal to concurrent reviewer in addition to specified number of copies to Government.

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

a. Transmittal Form for Paper Submittals: Use facsimile of sample form included in Project Manual.
b. Transmittal Form for Paper Submittals: Provide locations on form for the following information:

1) Project name.
2) Date.
3) Destination (To:).
4) Source (From:).
5) Name and address of Architect.
6) Name of Construction Manager.
7) Name of Contractor.
8) Name of firm or entity that prepared submittal.
9) Names of subcontractor, manufacturer, and supplier.
10) Category and type of submittal.
11) Submittal purpose and description.
12) Specification Section number and title.
13) Specification paragraph number or drawing designation and generic name for each of multiple items.
14) Drawing number and detail references, as appropriate.
15) Indication of full or partial submittal.
16) Transmittal number[, numbered consecutively].
17) Submittal and transmittal distribution record.
18) Remarks.
19) Signature of transmitter.

E. Electronic Submittals: 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., LNHS-061000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., LNHS-061000.01.A).

3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Government.
4. Transmittal Form for Electronic Submittals: Use software-generated form from electronic project management software acceptable to Owner, containing the following information:

a. Project name.
b. Date.
c. Name and address of Architect.
d. Name of Construction Manager.
e. Name of Contractor.
f. Name of firm or entity that prepared submittal.
g. Names of subcontractor, manufacturer, and supplier.
h. Category and type of submittal.
i. Submittal purpose and description.
j. Specification Section number and title.
k. Specification paragraph number or drawing designation and generic name for each of multiple items.
l. Drawing number and detail references, as appropriate.
m. Location(s) where product is to be installed, as appropriate.
n. Related physical samples submitted directly.
o. Indication of full or partial submittal.
p. Transmittal number[, numbered consecutively].
q. Submittal and transmittal distribution record.
r. Other necessary identification.
s. Remarks.

5. Metadata: Include the following information as keywords in the electronic submittal file metadata:

a. Project name.
b. Number and title of appropriate Specification Section.
c. Manufacturer name.
d. Product name.
e. <Insert required information>.

F. Options: Identify options requiring selection by Government.

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

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

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

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

J. Use for Construction: Retain complete copies of submittals on Project site. Use only final action submittals that are marked with approval notation from Government.

PART 2 - PRODUCTS

2.1 SUBMITTAL PROCEDURES

A. General Submittal Procedure Requirements:

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

   a. Government will return annotated file. Annotate and retain one copy of file as an electronic Project record document file.

2. Action Submittals: Submit three paper copies of each submittal unless otherwise indicated. Government will return two copies.
3. Informational Submittals: Submit two paper copies of each submittal unless otherwise indicated. Government will not return copies.
4. Certificates and Certifications Submittals: Provide a statement that includes signature of entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity.

   a. Provide a digital signature with digital certificate on electronically-submitted certificates and certifications where indicated.
   b. Provide a notarized statement on original paper copy certificates and certifications where indicated.

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

1. If information must be specially prepared for submittal because standard published data are not suitable for use, submit as Shop Drawings, not as Product Data.
2. Mark each copy of each submittal to show which products and options are applicable.
3. Include the following information, as applicable:

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

4. For equipment, include the following in addition to the above, as applicable:

   a. Wiring diagrams showing factory-installed wiring.
   b. Printed performance curves.
   c. Operational range diagrams.
   d. Clearances required to other construction, if not indicated on accompanying Shop Drawings.

5. Submit Product Data before or concurrent with Samples.

6. Submit Product Data in the following format:

    a. PDF electronic file.

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

1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:

    a. Identification of products.
    b. Schedules.
    c. Compliance with specified standards.
    d. Notation of coordination requirements.
    e. Notation of dimensions established by field measurement.
    f. Relationship and attachment to adjoining construction clearly indicated.
    g. Seal and signature of professional engineer if specified.

2. Sheet Size: Except for templates, patterns, and similar full-size drawings, submit Shop Drawings on sheets at least 8-1/2 by 11 inches, but no larger than 24 by 36 inches.
3. Submit Shop Drawings in the following format:

    a. PDF electronic file.

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

1. Transmit Samples that contain multiple, related components such as accessories together in one submittal package.
2. Identification: Attach label on unexposed side of Samples that includes the following:

    a. Generic description of Sample.
    b. Product name and name of manufacturer.
    c. Sample source.
    d. Number and title of applicable Specification Section.

3. For projects where electronic submittals are required, provide corresponding electronic submittal of Sample transmittal, digital image file illustrating Sample characteristics, and identification information for record.
4. Disposition: Maintain sets of approved Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.

    a. Samples that may be incorporated into the Work are indicated in individual Specification Sections. Such Samples must be in an undamaged condition at time of use.
    b. Samples not incorporated into the Work, or otherwise designated as Owner's property, are the property of Contractor.

5. Samples for Initial Selection: Submit manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available.

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

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

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

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

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

1. Submit product schedule in the following format:

    a. PDF electronic file.

F. Coordination Drawings Submittals: Comply with requirements specified in Section 013100 "Project Management and Coordination."

G. Contractor's Construction Schedule: Comply with requirements specified in Section 013200 "Construction Progress Documentation."

H. Test and Inspection Reports and Schedule of Tests and Inspections Submittals: Comply with requirements specified in Section 014000 "Quality Requirements."

I. Closeout Submittals and Maintenance Material Submittals: Comply with requirements specified in Section 017700 "Closeout Procedures."

J. Maintenance Data: Comply with requirements specified in Section 017823 "Operation and Maintenance Data."

K. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements in the Contract Documents. Submit record of Welding Procedure Specification

and Procedure Qualification Record on AWS forms. Include names of firms and personnel certified.

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

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

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

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

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

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

B. Project Closeout and Maintenance Material Submittals: See requirements in Section 017700 "Closeout Procedures."

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

3.2 GOVERNMENT’S ACTION

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

B. Action Submittals: Government will review each submittal, make marks to indicate corrections or revisions required, and return it.

C. Informational Submittals: Government will review each submittal and will not return it, or will return it if it does not comply with requirements. Government will forward each submittal to appropriate party.

D. Incomplete submittals are unacceptable, will be considered nonresponsive, and will be returned for resubmittal without review.

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

END OF SECTION 013300

SECTION 01 35 13.22 – ARCHEOLOGICAL PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section consists of protecting archeological resources contained in soil deposits.

1.2 DEFINITIONS

A. Archeological Resources: Archeological resources are physical evidences of past human activity, including evidences of effects of that activity on the environment. Archeological resources represent both prehistoric and historic time periods, found above and below ground and under water.

B. Archeologically Sensitive Areas: Areas having potential to contain significant (National Register eligible) archeological resources. If National Register eligible or listed archeological resources could not be avoided, an appropriate mitigation strategy would be developed in consultation with state historic preservation officer and, if necessary, associated American Indian tribes.

C. Non-sensitive Areas: Areas with little potential of containing significant (National Register eligible) archeological resources.

D. Archeological Monitor: Representative of Government designated to oversee construction activities that could disturb archeological resources.

E. Archeological Resources Protection Act (ARPA) of 1979 (Public Law (P.L.) 96-95; 93 United States Statues at Large (Stat.) 712): defines archeological resources as any material remains of past human life or activities that are of archeological interest and at least 100 years old; Section 4 of the statute describes the requirements that must be met before Federal authorities can issue a permit to excavate or remove any archeological resource on Federal or Indian lands; the curatorial requirements of artifacts, and other materials excavated or removed.

1.3 SUBMITTALS

A. Daily Work Schedule: Detail construction work in archeologically sensitive areas. Submit to Contracting Officer (CO) 30 days before start of ground disturbing site work.

1.4 QUALITY ASSURANCE

A. At least one week before on-site work begins, Contractor shall meet with Contracting Officer and Archeological Monitor to discuss Daily Work Schedule, equipment, and special methods used in archeologically sensitive areas. Contractor shall ensure approved Daily Work Schedule is followed throughout construction.

PART 2 - PRODUCTS

2.1 DAILY WORK SCHEDULE

A. Daily Work Schedule is required for work occurring within archeologically sensitive areas. Include all work that is to occur within the area and key the schedule to the drawings to include:

1. Starting and ending dates of ground-disturbing construction.
2. Locations of temporary facilities, such as barriers, field offices, staging areas, sanitary facilities, borrow pits, and haul and access roads.
3. Types of construction, such as clearing, topsoil stripping, structure or trench excavation, landscaping, and post construction clean-up.
4. Methods and equipment used for each type of construction.
5. Plan for relocating work in the event of temporary work stoppages at each archeologically sensitive area

PART 3 - EXECUTION

3.1 OBSERVATION

A. Archeological Monitor will observe ground-disturbing site work, including construction of temporary facilities, at archeologically sensitive areas, from a safe location mutually agreed on by Contractor and Monitor. As new ground is broken, Monitor will examine excavated materials, using construction layout centerline and perimeter staking as a reference point to record locations of findings.

3.2 DISCOVERY OF RESOURCES

A. If Archeological Monitor discovers resources, immediate relocation of work to a non-sensitive area may be required for Monitor to identify and document resources and, if necessary, develop appropriate mitigation plan. While Archeological Monitor is documenting resources in sensitive areas, Contractor shall relocate work to non-sensitive areas where monitoring is not normally required.

B. If resources are discovered while Archeological Monitor is absent, stop work immediately and report the discovery to the Contracting Officer.

3.3 WORK STOPPAGE

A. Contractor shall plan, schedule, and execute work to prevent stoppages at one area from stopping all work at construction site.

END OF SECTION 01 35 13.22

SECTION 01 35 23 - SAFETY REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes establishing an effective accident prevention program and providing a safe working environment for all personnel and visitors.

1.2 SUBMITTALS

A. Accident Prevention Plan (APP): After contract award and before the Pre-Construction conference, submit for review, an Accident Prevention Plan. The Contracting Officer will review the proposed Plan. If the plan requires any revisions or corrections, the Contractor shall resubmit the Plan within 10 days. No progress payments will be made until the Plan is accepted.

1.3 QUALITY ASSURANCE

A. Comply with contract clauses entitled "Accident Prevention" and "Permits and Responsibilities". In case of conflicts between Federal, State, and local safety and health requirements, the most stringent shall apply. Equipment or tools not meeting OSHA requirements will not be allowed on the project sites. Failure to comply with the requirements of this section and related sections may result in suspension of work.

B. Qualifications of Employees:

1. All employees must be physically and able to perform their assigned duties in a safe manner.
2. Do not allow employees to perform work whose ability or alertness is impaired because of prescription or illegal drug use, fatigue, illness, intoxication, or other conditions that may expose themselves or others to injury.
3. Operators of vehicles, hoisting equipment, and hazardous plant equipment shall be able to understand signs, signals, and operating instructions, and be fully capable of operating such equipment. Provide operating instructions for all equipment. Newly hired operators shall be individually tested by an experienced operator or supervisor to determine if they are capable of safely operating equipment. Retain copies of all operators licenses and/or certifications onsite.

1.4 ACCIDENT REPORTING

A. Reportable Accidents (per OSHA 29CFR 1904): A project reportable accident is defined as death, occupational disease, traumatic injury to employees or the public, fires, and property damage by accident in excess of $100. Notify Contracting Officer immediately in the event of a reportable accident. Within 7 days of a reportable accident, fill out and forward to Contracting Officer an Accident/Property Damage Report (Form CM-22). Form may be obtained from the Contracting Officer.

PART 2 - PRODUCTS

2.1 ACCIDENT PREVENTION PLAN (APP)

A. The Plan shall be written to comply with OSHA and project requirements (a generic plan is not acceptable) including but not limited to the following:

1. Name of responsible supervisor to carry out the program.
2. Weekly and monthly safety meetings shall be documented with topic and attendees.
3. First aid and rescue procedures.
4. Outline of each phase of the work, the hazards associated with each major phase, and the methods proposed to provide for property protection and safety of the public, National Park Service personnel, and Contractor's employees. Identify the work included under each phase, with an Job Hazard Analysis (JHA)/Job Safety Analysis (JSA), etc.
5. Training, both initial and continuing.
6. Planning for possible emergency situations, such as cave-ins, earthquake, explosions,, fires, floods, power outages, slides, and wind storms. Such planning shall take into consideration the nature of construction, site conditions, and degree of exposure of persons and property.

2.2 FIRST AID FACILITIES

A. Provide adequate facilities for the number of employees and appropriate to the hazards associated with the types of ongoing construction work at the site.

2.3 PERSONNEL PROTECTIVE EQUIPMENT

A. Meet requirements of applicable ANSI standards. Selection shall conform to OSHA 29CFR 1926.95 Subpart E.

PART 3 - EXECUTION

3.1 EMERGENCY INSTRUCTIONS

A. Post telephone numbers and reporting instructions for ambulance, physician, hospital, fire department, and police in conspicuous locations at the work site.

3.2 FIRE AND LIFE SAFETY

A. Comply with the requirements of NFPA 241 (Standard for Safeguarding Construction, Alteration, and Demolition Operations).

B. Store hazardous materials in accordance with manufacturers and OSHA 29CFR1926 Subpart D requirements. Maintain readily available, on site, MSDS/Safety Data Sheets (SDS) for each chemical.

1. Immediately report all spills of hazardous materials to the park.
2. Maintain a spill emergency response kit.
3. Train employees how to respond to a spill and use the emergency response kit.

3.3 PROTECTIVE EQUIPMENT

A. Inspect personal protective equipment daily and maintain in a serviceable condition. Clean, sanitize, and repair personal items, as appropriate, before issuing them to another individual.

B. Inspect, maintain, and document other protective equipment and devices before use and on a periodic basis to ensure safe operation. Retain inspection documentation onsite.

3.4 SAFETY MEETINGS

A. As a minimum, conduct one weekly 15-minute "toolbox" safety meetings. These meetings shall be conducted by a foreman or supervisor and attended by all construction personnel at the worksite. Topics need to coincide with work scheduled for the following week. Document and submit meeting minutes to the Contracting Officer within one day after the meeting.

B. Conduct monthly safety meetings for all levels of supervision. Meetings shall be attended by all contractors and subcontractors performing work on the site. Notify the Contracting Officer of meeting dates and times. These meetings shall be used to review the effectiveness of the Contractor's safety effort, to resolve current health and safety problems, to provide a forum for planning safe construction activities, and for updating the Accident Prevention Plan. The Contracting Officers Representative will attend the meeting and enter the results of the meetings into the daily log.

3.5 HARD HATS AND PROTECTIVE EQUIPMENT AREAS

A. A hard hat use area shall be designated by the Contractor. The hard hat area shall be posted by the Contractor in a manner satisfactory to the Contracting Officer.

B. It is the Contractor's responsibility to require all those working on or visiting the site to wear hard hats and other necessary personal protective equipment in good repair at all times. As a minimum, maintain six hard hats and all other APP required equipment.

3.6 TRAINING

A. First Aid: Provide adequate training to an adequate number of personnel to ensure prompt and efficient first aid.

B. Hazardous Material: Train and instruct each employee exposed to hazardous material in safe and approved methods of handling and storage. Hazardous materials are defined as explosive, flammable, poisonous, corrosive, oxidizing, irritating, or otherwise harmful substances that could cause death or injury.

END OF SECTION 01 35 23

SECTION 01 35 91 - HISTORIC PRESERVATION TREATMENT PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes special procedures for historic treatment on Project including, but not limited to:

1. Definitions
2. Submittals
3. Quality Assurance
4. Storage and protection of existing historic materials
5. Project site conditions
6. Historic Preservation Treatment Plan
7. Protection, General
8. Protection during application of chemicals
9. Protection during use of heat-generating equipment
10. Historic preservation treatment procedures

1.2 DEFINITIONS

A. "Preservation" - To apply measures necessary to sustain existing form, integrity, and materials of historic property. Work may include preliminary measures to protect and stabilize the property.

B. "Rehabilitation" - To make possible a compatible use for property through repair, alterations, and additions while preserving those portions or features that convey its historical, cultural, or architectural values.

C. "Restoration" - To accurately return form, features, and character of a property to its appearance at a particular period of time by means of removal of features from other periods in its history and repair and reconstruction of missing and deteriorated features from the restoration period.

D. "Reconstruction" - To reproduce in exact form and detail, a building, structure, or artifact as it appeared at a specific period in time. Reconstructed elements do not possess historic integrity in their own right since they are-not original fabric.

E. "Stabilize" - To apply measures designed to reestablish a weather-resistant enclosure and structural reinforcement of an item or portion of the building while maintaining essential form as it exists at present. This level of intervention is aimed at retarding or arresting adverse impacts to structures.

F. "Protect and Maintain" - To remove deteriorating corrosion, reapply protective coatings, and install protective measures such as temporary guards; to provide the least degree of intervention.

G. "Repair" - To stabilize, consolidate, or conserve; to retain existing materials and features while employing as little new material as possible. Repair includes patching, piecing-in, splicing, consolidating, or otherwise reinforcing or upgrading materials. Within restoration, repair also includes limited replacement in kind, rehabilitation, and reconstruction, with compatible

substitute materials for deteriorated or missing parts of features when there are surviving prototypes.

H. "Replace" - To duplicate in its entirety, a historic element or feature by matching its historic pattern, detail and appearance. Replacement is justified when original or historic elements are damaged beyond repair or are missing. Replacement conditions and methods include:

1. Replacement with Original or Historic Fabric: Includes fabric salvaged from other locations or projects having identical architectural qualities. Duplication of appearance using identical material possessing historical significance.
2. Replacement with New Materials: Includes replacement with new material of like kind (custom fabricated of manufactured). Duplication of appearance using like material.
3. Replacement with Substitute Materials: Includes replacement with a compatible substitute that is frequently contemporary and unlike the historic fabric. Duplication of appearance using modern (non-traditional) material Use of substitute materials is not approved unless matching materials are not available.

I. "Remove" - To demolish or detach items from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged or removed and reinstalled.

J. "Remove and Salvage" - To detach items from existing construction and deliver them ready for reuse to Contracting Officer (CO) or designee.

K. "Remove and Reinstall" - To detach items from existing construction, repair and prepare for reuse, and reinstall where indicated.

L. "Existing to Remain" or "Retain" - Existing items of construction not to be removed and not otherwise indicated to be removed and salvaged or removed and reinstalled.

M. "Material in Kind" - Material that closely matches existing materials through comparison of architectural qualities and salient characteristic such as species, cut, color, grain, dimension, profile, thickness, and finish.

1.3 SUBMITTALS

A. Historic Preservation Treatment Plan:

1. After contract award and before Pre-Construction conference, submit for approval a written Historic Preservation Treatment Plan (HPTP).
2. If the plan requires revisions or corrections, Contractor shall resubmit plan within 10 days.
3. No change in approved plan may be made without written concurrence by Contracting Officer.

B. Alternative Methods and Materials: If alternative methods and materials to those indicated are proposed for any phase of work, provide a written description including evidence of successful use on other, comparable projects, and program of testing to demonstrate effectiveness for use on this Project.

1.4 QUALITY ASSURANCE

A. Historic Preservation Treatment Specialist Qualifications: Experienced firm with required certifications and training able to demonstrate through past performance they are qualified to perform this work.

1.5 STORAGE AND PROTECTION OF HISTORIC MATERIALS

A. Removed and Salvaged Historic Materials:

1. Clean salvaged historic items.
2. Pack or crate items after cleaning. Identify contents of containers.
3. Store items in secure area until delivery to Contracting Officer.
4. Transport items to storage area determined by COR.
5. Protect items from damage during transport and storage.
6. Do not dispose of items removed from existing construction without prior written consent of Contracting Officer.

B. Removed and Reinstalled Historic Materials:

1. Clean and repair historic items to functional condition adequate for intended reuse.
2. Pack or crate items after cleaning and repairing. Identify contents of containers.
3. Protect items from damage during transport and storage.
4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use as designed.

C. Existing Historic Materials to Remain: Protect construction indicated to remain against damage and soiling during historic treatment. When permitted by Contracting Officer, items may be removed to suitable, protected storage location during historic treatment and cleaned and reinstalled in their original locations after historic treatment operations are complete.

D. Storage and Protection: When removed from existing location, store historic materials within weather-tight enclosure protected from wetting by rain, snow, or ground water, and temperature variations. Secure stored materials to protect from theft.

1. Identify removed items with an inconspicuous mark indicating original location.
2. Develop key plan when many similar items are scheduled for removal and reinstallation.

1.6 PROJECT-SITE CONDITIONS

A. Exterior Cleaning and Repairing:

1. Proceed with work only when forecasted weather conditions are favorable.

a. Wet Weather: Do not attempt repairs during rainy or foggy weather. Do not apply primer, paint, putty, or epoxy when relative humidity is above 80 percent. Do not remove exterior elements of structures when rain is forecast or in progress.

b. Do not perform exterior wet work when air temperature is below 40 degrees Fahrenheit (5 degrees Celsius).
c. Do not begin cleaning, patching, or repairing given likelihood of frost or freezing.
d. Do not begin cleaning when either air or surface temperature is below 45 degrees Fahrenheit (7 degrees Celsius) unless approved means are provided for maintaining 45 degrees Fahrenheit (7 degrees Celsius) temperature of air and materials during, and for 48 hours subsequent to, cleaning.

2. Perform cleaning and rinsing of the exterior only during daylight hours.

B. National Park Service will occupy portions of building immediately adjacent to historic treatment area. Conduct historic treatment so National Park Service operations will not be disrupted. Provide **72** hours' notice to Contracting Officer of activities that will affect National Park Service operations.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 HISTORIC PRESERVATION TREATMENT PLAN

A. Prepare written plan for preservation work covering preservation components of project. Plan shall verify construction strategy and intent is compatible with Department of the Interior's (DOI) standards for Treatment of Historic Properties, guidelines for Treatment of Cultural Landscapes, and National Park Service management policies for cultural resources. Plan shall satisfy both project scope and resource protection requirements. Plan shall include:

1. Organized list of preservation components of project, systems, and tasks
2. Staging and sequence of work
3. Disassembly and reassembly techniques and steps
4. Equipment and tools required
5. Supplies and materials with manufacturer or supplier identified including specific clean up/storage procedure including frequency and documentation of such.
6. Skilled trades and crafts required
7. Anticipated testing and analysis of fabric
8. Additional investigations for extents or magnitude of treatments needed
9. Protective measures
10. Seasonal limitations on work
11. Alternative means if primary treatment method is unfeasible
12. Work conducted off-site (Approval from Contracting Officer required prior to taking resources off-site).

3.2 PROTECTION, GENERAL

A. Comply with manufacturer's written instructions for precautions and effects of products and procedures on adjacent building materials, components, and vegetation.

B. Ensure supervisory personnel are present when work begins and during progress.

C. Temporary Protection of Historic Materials during Construction:

1. Protect existing materials during installation of temporary protections and construction. Do not deface or remove existing materials.
2. Attachments of temporary protection to existing construction shall be approved by Contracting Officer prior to installation.

D. Protect landscape work adjacent to or within work areas as follows:

1. Provide barriers to protect tree trunks.
2. Bind spreading shrubs.
3. Coverings shall allow plants to breathe. Remove coverings at end of day. Do not cover plant material with waterproof membrane more than 8 hours at a time.
4. Set scaffolding and ladder legs away from plants.

E. Existing Drains: Prior to start of work or cleaning operations, test drains and other water removal systems to ensure drains and systems function properly. Notify Contracting Officer immediately of stopped or blocked drains or systems. Do not begin Work of this Section until drains are in working order.

1. Provide method to prevent solids including stone or mortar residue from entering drains or drain lines. Clean out drains and drain lines blocked or filled because of work performed under this Contract.
2. Protect storm drains from pollutants. Block drains or filter out sediments, allowing only clean water to pass.

3.3 PROTECTION DURING APPLICATION OF CHEMICALS

A. Protect persons, motor vehicles, surrounding surfaces of building being restored, building site, plants, and surrounding buildings from harm or damage resulting from applications of chemical cleaners and paint removers.

B. Cover adjacent surfaces with materials proven to resist chemical cleaners selected for Project unless chemicals being used will not damage adjacent surfaces. Use covering materials containing only waterproof, UV (ultraviolet)-resistant adhesives. Apply masking agents to comply with manufacturer's written instructions. Do not apply liquid masking agent to painted or porous surfaces. Promptly remove masking to prevent adhesive staining on completion.

C. Do not clean surfaces during winds of sufficient force to spread cleaning solutions to unprotected surfaces.

D. Neutralize and collect alkaline and acid wastes and dispose of outside park boundaries.

E. Dispose of runoff from chemical operations by legal means and in a manner preventing soil erosion, undermining of paving and foundations, damage to landscaping, and water penetration into building interiors.

F. Document daily clean-up, proper storage, and disposition of any flammable/combustible materials with daily reports.

3.4 PROTECTION DURING USE OF HEAT-GENERATING EQUIPMENT

A. Comply with following procedures while performing work with heat-generating equipment, including welding, cutting, soldering, brazing, paint removal with heat, and other operations where open flames or implements utilizing heat are used:

1. Obtain Contracting Officer's approval for operations involving use of open-flame or welding equipment.

    a. Notification shall be given for each occurrence and location of work with heat-generating equipment.
    b. Obtain appropriate permit from the park as required.

2. As far as practical, use heat-generating equipment in shop areas or outside building.
3. Before work with heat-generating equipment commences, furnish fire watch (or watches) for location(s) where work is to be performed.
4. Do not perform work with heat-generating equipment in or near rooms or in areas where flammable liquids or explosive vapors are present or thought to be present. Use combustible gas indicator test to ensure area is safe.
5. Remove and keep area free of combustibles, including, rubbish, paper, waste, etc., within area of operations.

    a. If combustible material cannot be removed, provide fireproof blankets to cover such materials.

6. Where possible, furnish and use baffles of metal or gypsum board to prevent spraying of sparks or hot slag into surrounding combustible material.
7. Prevent extension of sparks and particles of hot metal through open windows, doors, holes, and cracks in floors, walls, ceilings, roofs, and other openings.
8. Inspect each location of day's work not sooner than 30 minutes after completion of operations to detect hidden or smoldering fires; ensure proper housekeeping is maintained.

B. Where sprinkler protection exists and is functional, maintain without interruption while operations are performed. If operations are performed near automatic sprinkler heads, shield individual heads temporarily with guards.

3.5 HISTORIC PRESERVATION TREATMENT PROCEDURES

The principal aim of preservation work is to halt the process of deterioration and stabilize the item's condition to sustain the integrity of the historic element, feature or structure being preserved. Cyclic maintenance is often required as well as repair work. Repair is required where specifically indicated. The following procedures shall be followed:

1. Retain as much existing material as possible; repair and consolidate rather than replace.

2. Use additional material or structure to reinforce, strengthen, prop, tie, and support existing material or structure.
3. Use reversible processes wherever possible.
4. Use traditional replacement materials and techniques if possible. New work shall be distinguishable from old work and original materials and techniques.
5. Record repair work during construction with periodic construction photos and daily inspection reporting.

B. Prohibit smoking by personnel performing work on or near historic structures.

C. Notify Contracting Officer of visible changes in integrity of material or components due to environmental causes including biological attack, UV degradation, freezing, or thawing, or due to structural defects including cracks, movement, or distortion.

1. Do not proceed with work in question until directed by Contracting Officer.

D. Where Work requires existing features to be removed, cleaned, and reinstalled, perform operations without damage to material itself, to adjacent materials, or to substrate.

E. Identify new or replacement materials and features with inconspicuous, permanent marks to distinguish from original materials. Record legend of identification marks and locations of these marks on Record Drawings.

F. When cleaning, match samples of existing materials that have been cleaned and identified for acceptable cleaning levels. Avoid over-cleaning to prevent damage. Use gentlest methods available. Initiate cleaning using hand cleaning methods before introducing power cleaning methods and equipment.

END OF SECTION 01 35 91

SECTION 01 40 00 - QUALITY REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes administrative and procedural requirements for quality assurance and quality control.

B. Testing and inspecting services are required to verify compliance with requirements specified or indicated. These services do not relieve Contractor of responsibility for compliance with the Contract Document requirements. The quality of all work shall be the responsibility of the Contractor.

1. Specified tests, inspections, and related actions do not limit Contractor's other quality assurance and control procedures that facilitate compliance with the Contract Document requirements.

C. See Divisions 02 through 49 Sections for specific test and inspection requirements.

1.2 DEFINITIONS

A. Quality Assurance Services: Activities, actions, and procedures performed before and during execution of the work to guard against defects and deficiencies and substantiate that proposed construction will comply with requirements.

B. Quality Control Services: Tests, inspections, procedures, and related actions during and after execution of the work to evaluate that actual products incorporated into the work and completed construction comply with requirements.

C. Preconstruction Testing: Tests and inspections that are performed specifically for the project before products and materials are incorporated into the work to verify performance or compliance with specified criteria.

D. Product Testing: Tests and inspections that are performed by a Nationally Recognized Testing Laboratory (NRTL), a National Voluntary Laboratory Accreditation Program (NVLAP), or a testing agency qualified to conduct product testing, to establish product performance and compliance with industry standards.

E. Source Quality Control Testing: Tests and inspections that are performed at the source, i.e., plant, mill, factory, or shop.

F. Field Quality Control Testing: Tests and inspections that are performed on-site for installation of the work and for completed work.

G. Testing Agency or Laboratory: An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall mean the same as testing agency.

H. Installer/Applicator/Erector: Contractor or another entity engaged by Contractor as an employee, Subcontractor, or Sub-subcontractor, to perform a particular construction operation, including installation, erection, application, and similar operations.

1. Using a term such as “carpentry” does not imply that certain construction activities must be performed by accredited or unionized individuals of a corresponding generic name, such as “carpenter.” It also does not imply that requirements specified apply exclusively to trades people of the corresponding generic name.

1.3 CONFLICTING REQUIREMENTS

A. Reference Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quality levels, comply with the most stringent requirement. Refer uncertainties and requirements that are different, but apparently equal, to Contracting Officer for a decision before proceeding.

B. Minimum Quality Levels: The quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to Contracting Officer for a decision before proceeding.

1.4 SUBMITTALS

A. Quality Control Plan:

1. After contract award and before the Pre-Construction conference, submit for approval a written Contractor Quality Control (CQC) plan.

2. If the plan requires any revisions or corrections, the Contractor shall resubmit the plan within 10 days.

3. The Government reserves the right to require changes in the plan during the contract period as necessary to obtain the quality specified.

4. No change in the approved plan may be made without written concurrence by the Contracting Officer.

B. Qualification Data: For testing agencies specified in “Quality Assurance” Article to demonstrate their capabilities and experience. Include proof of qualifications in the form of a recent report on the inspection of the testing agency by a recognized authority.

C. Contractor's Quality Control Daily Reports: Submit showing all inspections and tests on the first workday following the date covered by the report. Quality Control Supervisor shall utilize the forms attached at the end of this Section.

D. Test Reports

1. Test reports shall be completed by the person performing the test.

2. Submit Daily Test Information Sheets with Quality Control Daily Reports.

3. Submit failing test results and proposed remedial actions within four hours of noted deficiency.

4. Submit three copies of complete test results no later than one calendar day after the test was performed.

E. Accessibility Inspection Report:

1. Fill out the applicable sections of the Accessibility Inspection Report and attach to the Quality Control Daily Report.

2. Utilize the attached Accessibility Inspection form to document compliance with the Architectural Barriers Act Accessibility Standards (ABAAS).

3. Inspect at various stages of construction as needed to insure the finished product meets the standards.

4. Submit report not later than one calendar day after the inspection was performed.

F. Off-Site Inspection Reports: Submit prior to shipment.

G. If the CQC plan and Quality Control Daily Reports are not submitted as specified, the Contracting Officer may retain all payments until such time a plan is accepted and implemented or may retain payments for work completed on days there are no Quality Control Daily Reports.

H. Permits, Licenses, and Certificates: For NPS records, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents, established for compliance with standards and regulations bearing on performance of the work.

1.5 QUALITY ASSURANCE

A. General: Qualifications paragraphs in this Article establish the minimum qualification levels required; individual Specification Sections specify additional requirements.

B. Contractors Quality Control Staff:

1. The Contractor's Quality Control Supervisor may also perform other duties.

2. The Contractor's designated Quality Control Supervisor shall be on the project site whenever contract work is in progress.

3. The Contractor's job supervisory staff may be used to assist the Quality Control Supervisor supplemented, as necessary, by additional certified testing technicians.

C. Installer Qualifications: A firm or individual experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.

D. Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

E. Fabricator Qualifications: A firm experienced in producing products similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

F. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated (including Structural Tests and Special Inspections (STSI). Engineering services are defined as those performed for installations of the system, assembly, or products that are similar to those indicated for this Project in material, design, and extent.

G. Testing Agency Qualifications: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual Sections; and where required by Contract, is acceptable to the Contracting Officer.

1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.

2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.

3. All measuring devices, laboratory equipment, and instruments shall be calibrated at established intervals against certified standards in accordance with NBS requirements. Upon request, measuring and testing devices shall be made available for use by the Government for verification tests.

H. Factory-Authorized Service Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.

1.6 QUALITY CONTROL

A. Manufacturer's Field Services: Where indicated, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including service connections. Report results in writing.

B. Re-testing/Re-inspecting: Regardless of whether original tests or inspections were Contractor's responsibility, provide quality-control services, including retesting and re-inspecting, for construction that replaced work that failed to comply with the Contract Documents.

C. Testing Agency Responsibilities: Cooperate with NPS and Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.

1. Notify Contracting Officer and Contractor promptly of irregularities or deficiencies observed in the work during performance of its services.

2. Determine the location from which test samples will be taken and in which in-situ tests are conducted.

3. Conduct and interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from requirements.

4. Submit 3 copies of the certified written report of each test, inspection, and similar quality-control service through Contractor.

5. Do not release, revoke, alter, or increase the Contract Document requirements or approve or accept any portion of the work.

D. Coordination: Coordinate sequence of activities to accommodate required quality assurance and control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting.

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

PART 2 - PRODUCTS

2.1 QUALITY CONTROL PLAN

A. The Quality Control Plan shall include:

1. A list of personnel responsible for quality control and assigned duties. Include each person's qualifications.

2. A copy of a letter of direction to the Contractor's Quality Control Supervisor outlining assigned duties.

3. Names, qualifications, and descriptions of laboratories to perform sampling and testing, and samples of proposed report forms.

4. Methods of performing, documenting, and enforcing quality control of all work.

5. Methods of monitoring and controlling environmental pollution and contamination as required by regulations and laws.

PART 3 - EXECUTION

3.1 OFF-SITE CONTROL

A. Items that are fabricated or assembled off-site shall be inspected for quality control at the place of fabrication.

3.2 ON-SITE CONTROL

A. Items that are assembled on-site shall be inspected for quality control on-site. No fabrication on-site.

3.3 DOCUMENTATION

A. Maintain Quality Control Daily Reports, Daily Test Report Information Sheets, and Accessibility Inspection Reports (attached) of quality control activities and tests.

B. Quality Control Daily Reports may not be substituted for other written reports required under clauses of the contract, such as Disputes, Differing Site Conditions, or Changes.

3.4 ENFORCEMENT

A. The Contractor shall stop work on any item or feature pending satisfactory correction of any deficiency noted by the quality control staff or the Contracting Officer.

3.5 REPAIR AND PROTECTION

A. General: On completion of testing, inspecting, sample taking, and similar services, repair damaged construction and restore substrates and finishes.

1. Provide materials and comply with installation requirements specified in other Specification Sections. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible.

B. Protect construction exposed by or for quality-control service activities.

C. Repair and protection are Contractor's responsibility, regardless of the assignment of responsibility for quality-control services.

END OF SECTION 01 40 00

SECTION 01 73 29 - CUTTING AND PATCHING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes procedural requirements for cutting and patching on buildings that contain historic fabric.

B. The Contractor shall note the historical significance of the buildings and the site at which the Work will be performed.
   1. Because of the historic nature of the buildings and site, certain aspects of the Work may not be carried out with the materials and/or methods commonplace in the modern construction industry.
   2. It is incumbent upon the Contractor to furnish mechanics who can and will execute first-class workmanship in the materials and methods specified, and who will take the necessary precautions to protect the elements of this historic structure.

1.2 SUBMITTALS

A. Cutting and Patching Plan: Submit a Plan describing procedures at least ten (10) days before the time cutting and patching will be performed, requesting approval to proceed. Include the following information:
   1. Extent: Describe cutting and patching, show how they will be performed, and indicate why they cannot be avoided.
   2. Changes to In-Place Construction: Describe anticipated results. Include changes to structural elements and operating components as well as changes in building's appearance and other significant visual elements.
   3. Products: List products to be used and firms or entities that will perform the Work.
   4. Dates: Indicate when cutting and patching will be performed.
   5. Utility Services and Mechanical/Electrical Systems: List services/systems that cutting and patching procedures will disturb or affect. List services/systems that will be relocated and those that will be temporarily out of service. Indicate how long services/systems will be disrupted.
   6. Structural Elements: Where cutting and patching involve adding reinforcement to structural elements, submit details and engineering calculations showing integration of reinforcement with original structure. Do not cut and patch structural elements in a manner that could change their load carrying capacity or increase deflection.
   7. Contracting Officer's: Obtain approval of cutting and patching plan before cutting and patching. Approval does not waive right to later require removal and replacement of unsatisfactory work.

1.3 QUALITY ASSURANCE

A. Structural Elements: Do not cut and patch structural elements in a manner that could change their load-carrying capacity or load-deflection ratio. Character-defining features to be preserved include, without limitation, the following structural elements:
   1. Porches, porticos and loggia columns and colonnettes.
   2. Load-bearing brick masonry walls.

B. Operational Elements: Do not cut and patch operating elements and related components in a manner that results in reducing their capacity to perform as intended or that results in increased maintenance or decreased operational life or safety. Operating elements include the following:
   1. Windows and doors, and associated operating hardware.

C. Miscellaneous Elements: Do not cut and patch miscellaneous elements or related components in a manner that could change their load-carrying capacity, that results in reducing their capacity to perform as intended, or that results in increased maintenance or decreased operational life or safety.

D. Visual Requirements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch construction exposed on the exterior or in occupied spaces in a manner that would, in Contracting Officer's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.

1.4 WARRANTY

A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during cutting and patching operations, by methods and with materials so as not to void existing warranties.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Comply with requirements specified in other Sections.

B. In-Place Materials: Use materials identical to in-place materials. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.

   1. If identical materials are unavailable or cannot be used, use materials that, when installed, will match the visual and functional performance of in-place materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces to be cut and patched and conditions under which cutting and patching are to be performed.

   1. Compatibility: Before patching, verify compatibility with and suitability of substrates, including compatibility with in-place finishes or primers.

   2. Proceed with installation only after unsafe or unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Temporary Support: Provide temporary support of Work to be cut.

B. Protection: Protect in-place construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of Project that might be exposed during cutting and patching operations.

C. Adjoining Areas: Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.

D. Existing Utility Services and Mechanical/Electrical Systems: Where existing services/systems are required to be removed, relocated, or abandoned, bypass such services/systems before cutting to minimize interruption to occupied areas.

3.3 PERFORMANCE

A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
   1. Cut in-place construction to provide for installation of other components or performance of other construction, and subsequently patch as required to restore surfaces to their original condition.

B. Cutting: Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original Installer; comply with original Installer's written recommendations.
   1. In general, use hand tools or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots as small as possible, neatly to size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
   2. Finished Surfaces: Cut or drill from the exposed or finished side into concealed surfaces.
   3. Concrete: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.
   4. Mechanical and Electrical Services: Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after cutting.
   5. Proceed with patching after construction operations requiring cutting are complete.

C. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other Work. Patch with durable seams that are as invisible as possible. Provide materials and comply with installation requirements specified in other Sections.
   1. Inspection: Where feasible, test and inspect patched areas after completion to demonstrate integrity of installation.
   2. Exposed Finishes: Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.

3. Floors and Walls: Where walls or partitions that are removed extend one finished area into another, patch and repair floor and wall surfaces in the new space. Provide an even surface of uniform finish, color, texture, and appearance. Remove in-place floor and wall coverings and replace with new materials, if necessary, to achieve uniform color and appearance.
4. Ceilings: Patch, repair, or re-hang in-place ceilings as necessary to provide an even- plane surface of uniform appearance.
5. Exterior Building Enclosure: Patch components in a manner that restores enclosure to a weather tight condition.

D. Cleaning: Clean areas and spaces where cutting and patching are performed. Completely remove paint, mortar, oils, putty, and similar materials.

END OF SECTION 01 73 29

SECTION 01 73 40 – EXECUTION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section sets forth the general procedural requirements for execution of the Work of this contract.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. The General Requirements, Technical Specifications and drawings included in this Project Manual and all other contract documents.

1.3 SUBMITTALS

A. As required by individual Division 01 and Technical Specifications sections.

1.4 QUALITY ASSURANCE

A. Historically Significant Building: The Contractor shall note the historical significance of the site and building at which the Work will be performed. Because of the historic nature of the site, certain aspects of the Work may not be executed with the materials and/or methods commonplace in the modern construction industry. It is incumbent upon the Contractor to furnish mechanics who can and will execute first-class workmanship in the materials and methods specified, and who will take the necessary precautions to protect the elements of this historic structure.

B. The work shall be executed in the contractor's best, workman like manner as required by these specifications, drawings, existing field conditions and applicable codes and regulations.

C. Project drawings are diagrammatic and are not meant to show every detail. Significant differences between the drawings and existing conditions shall be brought to the attention of the Government for resolution prior to beginning the Work.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Existing Conditions: Contractor shall verify all existing conditions prior to beginning Work.
   1. Review of Contract Documents and Existing Conditions prior to performing and work. Immediately on discovery of the need for clarification of the Contract Documents caused by differing field conditions outside the control of the Contractor, submit a request for information to the Government in accordance with Division 01 Specification 01 31 00 "Project Management and Coordination".
   2. Before beginning work, investigate and verify the existence and location of mechanical and electrical systems and other construction affecting the Work.
   3. Before construction, verify the location and points of connection of utility services.

B. Existing Utilities: The existence and location of underground and other utilities and construction indicated as existing are not guaranteed. Before beginning site work, investigate and verify the existence and location of underground utilities and other construction affecting the Work.
   1. Before construction, verify the location and invert elevation at points of connection of sanitary sewer, storm sewer, and water-service piping; and underground electrical services.

C. Acceptance of Conditions: Examine substrates, areas, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers;
   2. Examine rough-in locations and connections before equipment and fixture installation;
   3. Examine all existing walls, floors, and roofs for suitable conditions where products and systems are to be installed;
   4. Proceed with installation only after unsatisfactory conditions have been corrected;
   5. Proceeding with the Work indicates acceptance of substrates, surfaces and conditions and assurance that the work can be installed and warranted as specified.

3.2 PREPARATION

A. Field Measurements: Take field measurements as required to fit the Work properly. Recheck measurements before installing each product.

B. Space Requirements: Verify space requirements and dimensions of items shown diagrammatically on Drawings.

C. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication.

3.3 PROTECTION

A. Protect existing site and building elements to remain from damage throughout the performance of the Work. If existing elements to remain are damaged they shall be repaired restored to their original condition in function and appearance, at no additional cost to the Government.

B. The Work will be performed at a historic site and in a historic building. All historical materials scheduled to remain shall be protected from damage throughout the course of the Work.
   1. If historical material is damaged, contact the Government immediately for resolution.
   2. Refer to Division 01 Specification Section “Historic Preservation Treatment Procedures” for additional requirements.

C. Protection of Installed Work: Supervise construction operations to ensure that no part of the construction completed or in progress, is subject to harmful, dangerous, damaging, or otherwise deleterious exposure during the construction period.

3.4 INSTALLATION

A. General: Locate the Work and all of its components accurately, in correct alignment and elevation, as indicated and or required by field conditions to match existing construction.
   1. Make vertical work plumb and make horizontal work level.

2. Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.
3. Conceal pipes, ducts, and wiring in finished areas, unless otherwise indicated.

B. Comply with manufacturer's written instructions and recommendations for installation of products.

C. Install products at the time and under conditions that will ensure the best possible results. Maintain conditions required for product performance until Substantial Completion.

D. Conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.

E. Tools and Equipment: Do not use tools or equipment that produce harmful noise levels.

F. Anchors and Fasteners: Provide anchors and fasteners as required to anchor each component securely in place, accurately located and aligned with other portions of the Work.
1. Allow for building movement, including thermal expansion and contraction.
2. Coordinate installation of anchorages. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

G. Mounting Heights: Where mounting heights are not indicated, mount components at standard industry heights and/or as directed by the Government.
1. Comply with the requirements of the American Barriers Act (ABA) for mounting heights of components required to be accessible to the disabled.

H. Joints: Make joints of uniform width. Where joint locations in exposed work are not indicated, arrange joints for the best visual effect. Fit exposed connections together to form hairline joints.

I. Hazardous Materials: Use products, cleaners, and installation materials that are not considered hazardous.

3.5 PROGRESS CLEANING

A. Clean Project site and work areas daily, including common areas. Enforce cleaning requirements strictly.
1. Maintain Project site free of waste materials and debris.
2. Comply with requirements in NFPA 241 for removal of combustible waste materials and debris.
3. Do not hold materials more than 7 days during normal weather or 3 days if the temperature is expected to rise above 80 deg F.
4. Dispose of materials lawfully.
   a. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately and dispose of legally, according to regulations.

B. Work Areas: Keep Work Areas clean and orderly. Clean areas where work is in progress to the level of cleanliness necessary for proper execution of the Work.
1. Remove liquid spills promptly.

2. Where dust would impair proper execution of the Work, broom-clean or vacuum the entire work area, as appropriate.
3. Contractor shall provide progress cleaning that minimizes sources of food, water, and harborage available to pests.

C. Keep installed work clean. Clean installed surfaces according to written instructions of manufacturer or fabricator of product installed, using only cleaning materials specifically recommended. If specific cleaning materials are not recommended, use cleaning materials that are not hazardous to health or property and that will not damage exposed surfaces.
1. Utilize non-toxic cleaning materials and methods.
a. Comply with GS 37 for general purpose cleaning and bathroom cleaning.

D. Concealed Spaces: Remove debris from concealed spaces before enclosing the space.

E. Exposed Surfaces in Finished Areas: Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration at time of Substantial Completion.

F. Waste Disposal: Dispose of all waste off site in a legal manner.
1. Burying or burning waste materials within the park is not permitted.
2. Washing waste materials down sewers or into waterways is not be permitted.

G. During handling and installation, clean and protect construction in progress and adjoining materials already in place. Apply protective covering where required to ensure protection from damage or deterioration at Substantial Completion.

H. Once installed, clean and provide maintenance on completed construction as frequently as necessary to maintain the construction until substantial completion.
1. Adjust and lubricate operable components to ensure operability without damaging effects.

3.6 STARTING AND ADJUSTING

A. Start equipment and operating components to confirm proper operation. Remove malfunctioning units, replace with new units, and retest.

B. Adjust operating components for proper operation without binding. Adjust equipment for proper operation.

C. Test each piece of equipment to verify proper operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Manufacturer's Field Service: If a factory-authorized service representative is required to inspect field-assembled components and equipment installation, comply with qualification requirements in Division 01 Section "Quality Requirements."

3.7 PROTECTION OF INSTALLED CONSTRUCTION

A. Provide final protection and maintain conditions that ensure installed Work is without damage or deterioration at time of Substantial Completion.

B. Comply with manufacturer's written instructions for temperature and relative humidity.

3.8 CORRECTION OF THE WORK

A. Repair or remove and replace defective construction. Restore damaged substrates and finishes. Comply with requirements in Division 01 Section "Cutting and Patching."
   1. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment.

B. Restore permanent facilities used during construction to their specified condition.

C. Remove and replace damaged surfaces that are exposed to view if surfaces cannot be repaired without visible evidence of repair.

D. Repair components that do not operate properly. Remove and replace operating components that cannot be repaired.

E. Remove and replace chipped, scratched, and broken glass or reflective surfaces.

3.9 FINAL CLEANING

A. General: Provide final cleaning in accordance with ASTM E1971.

B. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations.

C. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a portion(s) of Project:
   1. Clean Project site, building, yard, and grounds, in areas disturbed by construction activities, including landscape development areas as follows:
   2. Sweep all wood flooring broom clean;
   3. Remove petrochemical spills, stains, and other foreign deposits;
   4. Rake grounds disrupted by the work to a smooth, even-textured surface;
   5. Remove tools, construction equipment, machinery, and surplus material;
   6. Remove construction dust from all protruding ledges;
   7. Remove all project generated waste from site and dispose of it in a legal manner.
   8. Clean all windows and glazing;
   9. Restore all fencing
   10. Restore all landscape features;
   11. Restore parking area.

END OF SECTION 01 73 40

SECTION 01 74 19 - CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for:

1. Salvaging nonhazardous demolition and construction waste.
2. Recycling nonhazardous demolition and construction waste.
3. Disposing of nonhazardous demolition and construction waste.

1.2 DEFINITIONS

A. Construction Waste: Building and site improvement materials and other solid waste resulting from construction, remodeling, renovation, or repair operations. Construction waste includes packaging.

B. Demolition Waste: Building and site improvement materials resulting from demolition or selective demolition operations.

C. Solid Waste: Garbage, debris, sludge, or other discharged material (except hazardous waste) including solid, liquid, semisolid, or contained gaseous materials resulting from domestic, industrial, commercial, mining, or agricultural operations.

D. Debris: Non-hazardous solid waste generated during construction, demolition, or renovation of a structure which exceeds 2.5 inch (60 millimeter) particle size that is: a manufactured object; plant or animal matter; or natural geologic material (e.g. cobbles and boulders). A mixture of debris and other material such as soil or sludge is also subject to regulation as debris if mixture is comprised primarily of debris by volume, based on visual inspection.

E. Disposal: Removal off-site of demolition and construction waste and subsequent sale, recycling, reuse, or deposit in landfill or incinerator acceptable to authorities having jurisdiction.

F. Environmental Pollution and Damage: Presence of chemical, physical, or biological elements or agents which adversely affect human health or welfare; unfavorably alter ecological balances; or degrade utility of environment for aesthetic, cultural, or historical purposes.

G. Garbage: Refuse and scraps resulting from preparation, cooking, dispensing, and consumption of food.

H. Hazardous Materials: Material regulated as a hazardous material in accordance with 49 CFR 173 (Code of Federal Regulations), requires a Material Safety Data Sheet (MSDS) in accordance with 29 CFR 1910.1200, or which during end use, treatment, handling, storage, transportation or disposal meets or has components which meet or have potential to meet the definition of Hazardous Waste in accordance with 40 CFR 261.

I. Recycle: Recovery of demolition or construction waste for subsequent processing in preparation for reuse.

J. Salvage: Recovery of demolition or construction waste and subsequent sale or reuse in another facility.

K. Single-use plastic products: Plastic items intended to be disposed of immediately after use, including plastic and polystyrene food and beverage containers, bottles, straws, cups, cutlery, and disposable plastic bags.

1.3 PERFORMANCE REQUIREMENTS

A. If waste materials encountered during deconstruction/demolition or construction phase are found to contain lead, asbestos, polychlorinated biphenyls (PCBs), (such as fluorescent lamp ballasts), or other harmful substances, they are to be handled and removed in accordance with local, state, and federal laws and requirements concerning hazardous waste.

B. Existing items and material to be removed during deconstruction/demolition phase shall be reused in construction phase of the Project. Items that cannot be reused shall be recycled. Items considered for reuse must be in refurbishable condition and must meet quality standards set forth in these specifications. Contractor shall ensure quality of the item(s) in question will meet or exceed accepted industry or trade standards for first quality commercial grade application. During construction, deconstruction, or demolition Contracting Officer (CO) may designate other objects or materials for reuse.

C. Salvage/Recycle Requirements: Government goal is to salvage and recycle as much nonhazardous demolition and construction waste as possible including the following materials:

D. Salvage/Recycle Requirements: Government goal is to salvage and recycle as much nonhazardous demolition and construction waste as possible. Government has established minimum goals for the following materials:

SUBMITTALS

E. Waste Management Plan: After award of contract and prior to scheduled Pre-Construction Conference, Contractor shall submit a draft Waste Management Plan to Contracting Officer for approval. Submit [**3**] copies of plan. Revise and resubmit Plan as required by Contracting Officer. Approval of Contractor's Plan will not relieve Contractor of responsibility for compliance with applicable environmental regulations.

F. Progress Documentation: Supplemental to Waste Management Plan, document solid waste disposal, diversion, and cost/revenue analysis and submit completed worksheet on a monthly basis. See Project Waste Management Plan Worksheet Sample, attached to the end of the Division 1 Specifications, and report totals to date for column headings.

G. Landfill and Incinerator Disposal Records: Indicate receipt and acceptance of waste by landfills and incinerator facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.

H. Qualification Data: For Waste Management Coordinator and refrigerant recovery technician.

I. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating refrigerant that was present was recovered and recovery was performed according to Environmental Protection Agency (EPA) regulations. Include name and address of technician and date refrigerant was recovered.

J. Progress payment requirements:

1. With each Application for payment, submit an updated Project Waste Management Plan worksheet for solid waste disposal and diversion.
2. With each Application for Payment, submit manifests, weight tickets, receipts, and invoices specifically identifying the Project and waste material.

K. Closeout Submittals

1. With Closeout Submittals, submit a summary of a Project Waste Management Plan worksheet for solid waste disposal and diversion.

1.4 QUALITY ASSURANCE

A. Refrigerant Recovery Technician Qualifications: Certified by EPA-approved certification program.

B. Regulatory Requirements: Comply with hauling and disposal regulations of authorities having jurisdiction.

C. Waste Management Meeting: Conduct separate meeting or cover in Pre-Construction Conference and comply with requirements in Section 01 31 00 "Project Management and Coordination." Review methods and procedures related to waste management including:

1. Review and discuss waste management plan including responsibilities of Waste Management Coordinator.
2. Review requirements for documenting quantities of each type of waste and its disposition.
3. Review and finalize procedures for materials separation and verify availability of containers and bins needed to avoid delays.
4. Review procedures for periodic waste collection and transportation to recycling and disposal facilities.
5. Review procedures for reduction of single-use plastic products on site.
6. Review waste management requirements for each trade.

PART 2 - PRODUCTS

2.1 WASTE MANAGEMENT PLAN

A. General: Develop plan consisting of waste identification and waste reduction work plan. **Include separate sections in plan for demolition and construction waste.** Indicate quantities by weight or volume but use same units of measure throughout waste management plan.

B. Waste Identification: Indicate anticipated types and quantities of **demolition**, **site-clearing and construction** waste generated by the Work. Include estimated quantities and assumptions for estimates.

C. Waste Reduction Work Plan: List each type of waste and whether it will be salvaged, recycled, or disposed of in landfill or incinerator. Include points of waste generation, total quantity of each type of waste, quantity for each means of recovery, and handling and transportation procedures.

1. Salvaged Materials for Reuse: For materials salvaged and reused in Project, describe methods for preparing salvaged materials before incorporation into the Work.
2. Salvaged Materials for Sale: For materials sold to individuals and organizations, include list of names, addresses, and telephone numbers.
3. Salvaged Materials for Donation: For materials donated to individuals and organizations, include list of names, addresses, and telephone numbers.
4. Recycled Materials: Include list of local receivers and processors and type of recycled materials each will accept. Include names, addresses, and telephone numbers.
5. Disposed Materials: Indicate how and where materials will be disposed of. Include name, address, and telephone number of each landfill and incinerator facility.
6. Handling and Transportation Procedures: Include method used for separating recyclable waste including sizes of containers, container labeling, and designated location on Project site where materials separation will be located.
7. Reduction of single-use plastic products: Include methods for water distribution to include bottle refilling stations if available for personnel.

D. Cost/Revenue Analysis: Indicate total cost of waste disposal as if there was no waste management plan and net additional cost or net savings resulting from implementing waste management plan. Include:

1. Landfill tip fees per ton.
2. If diverted, tip fee savings from landfill diversion.
3. Costs of recycling, salvage, or reuse.
4. Revenue from recycling, salvage, or reuse.
5. Total cost or savings from diversion. (Calculate by using tip fee savings and subtracting costs of recycling or adding revenue from recycling.)

PART 3 - EXECUTION

3.1 PLAN IMPLEMENTATION

A. General: Implement waste management plan as approved by Contracting Officer. Provide handling, containers, storage, signage, transportation, and other items as required to implement waste management plan during entire duration of Contract.

B. Waste Management Coordinator: Engage waste management coordinator responsible for implementing, monitoring, and reporting status of waste management work plan. Coordinator shall be present at Project site full time for duration of Project.

C. Contractor shall establish contacts with local recycling and reuse companies to set up lines of responsibility. Contractor shall be responsible for coordination in terms of identifying materials, pickup schedules, and standard quality for recycled materials.

D. Training: Train workers, subcontractors, and suppliers on proper waste management procedures, as appropriate for the Work occurring at Project site.

1. Distribute waste management plan to everyone concerned within [**three**] days of submittal return.
2. Distribute waste management plan to entities when they begin work on-site. Review plan procedures and locations established for salvage, recycling, and disposal.

E. Site Access and Temporary Controls: Conduct waste management operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

F. Separation facilities:

1. Contractor shall designate and Contracting Officer shall approve specific area or areas to facilitate separation of materials for potential reuse, salvage, recycling, and return.
2. Place waste and recycling bins near each other, and close to point of waste generation but out of traffic pattern.
3. Keep recycling and waste bin areas neat, clean, and clearly marked in order to avoid co-mingling of materials.
4. Protect bins during non-working hours from off-site contamination.
5. Check garbage dumpsters periodically for recyclables being thrown away and undocumented materials that could be recycled.

G. Materials handling procedures: Material to be recycled shall be protected from contamination and shall be handled, stored, and transported in a manner that meets requirements set by designated facilities for acceptance. Establish defined area for operations of each trade, especially woodcutting so off-cuts are kept in one area and can be sorted by dimension for future reuse.

3.2 SALVAGING DEMOLITION WASTE

A. Salvaged Items for Reuse in the Work:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers.
3. Store items in secure area until installation.
4. Protect items from damage during transport and storage.
5. Install salvaged items to comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make items functional for use indicated.

B. Salvaged Items for Governments Use:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers.
3. Allow for inspection if necessary.
4. Store items in secure area until delivery to Government.

5. Transport items to storage area **designated by Government**.
6. Protect items from damage during transport and storage.

3.3 RECYCLING **DEMOLITION AND CONSTRUCTION** WASTE, GENERAL

A. Procedures: Separate recyclable waste from other waste materials, trash, and debris. Separate recyclable waste by type at Project site to maximum extent practical.

1. Provide appropriately marked containers or bins for controlling recyclable waste until removed from Project site. Include list of acceptable and unacceptable materials at each container and bin.

   a. Inspect containers and bins for contamination and remove contaminated materials if found.

2. Stockpile processed materials on-site without intermixing with other materials. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
3. Stockpile materials away from construction area. Do not store within drip line of remaining trees.
4. Store components off ground and protect from weather.
5. Remove recyclable waste off Government property and transport to recycling receiver or processor.

3.4 RECYCLING DEMOLITION WASTE

A. Asphaltic Concrete Paving: Grind asphalt to maximum **1-1/2 inch (38 millimeter)**] [**4 inch (100 millimeter** size.

B. Asphaltic Concrete Paving: Break up and transport paving to asphalt-recycling facility.

C. Concrete: Remove reinforcement and other metals from concrete and sort with other metals.

1. Pulverize concrete to maximum **4 inch (100 millimeter)** size.

D. Masonry: Remove metal reinforcement, anchors, and ties from masonry and sort with other metals.

1. Pulverize masonry to maximum **4 inch (100 millimeter)** size.
2. Clean and stack undamaged, whole masonry units on wood pallets.

E. Wood Materials: Sort and stack members according to size, type, and length. Separate lumber, engineered wood products, panel products, and treated wood materials.

F. Metals: Separate metals by type.

1. Structural Steel: Stack members according to size, type of member, and length.
2. Remove and dispose of bolts, nuts, washers, and other rough hardware.

G. Asphalt Shingle Roofing: Separate organic and glass-fiber asphalt shingles and felts. Remove and dispose of nails, staples, and accessories.

H. Gypsum Board: Stack large clean pieces on wood pallets and store in a dry location. Remove edge trim and sort with other metals. Remove and dispose of fasteners.

I. Acoustical Ceiling Panels and Tile: Stack large clean pieces on wood pallets and store in dry location.

1. Separate suspension system, trim, and other metals from panels and tile and sort with other metals.

J. Carpet: Roll large pieces tightly after removing debris, trash, adhesive, and tack strips.

1. Store clean, dry carpet in closed container or trailer provided by Carpet Reclamation Agency or carpet recycler.

K. Equipment: Drain tanks, piping, and fixtures. Seal openings with caps or plugs. Protect equipment from exposure to weather.

L. Plumbing Fixtures: Separate by type and size.

M. Piping: Reduce piping to straight lengths and store by type and size. Separate supports, hangers, valves, sprinklers, and other components by type and size.

N. Lighting Fixtures: Separate lamps by type and protect from breakage.

O. Electrical Devices: Separate switches, receptacles, switchgear, transformers, meters, panelboards, circuit breakers, and other devices by type.

P. Conduit: Reduce conduit to straight lengths and store by type and size.

Q. Electronic Products: Ensure non-usable electronic products are reused, donated, sold, or recycled using environmentally sound management practices at end of life.

3.5 RECYCLING CONSTRUCTION WASTE

A. Packaging:

1. Cardboard and Boxes: Break down packaging into flat sheets. Bundle and store in dry location.
2. Polystyrene Packaging: Separate and bag materials.
3. Pallets: As much as possible, require deliveries using pallets to remove pallets from Project site. For pallets that remain on-site, break down pallets into component wood pieces and comply with requirements for recycling wood.
4. Crates: Break down crates into component wood pieces and comply with requirements for recycling wood.

B. Wood Materials:

1. Clean Cut-Offs of Lumber: Grind or chip into small pieces.
2. Clean Sawdust: Bag sawdust not containing painted or treated wood.

C. Gypsum Board: Stack large clean pieces on wood pallets and store in dry location.

1. Clean Gypsum Board: Grind scraps of clean gypsum board using small mobile chipper or hammer mill. Screen out paper after grinding.

3.6 DISPOSAL OF WASTE

A. General: Except for items or materials to be salvaged, recycled, or otherwise reused, remove waste materials from Project site and legally dispose in landfill or incinerator acceptable to authorities having jurisdiction.

1. Except as otherwise specified, do not allow waste materials to accumulate on-site.
2. Remove and transport debris in manner preventing spillage on adjacent surfaces and areas.

B. Burning: Do not burn waste materials.

C. Disposal: Transport waste materials off Government property and legally dispose of them.

END OF SECTION 01 74 19

SECTION 01 77 00 - CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following:

1. Substantial Completion procedures.
2. Final completion procedures.
3. Warranties.
4. Final cleaning.
5. Repair of the Work.

B. Related Requirements:

1. Section 017823 "Operation and Maintenance Data" for operation and maintenance manual requirements.
2. Section 017839 "Project Record Documents" for submitting record Drawings, record Specifications, and record Product Data.

1.2 DEFINITIONS:

A. The Contractor or This Contractor: The Firm or Individual(s) identified as the Prime Contractor in the Project Notice of Award.

B. The Government: A government employee or an individual or Firm contracted by government. All correspondence between this Contractor and the government will be as directed by the government's Contracting Officer (CO).

1.3 ACTION SUBMITTALS

A. Product Data: For cleaning agents.

B. Contractor's List of Incomplete Items: Initial submittal at Substantial Completion.

C. Certified List of Incomplete Items: Final submittal at Final Completion.

1.4 CLOSEOUT SUBMITTALS

A. Certificates of Release: From authorities having jurisdiction.

B. Certificate of Insurance: For continuing coverage.

C. Field Report: For pest control inspection.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Schedule of Maintenance Material Items: For maintenance material submittal items specified in other Sections.

1.6 SUBSTANTIAL COMPLETION PROCEDURES

A. Contractor's List of Incomplete Items: Prepare and submit a list of items to be completed and corrected (Contractor's punch list), indicating the value of each item on the list and reasons why the Work is incomplete.

B. Submittals Prior to Substantial Completion: Complete the following a minimum of **10** business days prior to requesting inspection for determining date of Substantial Completion. List items below that are incomplete at time of request.

1. Certificates of Release: Obtain and submit releases from authorities having jurisdiction permitting Owner unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
2. Submit closeout submittals specified in other Division 01 Sections, including project record documents, operation and maintenance manuals, final completion construction photographic documentation, damage or settlement surveys, property surveys, and similar final record information.
3. Submit closeout submittals specified in individual Sections, including specific warranties, workmanship bonds, maintenance service agreements, final certifications, and similar documents.
4. Submit maintenance material submittals specified in individual Sections, including tools, spare parts, extra materials, and similar items, and deliver to location designated by the Government. Label with manufacturer's name and model number where applicable.
5. Submit test/adjust/balance records.
6. Submit changeover information related to Owner's occupancy, use, operation, and maintenance.

C. Procedures Prior to Substantial Completion: Complete the following a minimum of **10** buisness days prior to requesting inspection for determining date of Substantial Completion. List items below that are incomplete at time of request.

1. Advise the Government of pending insurance changeover requirements.
2. Make final changeover of permanent locks and deliver keys to Owner. Advise the Government of changeover in security provisions.
3. Complete startup and testing of systems and equipment.
4. Perform preventive maintenance on equipment used prior to Substantial Completion.
5. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment, and systems. Submit demonstration and training video recordings specified in Section 017900 "Demonstration and Training."
6. Advise Owner of changeover in heat and other utilities.
7. Participate with Owner in conducting inspection and walkthrough with local emergency responders.
8. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
9. Complete final cleaning requirements, including touchup painting.
10. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.

D. Inspection: Submit a written request for inspection to determine Substantial Completion a minimum of **10** business days prior to date the work will be completed and ready for final inspection and tests. On receipt of request, the Government will either proceed with inspection or notify Contractor of unfulfilled requirements. The Government will prepare the Certificate of Substantial Completion after inspection or will notify Contractor of items, either on Contractor's list or additional items identified by either the Designer or the Government, that must be completed or corrected before certificate will be issued.

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

1.7 FINAL COMPLETION PROCEDURES

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

1. Submit a final Application for Payment.
2. Certified List of Incomplete Items: Submit certified copy of Architect's Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by Architect. Certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.
3. Certificate of Insurance: Submit evidence of final, continuing insurance coverage complying with insurance requirements.
4. Submit pest-control final inspection report and warranty.
5. Instruct the Governments personnel in operation, adjustment, and maintenance of products, equipment, and systems.

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

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

1.8 LIST OF INCOMPLETE ITEMS (PUNCH LIST)

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

1. Organize list of spaces in sequential order.
2. Organize items applying to each space by major element, including categories for ceiling, individual walls, floors, equipment, and building systems.
3. Submit list of incomplete items in the following format:
   a. PDF electronic file. The Government will return annotated copy.

1.9 SUBMITTAL OF PROJECT WARRANTIES

A. Time of Submittal: Submit written warranties on request of Architect for designated portions of the Work where commencement of warranties other than date of Substantial Completion is indicated, or when delay in submittal of warranties might limit Owner's rights under warranty.

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

1. Bind warranties and bonds in heavy-duty, three-ring, vinyl-covered, loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2-by-11-inch (215-by-280-mm) paper.
2. Each warranty shall be in a plastic sheet holder intended for use in a three ring binder sized for an 8-12” by 11” paper inserted from the top.
3. Provide heavy paper dividers with plastic-covered tabs for each separate warranty. Mark tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product and the name, address, and telephone number of Installer.

4. Identify each binder on the front and spine with the typed or printed title "WARRANTIES," Project name, Project PMIS number and name of Contractor.
5. Warranty Electronic File: Scan warranties and bonds and assemble complete warranty and bond submittal package into a single indexed electronic PDF file with links enabling navigation to each item. Provide bookmarked table of contents at beginning of document.

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

PART 2 - PRODUCTS

2.1 MATERIALS

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

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

PART 3 - EXECUTION

3.1 FINAL CLEANING

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

B. Cleaning: Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.

1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for all areas affected by the Project or for a designated portion of the Project:

a. Clean Project site, yard, and grounds, in areas disturbed by construction activities of rubbish, waste material, litter, and other foreign substances.
b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
c. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
d. Remove tools, construction equipment, machinery, and surplus material from Project site.
e. Remove snow and ice to provide safe access to building.
f. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
g. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
h. Sweep concrete floors broom clean in unoccupied spaces.
i. Vacuum carpet and similar soft surfaces, removing debris and excess nap; clean according to manufacturer's recommendations if visible soil or stains remain.
j. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Replace chipped or broken glass and other damaged transparent materials. Polish mirrors and glass, taking care not to scratch surfaces.

k. Remove labels that are not permanent.
l. Wipe surfaces of mechanical and electrical equipment and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
m. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
n. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
o. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency.
p. Leave Project clean and ready for occupancy.

C. Pest Control: Comply with pest control requirements in Section 015000 "Temporary Facilities and Controls." Prepare written report.

3.2 REPAIR OF THE WORK

A. Complete repair and restoration operations before requesting inspection for determination of Substantial Completion.

B. Repair or remove and replace defective construction, materials and equipment. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment. Where damaged or worn items cannot be repaired or restored, provide replacements. Remove and replace operating components that cannot be repaired. Restore damaged construction and permanent facilities used during construction to specified condition.

1. Remove and replace chipped, scratched, and broken glass, reflective surfaces, and other damaged transparent materials.

2. Touch up and otherwise repair and restore marred or exposed finishes and surfaces. Replace finishes and surfaces that that already show evidence of repair or restoration.

a. Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates. Remove paint applied to required labels and identification.

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

4. Replace burned-out bulbs, bulbs noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and mercury vapor fixtures to comply with requirements for new fixtures.

END OF SECTION 017700

SECTION 01 78 23 - OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 SUMMARY

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

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

1.2 DEFINITIONS

A. Contracting Officer.

B. Contractor: Shall mean a Firm or Individual(s) identified as the Prime Contractor in the Project Notice of Award.

C. Government: Shall mean a government employee or an individual or Firm contracted by government. All correspondence between this Contractor and the government will be as directed by the government's Contracting Officer (CO).

1.3 CLOSEOUT SUBMITTALS

A. Manual Content: Operations and maintenance manual content is specified in individual Specification Sections to be reviewed at the time of Section submittals. Submit reviewed manual content formatted and organized as required by this Section.

1. The Government will comment on whether content of operations and maintenance submittals are acceptable.
2. Where applicable, clarify and update reviewed manual content to correspond to revisions and field conditions.

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

1. PDF electronic file. Assemble each manual into a composite electronically indexed file. Submit on digital media acceptable to the Government.
   a. Name each indexed document file in composite electronic index with applicable item's name. Include a complete electronically linked operation and maintenance directory.
   b. Enable inserted reviewer comments on draft submittals.

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

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

PART 2 - PRODUCTS

2.1 REQUIREMENTS FOR EMERGENCY, OPERATION, AND MAINTENANCE MANUALS

A. Directory: Prepare a single, comprehensive directory of emergency, operation, and maintenance data and materials, listing items and their location to facilitate ready access to desired information.

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

1. Title page.
2. Table of contents.
3. Manual contents.

C. Title Page: Include the following information:

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

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

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

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

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

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

1. Binders: Heavy-duty, three-ring, vinyl-covered, post-type binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch (215-by-280-mm) paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.

a. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name,[and] subject matter of contents[, and indicate Specification Section number on bottom of spine]. Indicate volume number for multiple-volume sets.

2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section of the manual. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.
3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software storage media for computerized electronic equipment.
4. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.
   a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
   b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

2.2 EMERGENCY MANUALS

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

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

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

1. Fire.
2. Flood.
3. Gas leak.
4. Water leak.
5. Power failure.
6. Water outage.
7. System, subsystem, or equipment failure.
8. Chemical release or spill.

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

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

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

2.3 OPERATION MANUALS

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

1. System, subsystem, and equipment descriptions. Use designations for systems and equipment indicated on Contract Documents.
2. Performance and design criteria if Contractor is delegated design responsibility.
3. Operating standards.
4. Operating procedures.
5. Operating logs.
6. Wiring diagrams.
7. Control diagrams.
8. Piped system diagrams.
9. Precautions against improper use.
10. License requirements including inspection and renewal dates.

B. Descriptions: Include the following:

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

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

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

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

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

2.4 PRODUCT MAINTENANCE MANUALS

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

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

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

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

D. Maintenance Procedures: Include manufacturer's written recommendations and the following:

1. Inspection procedures.
2. Types of cleaning agents to be used and methods of cleaning.
3. List of cleaning agents and methods of cleaning detrimental to product.
4. Schedule for routine cleaning and maintenance.
5. Repair instructions.

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

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

2.5 SYSTEMS AND EQUIPMENT MAINTENANCE MANUALS

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

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

C. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:

1. Standard maintenance instructions and bulletins.
2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
3. Identification and nomenclature of parts and components.
4. List of items recommended to be stocked as spare parts.

D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:

1. Test and inspection instructions.
2. Troubleshooting guide.
3. Precautions against improper maintenance.
4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
5. Aligning, adjusting, and checking instructions.
6. Demonstration and training video recording, if available.

E. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.

F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.

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

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

PART 3 - EXECUTION

3.1 MANUAL PREPARATION

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

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

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

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

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

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

F. Comply with Section 017700 "Closeout Procedures" for schedule for submitting operation and maintenance documentation.

END OF SECTION 017823

SECTION 01 78 39 - PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 SUMMARY

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

1. Record Drawings.
2. Record Specifications.
3. Record Product Data.

B. Related Requirements:

1. Section 017823 "Operation and Maintenance Data" for operation and maintenance manual requirements.

1.2 CLOSEOUT SUBMITTALS

A. Record Drawings: Comply with the following:
1. Number of Copies: Submit copies of record Drawings as follows:

a. Initial Submittal:
1) Submit PDF electronic files of scanned record prints and [one] <Insert number> set(s) of file prints.

b. Final Submittal:
1) Submit PDF electronic files of scanned record prints and three set(s) of prints.
2) Print each drawing, whether or not changes and additional information were recorded.

B. Record Specifications: Submit annotated PDF electronic files of Project's Specifications, including addenda and contract modifications.

C. Record Product Data: Submit annotated PDF electronic files and directories of each submittal.

1.3 PRODUCTS

1.4 RECORD DRAWINGS

A. Record Prints: Maintain one set of marked-up paper copies of the Contract Drawings and Shop Drawings, incorporating new and revised Drawings as modifications are issued.

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

a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.

b. Record data as soon as possible after obtaining it.
c. Record and check the markup before enclosing concealed installations.

2. Mark the Contract Drawings and Shop Drawings completely and accurately. Use personnel proficient at recording graphic information in production of marked-up record prints.
3. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.
4. Note Construction Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.

B. Record Digital Data Files: Immediately before inspection for Certificate of Substantial Completion, review marked-up record prints with Government. When authorized, prepare a full set of corrected digital data files of the Contract Drawings, as follows:
1. Format: DWG, Version 2010, Microsoft Windows operating system.
2. Format: Annotated PDF electronic file with comment function enabled.
3. Incorporate changes and additional information previously marked on record prints. Delete, redraw, and add details and notations where applicable.
4. Refer instances of uncertainty to Governmentfor resolution.
5. Architect will furnish Contractor one set of digital data files of the Contract Drawings for use in recording information.

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

1. Record Prints: Organize record prints and newly prepared record Drawings into manageable sets. Bind each set with durable paper cover sheets. Include identification on cover sheets.
2. Format: Annotated PDF electronic file with comment function enabled.
3. Record Digital Data Files: Organize digital data information into separate electronic files that correspond to each sheet of the Contract Drawings. Name each file with the sheet identification. Include identification in each digital data file.
4. Identification: As follows:

a. Project name.
b. Date.
c. Designation "PROJECT RECORD DRAWINGS."
d. Name of Prime Contractor.
e. Name of Contractor.

1.5 RECORD SPECIFICATIONS

A. Preparation: Mark Specifications to indicate the actual product installation where installation varies from that indicated in Specifications, addenda, and contract modifications.

1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.
2. Mark copy with the proprietary name and model number of products, materials, and equipment furnished, including substitutions and product options selected.
3. Record the name of manufacturer, supplier, Installer, and other information necessary to provide a record of selections made.
4. Note related Modifications and record Drawings where applicable.

B. Format: Submit record Specifications as annotated PDF electronic file.

1.6 RECORD PRODUCT DATA

A. Preparation: Mark Product Data to indicate the actual product installation where installation varies substantially from that indicated in Product Data submittal.

1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.
2. Include significant changes in the product delivered to Project site and changes in manufacturer's written instructions for installation.
3. Note related Modifications and record Drawings where applicable.

B. Format: Submit record Product Data as annotated PDF electronic file.

1.7 MISCELLANEOUS RECORD SUBMITTALS

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

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

1.8 EXECUTION

1.9 RECORDING AND MAINTENANCE

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

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

END OF SECTION 017839

SECTION 01 79 00 - DEMONSTRATION AND TRAINING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for instructing National Park Service (NPS) personnel, including:

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

B. See Divisions 2 through 49 Sections for specific requirements for demonstration and training for products in those Sections.

1.2 SUBMITTALS

A. Instruction Program: Submit **two** copies of outline of instructional program for demonstration and training, including schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include learning objective and outline for each training module.

1. For each training session, Contractor shall submit for approval a proposed outline of subjects to be covered. Training shall not be conducted until outline is approved.

B. Demonstration and Training Video: Submit one of each DVD (digital video disc) for training sessions within **seven** days of end of each training module.

1. Label each DVD with date of demonstration or training, instructor's name, and provide an index of contents. Index shall list start and end time of each subject covered during training session. Sequence of training subjects shall follow sequence listed in approved training outline or as actually conducted

1.3 QUALITY ASSURANCE

A. Facilitator Qualifications: Firm or individual experienced in training or educating maintenance personnel in training program similar in content and extent for this Project, and whose work has resulted in training or education with a record of successful learning performance.

B. Instructor Qualifications: Factory-authorized service representative, complying with requirements in Section 01 40 00 "Quality Requirements," experienced in operation and maintenance procedures and training.

C. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data has been reviewed and approved by Contracting Officer (CO).

PART 2 - PRODUCTS

2.1 INSTRUCTION PROGRAM

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

1. All mechanical equipment and controls.
2. Environmental Topics

a. Overview of environmental issues related to building industry.
b. Overview of environmental issues related to Project.
c. Review of site-specific procedures and management plans implemented during construction:

1) Regulatory Requirements
2) Indoor Air Quality (IAQ) Management
3) Noise and Acoustics Management
4) Environmental Management
5) Construction Waste Management

d. Review of site-specific procedures and management plans to be implemented during operation and maintenance.

1) Include review of environmentally related aspects of Operations and Maintenance Manual.
2) Integrated Pest Management (IPM)

B. Training Modules: Develop a learning objective and teaching outline for each module. Include description of specific skills and knowledge that participant is expected to master. For each module, include instruction for:

1. Basis of System Design, Operational Requirements, and Criteria: Include system and equipment descriptions, operating standards, regulatory requirements, equipment function, operating characteristics, limiting conditions, and performance curves.
2. Documentation: Review emergency, operations, and maintenance manuals; Project Record Documents; identification systems; warranties and bonds; and maintenance service agreements.
3. Emergencies: Instructions on stopping; shutdown instructions; operating instructions for conditions outside normal operating limits; instructions on meaning of warnings, trouble indications, and error messages; and required sequences for electric or electronic systems.
4. Operations: Startup, break-in, control, and safety procedures; stopping and normal shutdown instructions; routine, normal, seasonal, and weekend operating instructions; operating procedures for emergencies and equipment failure; and required sequences for electric or electronic systems.
5. Adjustments: Alignments and checking, noise, vibration, economy, and efficiency adjustments.
6. Troubleshooting: Diagnostic instructions and test and inspection procedures.
7. Maintenance: Inspection procedures, types of cleaning agents, methods of cleaning, procedures for preventive and routine maintenance, and instruction on use of special tools.

8. Repairs: Diagnosis, repair, and disassembly instructions; instructions for identifying parts; and review of spare parts needed for operation and maintenance.

PART 3 - EXECUTION

3.1 INSTRUCTION

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

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

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

1. Schedule training with NPS through Contracting Officer with at least [**seven**] days' advance notice.
2. Conduct training sessions after equipment or system has been accepted and turned over to Government. Coordinate with commissioning requirements.
3. Coordinate with Integrated pest management requirements. Refer to specifications section and approved IPM plan.
4. Individual sections specify duration of training required. If no duration is listed, provide training of sufficient duration to adequately cover subjects.

3.2 DEMONSTRATION AND TRAINING VIDEO

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

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

B. Video Format: Digital Video Disc (DVD).

C. Video Recording: Record sessions with high resolution equipment. Instructor's voice shall be clearly audible and understandable on DVD. Utilize supplemental microphone worn by instructor.

D. Narration: Describe scenes on video. Include description of items being viewed. Describe vantage point, indicating location, direction (by compass point), and elevation or story of construction.

1. DVDs with poor video or audio quality will be rejected and training recorded again.

END OF SECTION 01 79 00

SECTION 024119 - SELECTIVE DEMOLITION

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Demolition and removal of selected portions of building or structure.
2. Demolition and removal of selected site elements.
3. Salvage of existing items to be reused or recycled.

B. Related Requirements:

1. Section 011000 "Summary" for restrictions on the use of the premises, Owner-occupancy requirements, and phasing requirements.
2. Section 017300 "Execution" for cutting and patching procedures.

1.3 DEFINITIONS

A. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged or removed and reinstalled.

B. Remove and Salvage: Carefully detach from existing construction, in a manner to prevent damage, and deliver to Owner.

C. Remove and Reinstall: Detach items from existing construction, prepare for reuse, and reinstall where indicated.

D. Existing to Remain: Existing items of construction that are not to be permanently removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 MATERIALS OWNERSHIP

A. Unless otherwise indicated, demolition waste becomes property of Contractor.

B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to Owner that may be uncovered during demolition remain the property of Owner.

1. Carefully salvage in a manner to prevent damage and promptly return to Owner.

1.5 PREINSTALLATION MEETINGS

A. Predemolition Conference:

1. Inspect and discuss condition of construction to be selectively demolished.
2. Review structural load limitations of existing structure.
3. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
5. Review areas where existing construction is to remain and requires protection.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For refrigerant recovery technician.

B. Proposed Protection Measures: Submit report, including drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control and , for noise control. Indicate proposed locations and construction of barriers.

C. Schedule of Selective Demolition Activities: Indicate the following:

1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure COR on-site operations are uninterrupted.
2. Interruption of utility services. Indicate how long utility services will be interrupted.
3. Coordination for shutoff, capping, and continuation of utility services.
4. Use of elevator and stairs.
5. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.

D. Inventory: Submit a list of items to be removed and salvaged and deliver to Owner prior to start of demolition.

E. Predemolition Photographs or Video: Submit before Work begins.

F. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

G. Warranties: Documentation indicated that existing warranties are still in effect after completion of selective demolition.

1.7 CLOSEOUT SUBMITTALS

A. Inventory: Submit a list of items that have been removed and salvaged.

B. Landfill Records: Indicate receipt and acceptance of hazardous wastes by a landfill facility licensed to accept hazardous wastes.

1.8 QUALITY ASSURANCE

A. Refrigerant Recovery Technician Qualifications: Certified by an EPA-approved certification program.

1.9 FIELD CONDITIONS

A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted.

B. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.

1. Before selective demolition, Owner will remove the following items:

a. Historical items

C. Notify Architect of discrepancies between existing conditions and Drawings before proceeding with selective demolition.

D. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.

1. Hazardous materials will be removed by Owner before start of the Work.
2. If suspected hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Hazardous materials will be removed by Owner under a separate contract.

E. Hazardous Materials: Hazardous materials are present in buildings and structures to be selectively demolished. A report on the presence of hazardous materials is on file for review and use. Examine report to become aware of locations where hazardous materials are present.

1. Hazardous material remediation is specified elsewhere in the Contract Documents.
2. Do not disturb hazardous materials or items suspected of containing hazardous materials except under procedures specified elsewhere in the Contract Documents.
3. Owner will provide material safety data sheets for suspected hazardous materials that are known to be present in buildings and structures to be selectively demolished because of building operations or processes performed there.

F. Historic Areas: Demolition and hauling equipment and other materials shall be of sizes that clear surfaces within historic spaces, areas, rooms, and openings, including temporary protection, by 12 inches (300 mm) or more.

G. Storage or sale of removed items or materials on-site is not permitted.

H. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.

1. Maintain fire-protection facilities in service during selective demolition operations.

1.10 WARRANTY

A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials so as not to void existing warranties. Notify warrantor before proceeding. Existing warranties include the following:

B. Notify warrantor on completion of selective demolition, and obtain documentation verifying that existing system has been inspected and warranty remains in effect. Submit documentation at Project closeout.

PART 2 - PRODUCTS

2.1 PEFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

B. Standards: Comply with ANSI/ASSE A10.6 and NFPA 241.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that utilities have been disconnected and capped before starting selective demolition operations.

B. Review record documents of existing construction provided by Owner. Owner does not guarantee that existing conditions are same as those indicated in record documents.

C. Survey existing conditions and correlate with requirements indicated to determine extent of selective demolition required.

D. When unanticipated mechanical, electrical, or structural elements that conflict with intended function or design are encountered, investigate and measure the nature and extent of conflict. Promptly submit a written report to Architect.

E. Perform an engineering survey of condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during selective building demolition operations.

1. Perform surveys as the Work progresses to detect hazards resulting from selective demolition activities.
2. Steel Tendons: Locate tensioned steel tendons and include recommendations for de-tensioning.

F. Survey of Existing Conditions: Record existing conditions by use of measured drawings and preconstruction photographs.

1. Comply with requirements specified in Section 013233 "Photographic Documentation."
2. Inventory and record the condition of items to be removed and salvaged. Provide photographs of conditions that might be misconstrued as damage caused by salvage operations.
3. Before selective demolition or removal of existing building elements that will be reproduced or duplicated in final Work, make permanent record of measurements, materials, and construction details required to make exact reproduction.

3.2 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS

A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.

1. Comply with requirements for existing services/systems interruptions specified in Section 011000 "Summary."

B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.

1. The COR will arrange to shut off indicated services/systems when requested by Contractor.
2. Arrange to shut off indicated utilities with utility companies.
3. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
4. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

    a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
    b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
    c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
    d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
    e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
    f. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.

g. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.

C. Refrigerant: Remove refrigerant from mechanical equipment to be selectively demolished according to 40 CFR 82 and regulations of authorities having jurisdiction.

3.3 PREPARATION

A. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

B. Temporary Facilities: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.

1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.
3. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
4. Cover and protect furniture, furnishings, and equipment that have not been removed.
5. Comply with requirements for temporary enclosures, dust control, heating, and cooling specified in Section 015000 "Temporary Facilities and Controls."

C. Temporary Shoring: Provide and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.

1. Strengthen or add new supports when required during progress of selective demolition.

3.4 SELECTIVE DEMOLITION, GENERAL

A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:

1. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.
2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.
3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.

4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain fire watch and portable fire-suppression devices during flame-cutting operations.
5. Maintain adequate ventilation when using cutting torches.
6. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
7. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
8. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
9. Dispose of demolished items and materials promptly

B. Work in Historic Areas: Selective demolition may be performed only in areas of the Project that are not designated as historic. In historic spaces, areas, and rooms or on historic surfaces, the terms "demolish" or "remove" shall mean historic "removal" or "dismantling" as specified in Section 013591 "Historic Treatment Procedures."

C. Reuse of Building Elements: Project has been designed to result in end-of-Project rates for reuse of building elements as follows. Do not demolish building elements beyond what is indicated on Drawings without Architect's approval.

D. Removed and Salvaged Items:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers.
3. Store items in a secure area until delivery to Owner.
4. Transport items to Owner's storage area designated by the park.
5. Protect items from damage during transport and storage.

E. Removed and Reinstalled Items:

1. Clean and repair items to functional condition adequate for intended reuse.
2. Pack or crate items after cleaning and repairing. Identify contents of containers.
3. Protect items from damage during transport and storage.
4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

F. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Architect, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.

3.5 SELECTIVE DEMOLITION PROCEDURES FOR SPECIFIC MATERIALS

A. Concrete: Demolish in small sections. Using power-driven saw, cut concrete to a depth of at least 3/4 inch (19 mm) at junctures with construction to remain. Dislodge concrete from reinforcement at perimeter of areas being demolished, cut reinforcement, and then remove remainder of concrete. Neatly trim openings to dimensions indicated.

B. Concrete: Demolish in sections. Cut concrete full depth at junctures with construction to remain and at regular intervals using power-driven saw, then remove concrete between saw cuts.

C. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain, using power-driven saw, then remove masonry between saw cuts.

D. Concrete Slabs-on-Grade: Saw-cut perimeter of area to be demolished, then break up and remove.

E. Resilient Floor Coverings: Remove floor coverings and adhesive according to recommendations in RFCI's "Recommended Work Practices for the Removal of Resilient Floor Coverings.

F. Roofing: Remove no more existing roofing than what can be covered in one day by new roofing and so that building interior remains watertight and weathertight.

1. Remove existing roof membrane, flashings, copings, and roof accessories.
2. Remove existing roofing system down to substrate.

3.6 DISPOSAL OF DEMOLISHED MATERIALS

A. General: Except for items or materials indicated to be recycled, reused, salvaged, reinstalled, or otherwise indicated to remain Owner's property, remove demolished materials from Project site and legally dispose of them in an EPA-approved landfill.

1. Do not allow demolished materials to accumulate on-site.
2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
3. Remove debris from elevated portions of building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
4. Comply with requirements specified in Section 017419 "Construction Waste Management and Disposal."

B. Burning: Do not burn demolished materials.

C. Burning: Burning of demolished materials will be permitted only at designated areas on Park’s property, provided required permits are obtained. Provide full-time monitoring for burning materials until fires are extinguished.

D. Disposal: Transport demolished materials and dispose of at designated spoil areas on Owner's property.

E. Disposal: Transport demolished materials off Owner's property and legally dispose of them.

3.7 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

END OF SECTION 024119

SECTION 03 10 00 - CONCRETE FORMWORK

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes all labor, materials and equipment necessary for providing and installing formwork for concrete.

B. General Design: The Contractor shall be responsible for the design of all formwork and for safety in its construction, use and removal.

1.2 QUALITY ASSURANCE

A. Qualifications: Formwork shall be constructed in accordance with the specified standards, as well as all pertinent codes and regulations. In cases where requirements of pertinent codes conflict with the requirements of these specifications, the more stringent shall govern.

B. Standards: Unless otherwise indicated, all materials, workmanship and practices shall conform to the following standards:

1. Standard Building Code

2. ACI 347 "Recommended Practice for Concrete Formwork"

3. Local codes and regulations

PART 2 - PRODUCTS

2. 1 MATERIALS

A. Form Lumber: Use form lumber when in contact with exposed concrete, conforming to the following or acceptable equivalent.

B. Lumber: Douglas Fir/Larch No. 2 grade, seasoned, surfaced on four sides.

C. Plywood: "Plyform", Class I or II, bearing the label of the Douglas Plywood Association. (Minimum 3/4-inch thickness).

D. Form Coatings: Form release coating shall be a paraffin base oil or mineral oil coating which effectively prevents absorption of moisture; prevents bonding with concrete; is non-staining to concrete; and leaves the concrete with a paintable surface.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Construction of Formwork: Forms shall be sufficiently strong to withstand the pressure resulting from the placement and vibration of concrete and shall be sufficiently rigid to maintain specified

tolerances. Forms shall be sufficiently tight to prevent loss of material, and shall be adequately braced against lateral, upward or downward movement.

B. Coating of Forms: Apply form coating to board forms prior to placing reinforcing. Keep form coatings off previously placed concrete.

C. Form Erection:

1. Provide a means of holding adjacent edges, ends of panels, and ends of sections tightly together and in accurate alignment so as to prevent the formation of ridges, fins, offsets, or similar surface defects of the finished concrete. Ensure that forms may be removed without damage to the surface of the finished concrete.

2. Provide a positive means of adjustment of shores and struts. Ensure that all settlement is taken up during concrete placing.

D. Removal of Forms

1. Forms and shoring shall remain in place until the concrete has reached a compressive strength equal to the specified 28-day compressive strength. Do not remove supports and re-shore. The following indicates the minimum allowable time after the last concrete is placed before forms, shoring, and/or bracing may be removed.

- Structural Item - Minimum Allowable Time

E. Do not remove forms from concrete which has been placed with outside air temperature below 50° F without first determining if the concrete has properly set regardless of the minimum times specified in the table above. Do not apply heavy loading on recently poured concrete. Immediately after forms are removed, the surface of the concrete shall be carefully examined and any irregularities in the surface shall be repaired and finished as specified.

F. Form Tolerances

1. Failure of the forms to produce the specified concrete surface tolerance shall be grounds for rejection of the concrete work. Rejected Work shall be repaired or replaced at no cost to the government.

END OF SECTION 03 10 00

SECTION 033000 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes, for the following:

1. Mechanical pad

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume; subject to compliance with requirements.

1.4 ACTION SUBMITTALS

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

B. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1. Indicate amounts of mixing water to be withheld for later addition at Project site.

C. Steel Reinforcement Shop Drawings: Placing drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.

D. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer detailing fabrication, assembly, and support of formwork.

1. Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and reshoring installation and removal.

E. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.

1. Location of construction joints is subject to approval of the Government

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data

B. Welding certificates

C. Material Certificates: For each of the following, signed by manufacturers:

1. Cementitious materials.
2. Admixtures.
3. Form materials and form-release agents.
4. Steel reinforcement and accessories.

D. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:

1. Aggregates

E. Floor surface flatness and levelness measurements indicating compliance with specified tolerances.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs on Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.4/D 1.4M, "Structural Welding Code - Reinforcing Steel."

PART 2 - PRODUCTS

2.1 FORM-FACING MATERIALS

A. Comply with ACI 301.

B. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch, minimum.

C. Earth forms may be used for footing forms where sides of the excavation are cut true, in firm soil. If earth is not suitable to be used as “earth form”, no consideration will be given to any claim for additional cost of formwork. Contractor shall provide material and labor to provide formwork without additional cost to the Government.

2.2 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 deformed.

B. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, Grade 60 deformed.
   1. For use where weldable reinforcing is called out in construction documents.

C. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, plain, fabricated from as-drawn steel wire into flat sheets.

2.3 REINFORCEMENT ACCESSORIES

A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

2.4 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:
   1. Portland Cement: ASTM C 150, Type I. Supplement with the following:
      a. Fly Ash: ASTM C 618, Class F.
      b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
      c. Use of supplemental cementitious materials may be rejected by the Government for certain applications on project.
   2. Blended Hydraulic Cement: ASTM C 595, Type IS portland blast-furnace slag, Type IP portland-pozzolan, Type I (PM) pozzolan-modified Portland, Type I (SM) slag-modified portland cement. Use of blended hydraulic cement may be rejected by the Government for certain applications on project.

B. Silica Fume: ASTM C 1240, amorphous silica. Use of blended hydraulic cement may be rejected by the Government for certain applications on project.

C. Normal-Weight Aggregates: ASTM C 33, coarse aggregate or better, graded. Select grading class per type of construction or location used, and in relation to specific weathering region. Provide aggregates from a single source.
   1. Maximum Coarse-Aggregate Size: See schedule on Construction Drawings.

D. Water: Shall be potable.

2.5 ADMIXTURES

A. Air-Entraining Admixture: ASTM C 260.

B. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those

permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.6 CONCRETE MIXTURES, GENERAL

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301 and ACI 318 chapter 5. Design mixtures shall meet the minimum requirements tabulated in the construction documents.

B. Cementitious Materials: Use fly ash, pozzolan, ground granulated blast-furnace slag, and silica fume as needed Limit percentage, by weight, of cementitious materials other than portland cement in concrete per ACI 301 requirements for concrete exposed to deicing chemicals. Requirements of table 4.1.2.9 of ACI 301 shall be adhered to.

C. Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing, high-range water-reducing, plasticizing, or retarding admixtures in concrete, as required, for placement and workability, and project specific conditions.

2.7 CONCRETE MIXTURES FOR BUILDING ELEMENTS

A. Equipment Pads:

1. Minimum Compressive Strength: 4000 psi at 28 days.

2.8 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.9 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M and furnish batch ticket information.

1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 FORMWORK

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.

B. Limit concrete surface irregularities, designated by ACI 347 as abrupt or gradual, as follows:

1. Class A, 1/8 inch for smooth-formed finished surfaces.
2. Class B, 1/4 inch for rough-formed finished surfaces.

C. Chamfer exterior corners and edges of permanently exposed concrete.

3.2 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for placing reinforcement.

1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that would reduce bond to concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.

1. Weld reinforcing bars according to AWS D1.4/D 1.4M, where indicated.

D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

E. Install welded wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.

3.3 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

B. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Government.

C. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

D. Hot-Weather Placement: Comply with ACI 305.1 and as follows:
1. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water.

3.4 MISCELLANEOUS CONCRETE ITEMS

A. Filling In: Fill in holes and openings left in concrete structures after work of other trades is in place unless otherwise indicated. Mix, place, and cure concrete, as specified, to blend with in-place construction. Provide other miscellaneous concrete filling indicated or required to complete the Work.

B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.

C. Equipment Pads:

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct concrete bases 8 inches high unless otherwise indicated; and extend base not less than 6 inches in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated or unless required for seismic anchor support.
3. Minimum Compressive Strength: 4000 psi at 28 days.
4. Provide neoprene isolation pads below mechanical equipment as recommended by manufacturer.

3.5 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.

B. Cure concrete according to ACI 308.1, by one or a combination of the following methods allowed in ACI 301.

3.6 CONCRETE SURFACE REPAIRS

A. Defective Concrete: Repair and patch defective areas when approved by Government. Remove and replace concrete that cannot be repaired and patched to Government's approval.

B. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.

C. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

3.7 FIELD QUALITY CONTROL

A. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 75 cu. Yd.

   a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method, for normal-weight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
5. Compression Test Specimens: ASTM C 31/C 31M.

   a. Cast and cure two sets of two standard cylinder specimens for each composite sample.

6. Compressive-Strength Tests: ASTM C 39/C 39M; test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days.

   a. Test one set of two field-cured specimens at 7 days and one set of two specimens at 28 days.
   b. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.

7. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.

8. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

B. Measure floor and slab flatness and levelness according to ASTM E 1155 within 24 hours of finishing.

END OF SECTION 033000

SECTION 230130.51 - HVAC AIR-DISTRIBUTION SYSTEM CLEANING-EXISTING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes cleaning HVAC air-distribution equipment, piping, ducts, and system components.

1.3 DEFINITIONS

A. ASCS: Air systems cleaning specialist.

B. NADCA: National Air Duct Cleaners Association.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For an ASCS.

B. Strategies and procedures plan.

C. Cleanliness verification report.

1.5 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

B. UL Compliance: Comply with UL 181 and UL 181A for fibrous-glass ducts.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine HVAC air-distribution equipment, ducts, plenums, and system components to determine appropriate methods, tools, and equipment required for performance of the Work.

B. Perform "Project Evaluation and Recommendation" according to NADCA ACR 2006.

C. Prepare written report listing conditions detrimental to performance of the Work.

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

3.2 PREPARATION

A. Prepare a written plan that includes strategies and step-by-step procedures. At a minimum, include the following:

1. Supervisor contact information.
2. Work schedule including location, times, and impact on occupied areas.
3. Methods and materials planned for each HVAC component type.
4. Required support from other trades.
5. Equipment and material storage requirements.
6. Exhaust equipment setup locations.

B. Use the existing service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry and for inspection.

C. Comply with NADCA ACR 2006, "Guidelines for Constructing Service Openings in HVAC Systems" Section.

3.3 CLEANING

A. Comply with NADCA ACR 2006.

B. Remove visible surface contaminants and deposits from within the HVAC system.

C. Systems and Components to Be Cleaned:

1. Air devices for supply and return air.
2. Air-terminal units.
3. Radiators and pipes
4. Ductwork:
   a. Supply, return, outsisde air, and exhaust-air ducts.
5. Filters and filter housings.

D. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process.

E. Particulate Collection:

1. For particulate collection equipment, include adequate filtration to contain debris removed. Locate equipment downwind and away from all air intakes and other points of entry into the building.
2. HEPA filtration with 99.97 percent collection efficiency for particles sized 0.3 micrometer or larger shall be used where the particulate collection equipment is exhausting inside the building,

F. Control odors and mist vapors during the cleaning and restoration process.

G. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.

H. System components shall be cleaned so that all HVAC system components are visibly clean. On completion, all components must be returned to those settings recorded just prior to cleaning operations.

I. Clean all air-distribution devices, registers, grilles, and diffusers.

J. Clean visible surface contamination deposits according to NADCA ACR 2006 and the following:

1. Clean air-handling units, airstream surfaces, components, condensate collectors, and drains.

2. Ensure that a suitable operative drainage system is in place prior to beginning wash-down procedures.

3. Clean evaporator coils, reheat coils, and other airstream components.

K. Duct Systems:

1. Create service openings in the HVAC system as necessary to accommodate cleaning.

2. Mechanically clean duct systems specified to remove all visible contaminants so that the systems are capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).

L. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.

M. Mechanical Cleaning Methodology:

1. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.

a. Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.

b. Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials such as duct and plenum liners.

2. Cleaning Mineral-Fiber Insulation Components:

a. Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR 2006.

b. Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).

c. Fibrous materials that become wet shall be discarded and replaced.

N. Coil Cleaning:

1. Measure static-pressure differential across each coil.
2. See NADCA ACR 2006, "Coil Surface Cleaning" Section. Type 1, or Type 1 and Type 2, cleaning methods shall be used to render the coil visibly clean and capable of passing Coil Cleaning Verification (see applicable NADCA ACR 2006).
3. Coil drain pans shall be subject to NADCA ACR 2006, "Non-Porous Surfaces Cleaning Verification." Ensure that condensate drain pans are operational.
4. Electric-resistance coils shall be de-energized, locked out, and tagged before cleaning.
5. Cleaning methods shall not cause any appreciable damage to, cause displacement of, inhibit heat transfer, or cause erosion of the coil surface or fins, and shall comply with coil manufacturer's written recommendations when available.
6. Rinse thoroughly with clean water to remove any latent residues.

O. Antimicrobial Agents and Coatings:

1. Apply antimicrobial agents and coatings if active fungal growth is reasonably suspected or where unacceptable levels of fungal contamination have been verified. Apply antimicrobial agents and coatings according to manufacturer's written recommendations and EPA registration listing after the removal of surface deposits and debris.
2. When used, antimicrobial treatments and coatings shall be applied after the system is rendered clean.
3. Apply antimicrobial agents and coatings directly onto surfaces of interior ductwork.
4. Sanitizing agent products shall be registered by the EPA as specifically intended for use in HVAC systems and ductwork.

3.4 CLEANLINESS VERIFICATION

A. Maintain ductwork in accordance with SMACNA “Duct Cleanliness for New Construction Guidelines.” Maintain “Advanced Cleanliness Level” as defined in the guideline.

B. Verify cleanliness according to NADCA ACR 2013, "Verification of HVAC System Cleanliness" Section.

C. Verify HVAC system cleanliness after mechanical cleaning and before applying any treatment or introducing any treatment-related substance to the HVAC system, including biocidal agents and coatings.

D. Perform visual inspection for cleanliness. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to cleanliness testing identified in “Additional Verification” paragraph below.

E. Verification of Coil Cleaning:

1. Measure static-pressure differential across each coil.
2. Coil will be considered clean if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection.

F. Prepare a written cleanliness verification report. At a minimum, include the following:

1. Written documentation of the success of the cleaning.

2. Site inspection reports, initialed by supervisor, including notation on areas of inspection, as verified through visual inspection.
3. Surface comparison and vacuum test results if required.
4. System areas found to be damaged.

G. Photographic Documentation: Comply with requirements in Division 01, Photographic Documentation.

3.5 RESTORATION

A. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR 2006, "Restoration and Repair of Mechanical Systems" Section.

B. Restore service openings capable of future reopening. Comply with requirements in Division 23, Metal Ducts. Include location of service openings in Project closeout report.

C. Replace fibrous-glass materials that cannot be restored by cleaning or resurfacing. Comply with requirements in Division 23, Metal Ducts and Division 23, Nonmetal Ducts.

D. Replace damaged insulation according to Division 23, Duct Insulation.

E. Ensure that closures do not hinder or alter airflow.

F. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.

END OF SECTION 230130.51

SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.1 DESCRIPTION

A. This section contains items of common or administrative nature that pertain to all mechanical work.

1.2 QUALITY ASSURANCE

A. All pressure vessels, including safety devices and appurtenances, shall comply with standards of and bear stamp of ASME.

1.3 COORDINATION

A. Interruption of Services: Coordinate shutdown of building mechanical and/or electrical systems with Contracting Officer.

B. Schedule of Work: Coordinate work with other trades. In scheduling, anticipate such items as installing equipment through available openings in structure.

C. Make minor changes in piping, and equipment locations to suit actual conditions.

1.4 PROTECTION

A. Completely cover motors and other machinery to protect from dirt and water. Cap all openings in pipe and ductwork to protect against entry of foreign matter.

PART 2 PRODUCTS NOT USED.

PART 3 EXECUTION

3.1 CUTTING AND PATCHING

A. Perform or pay for all cutting, fitting, repairing, patching and finishing of work of other sections where it is necessary to disturb such work to permit installation of mechanical work.

B. Before cutting of structural elements, obtain approval of Contracting Officer.

1. Use only approved methods.

2. Cut all holes neatly and as small as possible to admit work.

3. Do not weaken walls or floors; locate holes in concrete to miss structural sections.

C. Locate openings and sleeves to permit neat installation of piping, ductwork and equipment.

D. Do not remove or damage fireproofing materials.

1. Install hangers, inserts, supports and anchors prior to installation of fireproofing.

2. Repair or replace fireproofing removed or damaged, at no extra cost.

3.2 PENETRATIONS

A. Where mechanical items penetrate fire and/or smoke rated walls, ceilings and floors, seal annular spaces with approved fire rated material to maintain fire and smoke ratings.

3.3 INSTALLATION OF EQUIPMENT

A. Install all equipment in accordance with manufacturer's recommendations.

B. Provide all necessary anchoring devices and supports.

C. Install equipment to permit easy access for normal maintenance.

1. Maintain easy access to filters, motors, drives, etc.

2. Relocate items which interfere with access.

3. Connect equipment for ease of disconnecting. Provide isolation valves on both sides of equipment wherever new or existing equipment is installed to facilitate servicing, maintenance, and repair or replacement of equipment components.

D. Remove, relocate, and re-install all existing mechanical equipment to be re-used.

E. Provide rough-in and final connections to all equipment requiring mechanical services.

F. Install all fittings, valves and other items furnished as integral part of equipment but shipped loose.

3.4 WORK IN EXISTING BUILDING

A. Where relocation of existing equipment and piping systems is necessary in areas providing uninterruptible services, schedule work for minimal down time during unoccupied periods.

B. Assign an adequate crew to accomplish the job in the least possible time.

C. Fabricate and install interconnecting portions of these systems prior to shut-down for final connections.

D. Locate existing piping and make connections as required.

1. Do not cut into existing services without first verifying with Government that service has been correctly identified.

2. Perform work that interrupts any service (this includes cutting into existing lines for new connection) at time to cause the least interference to the normal operation of the building.

3. Inform Contracting Officer's Representative in advance (minimum 7 days) of any shut-off that will occur and give estimate of duration.

4. Begin work only after Contracting Officers Representative is fully informed and has agreed to schedule of shut-offs.

3.5 FIELD QUALITY CONTROL

A. Perform indicated tests to demonstrate workmanship, operation and performance.

1. Conduct tests in presence of Contracting Officers Representative and, if required, inspectors of agencies having jurisdiction.

2. Arrange date of tests in advance with Contracting Officers Representative, manufacturer and installer. Give all inspectors minimum of 48-hour notice.

3. Furnish or arrange for use of electrical energy, water or gas required for tests.

4. Furnish all lubricating materials required for test.

B. Repair or replace equipment and systems found inoperative or defective and re-test.

C. Test equipment and systems as indicated for each item, unless otherwise recommended by manufacturer.

D. Do not install distribution systems above electrical panels or any other electrical equipment.

E. Install all equipment with adequate service and maintenance clearances.

3.6 ADJUST AND CLEAN

A. Inspect all equipment and put in good working order.

B. Clean all exposed and concealed Items.

3.7 PUTTING SYSTEMS IN OPERATION -START-UP

A. Prior to final acceptance, at time agreed to by Contracting Officer's Representative, put all systems into satisfactory operation.

1. At first heating or cooling season following final acceptance, start up systems not started due to lack of seasonal design load.

B. Operate all systems in good working order for period of 5 working days.

END OF SECTION

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 ACTION SUBMITTALS

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

B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

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

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

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

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe Hangers:

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

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
2. Standard: MFMA-4.
3. Channels: Continuous slotted steel channel with inturned lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
6. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
7. Non-metallic Coatings: Plastic coating, jacket, or liner.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: [ASTM C 552, Type II cellular glass with 100-psig (688-kPa minimum compressive strength.

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

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

E. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

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

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

2.6 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece [plastic] [stainless-steel] base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: [Plastic] [Stainless steel].
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

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

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

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

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

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

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

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.

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

F. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

G. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

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

I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

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

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

L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

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

O. Insulated Piping:

1. Attach clamps and spacers to piping.

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

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

   a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
   b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
   c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
   d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
   e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

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

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

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

3.3 METAL FABRICATIONS

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

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

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

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

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

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

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

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

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

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

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

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

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

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

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).

8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

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

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.

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

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

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

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

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

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

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

END OF SECTION 230529

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient supports.
9. Resilient pipe guides.
10. Air-spring isolators.
11. Restrained-air-spring isolators.
12. Elastomeric hangers.
13. Spring hangers.
14. Snubbers.
15. Restraint channel bracings.
16. Restraint cables.
17. Seismic-restraint accessories.
18. Mechanical anchor bolts.
19. Adhesive anchor bolts.
20. Vibration isolation equipment bases.
21. Restrained isolation roof-curb rails.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic forces required to select vibration isolators and seismic restraints and for designing vibration isolation bases.

   a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-spring mounts and restrained-air-spring mounts to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following :

a. Ace Mountings Co., Inc.

b. California Dynamics Corporation.

c. Isolation Technology, Inc.

d. Kinetics Noise Control, Inc.

e. Mason Industries, Inc.

f. Vibration Eliminator Co., Inc.

g. Vibration Isolation.

h. Vibration Mountings & Controls, Inc.

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory or field cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties.
5. Surface Pattern: Smooth, Ribbed, or Waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient and elastomeric.

a. Surface Pattern: Smooth, Ribbed or Waffle pattern.

b. Infused nonwoven cotton or synthetic fibers.

2.2 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.

2. Mounting Plates:

   a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
   b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.

2. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

   a. Housing: Cast-ductile iron or welded steel.
   b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.
   d. Kinetics Noise Control, Inc.
   e. Mason Industries, Inc.
   f. Vibration Eliminator Co., Inc.
   g. Vibration Isolation.
   h. Vibration Mountings & Controls, Inc.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.5 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Ace Mountings Co., Inc.
   b. California Dynamics Corporation.
   c. Isolation Technology, Inc.

d. Kinetics Noise Control, Inc.

e. Mason Industries, Inc.

f. Vibration Eliminator Co., Inc.

g. Vibration Isolation.

h. Vibration Mountings & Controls, Inc.

2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

   a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
   b. Top plate with threaded mounting holes and elastomeric pad.
   c. Internal leveling bolt that acts as blocking during installation.

3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.6 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- (13-mm-) thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig (3.45 MPa)on isolation material providing equal isolation in all directions.

2.7 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- (13-mm-) thick neoprene

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.8 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Ace Mountings Co., Inc.

b. California Dynamics Corporation.

c. Isolation Technology, Inc.

d. Kinetics Noise Control, Inc.

e. Mason Industries, Inc.

f. Vibration Eliminator Co., Inc.

g. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.9 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression: Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Ace Mountings Co., Inc.

b. California Dynamics Corporation.

c. Kinetics Noise Control, Inc.

d. Mason Industries, Inc.

e. Vibration Eliminator Co., Inc.

f. Vibration Isolation.

g. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.10 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Kinetics Noise Control, Inc.
2. Mason Industries, Inc.
3. Vibration Mountings & Controls, Inc.

B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.

2.11 RESTRAINT CHANNEL BRACINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-Line, Inc.
2. Hilti, Inc.
3. Mason Industries, Inc.
4. Unistrut.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.12 RESTRAINT CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Kinetics Noise Control, Inc.
2. Loos & Co., Inc.
3. Vibration Mountings & Controls, Inc.

B. Restraint Cables: **ASTM A 603 galvanized** steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.13 SEISMIC-RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-Line, Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. TOLCO.

B. Hanger-Rod Stiffener: **Steel tube or steel slotted-support-system sleeve with internally bolted connections** to hanger rod.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to **rigid channel bracings and restraint cables**.

D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.14 MECHANICAL ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-Line, Inc.
2. Hilti, Inc.
3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.

B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.15 ADHESIVE ANCHOR BOLTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hilti, Inc.
2. Kinetics Noise Control, Inc.

3. Mason Industries, Inc.

B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.16 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. California Dynamics Corporation.
2. Kinetics Noise Control.
3. Mason Industries, Inc.
4. Vibration Eliminator Co., Inc.
5. Vibration Isolation.
6. Vibration Mountings & Controls, Inc.

B. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.

   a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Rails shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

   a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

D. Concrete Inertia Base: **Factory-fabricated or field-fabricated**, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

D. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
3. Brace a change of direction longer than 12 feet (3.7 m).

E. Install cables so they do not bend across edges of adjacent equipment or building structure.

F. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

G. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

H. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

I. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

J. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232113 "Hydronic Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least **four** of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Test and adjust restrained-air-spring isolator controls and safeties.

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

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.7 VIBRATION ISOLATION SCHEDULES

A. Provide vibration isolators and equipment bases for all rotating, piston driven or vibrating equipment in accordance with the following schedules. Selection of equipment isolators shall be based on approved equipment shop drawings.

Base & Isolator Types			
Base Types		Isolator Types	
A	No base, isolators attached directly to equipment.	1	Elastomeric pad.
B	Structural steel rails or base.	2	Elastomeric floor mount or hanger. Use restrained elastomeric mount where seismic restraint is required.
C	Concrete inertia base.	3	Spring floor isolator or hanger.
D	Curb-mounted base.	4	Restrained spring isolator.
		5	Thrust restraint.

Vibration Isolation - Pumps															
Pump Type	Horsepower and Other	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Close Coupled	≤7.5	All	B	2	0.25	C	3	0.75	C	3	0.75	C	3	0.75	1
	≥10	All	C	3	0.75	C	3	0.75	C	3	1.5	C	3	1.5	1
Large Inline	5 to 25	All	A	3	0.75	A	3	1.5	A	3	1.5	A	2	1.5	
	≥30	All	A	3	1.5	A	3	1.5	A	3	1.5	A	3	2.5	
End suction and split case	≤40	All	C	3	0.75	C	3	0.75	C	3	1.5	C	3	1.5	1
	50 to 125	All	C	3	0.75	C	3	0.75	C	3	1.5	C	3	2.5	1
	≥150	All	C	3	0.75	C	3	0.75	C	3	2.5	C	3	3.5	1

Notes:
1. Pumps: Type C bases strength and shape shall accommodate base elbow supports. Concrete bases (type C) shall be designed for a thickness of one-tenth the longest dimension with minimum thickness as follows: (1) for up to 30 hp, 6 in.; (2) for 40 to 75 hp, 8 in.; and (3) for 100 hp and up, 12 in. Pumps over 75 hp and multistage pumps shall be provided with supplemental restraining devices.

Vibration Isolation - Boilers and Steam Generators															
Boiler Type	Horsepower and Other	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Fire-tube	All	All	A	1	0.25	B	4	0.75	B	4	1.5	B	4	2.5	1
Water-tube, copper Fin	All	All	A	1	0.12	A	1	0.12	A	1	0.12	B	4	0.25	1

Notes:
1. Where equipment manufacturer indicates component cannot be installed directly on individual isolators (type A) provide equipment manufacturer recommended supplemental support (base type).

Vibration Isolation - Propeller Fans															
Fan Type	Horsepower and Other	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Wall-mounted	All	All	A	A	0.25	A	1	0.25	A	1	0.25	A	1	0.25	
Roof-mounted	All	All	A	A	0.25	A	1	0.25	B	4	1.5	D	4	1.5	

Vibration Isolation - Heat Pumps, Fan Coil Units and Computer Room Units															
Equipment Type	Horsepower and Other	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
Heat Pumps, Fan Coil Units and Computer Room Units	All	All	A	3	0.75	A	3	0.75	A	3	0.75	A/D	3	1.5	

Vibration Isolation - Packaged Air Handling Unit, Air Conditioning Units, Heating & Ventilating Units															
Fan Size	Fan HP, Static Pressure	RPM	Floor Span												Table Notes
			Slab on Grade			Up to 20 ft			20 to 30 ft			30 to 40 ft			
			Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	Base Type	Isolator Type	Min Defl., (in.)	
All	≤10	All	A	3	0.75	A	3	0.75	A	3	0.75	A	3	0.75	5,6
	≥15, ≤4 in. SP	Up to 300	A	3	0.75	A	3	3.5	A	3	3.5	C	3	3.5	1,3,4,5,6
		300 to 500	A	3	0.75	A	3	2.5	A	3	2.5	A	3	2.5	3,5,6
		501 and up	A	3	0.75	A	3	1.5	A	3	1.5	A	3	1.5	3,5,6
	≥15, ≥4 in. SP	Up to 300	B	3	0.75	C	3	3.5	C	3	3.5	C	3	3.5	1,2,3,4,5
		300 to 500	B	3	0.75	C	3	1.5	C	3	2.5	C	3	2.5	1,2,3,5
		501 and up	B	3	0.75	C	3	1.5	C	3	1.5	C	3	2.5	1,2,3,5

Notes:

1. Where available, use of packaged equipment manufacturer internal isolators meeting the above requirements is acceptable. Coordinate with equipment manufacturer. Provide documentation in both equipment submittals and in submittals for this Section.
2. Increase isolator deflection so isolator stiffness is less than one-tenth the stiffness of the supporting structure, as defined by the deflection due to load at the equipment support.
3. Where equipment manufacturer indicates component cannot be installed directly on individual isolators (type A) provide equipment manufacturer recommended supplemental support (base type).
4. Select isolator deflection so that resonance frequency is 40 percent or less of the lowest normal operating speed of equipment. Add a 1 in. thick pad (type 1) to the base plate of spring isolators (type 3).
5. Provide thrust restraints (type 5) for all ceiling-suspended and floor-mounted units operating at 2 in. of water or more total static pressure.
6. Fans and Air-Handling Equipment: For fans operating under 300 rpm, select isolator deflection so the isolator natural frequency is 40 percent or less than the fan speed. Flexible duct connectors shall be installed at the intake and discharge of all fans and air-handling equipment to reduce vibration transmission to air duct structures. Provide inertia bases (type C) for all class 2 and 3 fans and air handling equipment. Concrete inertia bases (type C) shall be designed for a minimum thickness of one-tenth the longest dimension, minimum 6 inches. Provide thrust restraints (type 5) with the same deflection as isolators for all fans and all base-mounted and suspended air-handling equipment operating at 2 in. or more total static pressure. Adjust restraint movement under normal operational static pressures.

3.8 PIPING SYSTEM VIBRATION ISOLATION

A. Vibration isolators for suspended piping:

1. Provide spring hangers for all piping in equipment rooms and up to 50 ft from vibration-isolated equipment and PRV stations. The first three hangers from the equipment shall be provided with the same deflection as the equipment isolators, with a maximum limitation of 2 in. deflection. Remaining hangers shall be spring or combination spring and elastomeric with 0.75 in. deflection. The first two hangers adjacent to the equipment shall be the positioning or pre-compressed type. Provide positioning hangers for all isolated piping 8 in. and larger. Piping over 2 inches in diameter suspended below or within 50 ft of conference rooms, classrooms and auditorium areas shall be hung with isolation hangers.

B. Vibration isolators for floor-supported piping:

1. Provide vibration isolators for floor supports for piping in equipment rooms to isolate equipment. Isolators shall be selected according to the guidelines for hangers. The first two adjacent floor supports shall be the restrained spring type, with a restraint/blocking feature to prevent load transfer to equipment flanges as the piping is filled or drained. Provide a slide plate where pipe is subjected to large thermal movement (PTFE, graphite, or steel) and shall be installed on top of the isolator. Provide a thermal barrier when rubber products are installed directly beneath steam or hot-water lines.

C. Vibration isolation for piping riser supports:

1. Provide resilient pipe riser support near to midpoint of riser and provide spring hangers at each floor or structural level to support riser and allow thermal expansion risers.
2. Provide spring hangers for first three hangers connected to branch piping at each level.

3.9 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Stencils.
6. Valve tags.
7. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: **Brass, 0.032-inch (0.8-mm)** minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

3. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
4. Fasteners: Stainless-steel [**rivets**] [**or**] [**self-tapping screws**].
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, **1/8 inch (3.2 mm)** thick, and having predrilled holes for attachment hardware.

B. Letter Color: **Black**.

C. Background Color: **White**.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

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

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

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

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

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

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

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

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: **At least 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances**.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, **1/8 inch (3.2 mm)** thick, and having predrilled holes for attachment hardware.

B. Letter Color: **Black**.

C. Background Color: **White**.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

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

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

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.

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

2.5 STENCILS

A. Stencils

1. Lettering Size: Minimum letter height of 1-1/4 inches (32 mm) for viewing distances up to 15 feet (4-1/2 m) and proportionately larger lettering for greater viewing distances.
2. Stencil Material: **Aluminum**
3. Stencil Paint: Exterior, gloss, **acrylic enamel** in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

4. Identification Paint: Exterior, **acrylic enamel** in colors according to ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

2.6 VALVE TAGS

A. Description: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.

1. Tag Material: **Brass, 0.032-inch (0.8-mm)** minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass **wire-link chain or beaded chain or S-hook**].

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: **3 by 5-1/4 inches (75 by 133 mm) minimum**
2. Fasteners: **Brass grommet and wire**
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

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

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1 **with painted, color-coded bands or rectangles** on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

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

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of **50 feet (15 m)**] along each run. Reduce intervals to 2**5 feet (7.6 m)** in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

D. Pipe Label Color Schedule:

1. Chilled-Water Piping: **White letters on a safety-blue background**
2. Heating Water Piping: **White letters on a safety-red background**.

3.5 DUCT LABEL INSTALLATION

A. Install **plastic-laminated** duct labels with permanent adhesive on air ducts in the following color codes:

1. **Blue**: For cold-air supply ducts.
2. **Yellow**: For hot-air supply ducts.
3. **Green**: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

B. Stenciled Duct Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.

C. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of **50 feet (15 m)** in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

   a. Chilled Water: **1-1/2 inches (38 mm)**
   b. Hot Water: **1-1/2 inches (38 mm)**

2. Valve-Tag Colors:

   a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.
   b. Flammable Fluids: Black letters on a safety-yellow background.
   c. Combustible Fluids: White letters on a safety-brown background.
   d. Potable and Other Water: White letters on a safety-green background.
   e. Compressed Air: White letters on a safety-blue background.
   f. Defined by User: White letters on a safety-purple background, black letters on a safety-white background, white letters on a safety-gray background, and white letters on a safety-black background

3.7 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Testing, Adjusting, and Balancing of Air Systems:
   a. Constant-volume air systems.
   b. Variable-air-volume systems.
2. Balancing Hydronic Piping Systems:
   a. Variable-flow hydronic systems.
3. Testing, adjusting, and balancing of equipment.
4. Testing, adjusting, and balancing of existing HVAC systems and equipment.
5. Procedures for equipment exhaust.
6. Duct leakage test verification.
7. Pipe leakage test verification.
8. HVAC-control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

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

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

1.4 INFORMATIONAL SUBMITTALS

A. 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.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 90 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Certified TAB reports.

E. Sample report forms.

F. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Specialists Qualifications, Certified by AABC, NEBB or TABB:

1. TAB Field Supervisor: Employee of the TAB firm certified as a TAB specialist.
2. TAB Technician: Employee of the TAB firm certified as a TAB technician.

B. TAB Conference: Meet with COR 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. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items:

a. The Contract Documents examination report.
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. TAB Report Forms: Use standard TAB contractor's forms approved by COR.

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

1.6 COORDINATION

A. Notice: Provide **seven** days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

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

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

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

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

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

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

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

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

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

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

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

N. Examine system pumps to ensure absence of entrained air in the suction piping.

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

P. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

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

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:
   1. Equipment and systems to be tested.
   2. Strategies and step-by-step procedures for balancing the systems.
   3. Instrumentation to be used.
   4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

   1. General:
      a. Permanent electrical-power wiring is complete.
      b. Automatic temperature-control systems are operational.

   2. Airside:
      a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
      b. Duct systems are complete with terminals installed.
      c. Volume, smoke, and fire dampers are open and functional.
      d. Equipment and duct access doors are securely closed.
      e. Clean filters are installed.
      f. Fans are operating, free of vibration, and rotating in correct direction.
      g. Variable-frequency controllers' startup is complete, and safeties are verified.
      h. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
      i. Windows and doors are installed and closed so indicated conditions for system operation can be met.
      j. Suitable access to balancing devices and equipment is provided.

3. Hydronics:
   a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
   b. Piping is complete with terminals installed.
   c. Water treatment is complete.
   d. Systems are flushed, filled, and air purged.
   e. Strainers are pulled and cleaned.
   f. Control valves are functioning in accordance with the sequence of operation.
   g. Shutoff and balance valves have been verified to be 100 percent open.
   h. Pumps are started, and proper rotation is verified.
   i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
   j. Variable-frequency controllers' startup is complete, and safeties are verified.
   k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in this Section and the applicable portions of one of the following standards and guidelines. Where the selected standard does not include all required procedures, select from alternate standard. Where conflicting procedures are found, comply with requirements of ASHRAE Standard 111 as required by ASHRAE 62.1-2019, Section 7.2.2, " Air Balancing and Verification of Outdoor Air Performance."
   1. AABC "National Standards for Total System Balance."
   2. ASHRAE 111 “Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems.”
   3. NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
   4. SMACNA “HVAC Systems - Testing, Adjusting and 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. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
   3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

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

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

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

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

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

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

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

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

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

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

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

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

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

3.5 GENERAL PROCEDURES FOR 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 percent.

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

C. 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 gage 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.

3.6 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from [**Architect**] [**Owner**] [**Construction Manager**] [**Commissioning Authority**] and comply with requirements in Section 232123 "Hydronic Pumps."

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

a. Monitor motor performance during procedures and do not operate motors in overload conditions.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.7 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Adjust the variable-flow hydronic system as follows:
   1. Verify pressure-differential sensor(s) location at end of main bypass branches.
   2. Compensating for Diversity: When the total flow rate of all terminal units is more than the indicated flow of the pumps, place a selected number of terminal units at minimum set-point flow with the remainder at maximum-flow condition until the total flow of the terminal units equals the indicated flow of the pump. Select the reduced-flow terminal units so they are distributed evenly among the branch piping.
      a. Determine diversity factor.
      b. Simulate system diversity by closing required number of control valves, as approved by the Design Professional.
   3. Adjust pumps to deliver total design pump flow.
      a. Measure pump TDH as follows:
         1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
         2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
         3) Convert pressure to head and correct for differences in gauge heights.
         4) Verify pump impeller size by measuring the TDH with the discharge valve closed and pump at full speed. Note the point on manufacturer pump curve at zero flow, and verify that the pump has the intended impeller size.
            a) If impeller size is not correct, and actual required flow and head cannot be achieved, manufacturer shall replace impeller with correct size.
         5) With valves open, start pump at slow speed and then ramp speed up until design water flow is achieved. Do not operate at full speed and use throttling to achieve desired flow. If pump is operating below 45 Hz at design flow, notify the design professional who will determine if pump impellers need to be trimmed due to field conditions and to allow full range of turn down.
         6) Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
         7) Report flow rates that are not within plus or minus 10 percent of design.
      b. Measure total water flow.
         1) Position valves for full flow through coils.
         2) Measure flow by main flow meter, if installed.
         3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
      c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.
   1. Measure flow in main and branch pipes.
   2. Adjust main and branch balance valves for design flow.
   3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.
   1. Measure flow at terminals.
   2. Adjust each terminal to design flow.
   3. Re-measure each terminal after it is adjusted.
   4. For three-way control valves, after verifying flow with valve open to the terminal, position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
   5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:
   1. Measure differential pressure, and verify that it is within manufacturer's specified range.
   2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:
   1. Measure and balance coils by either coil pressure drop or temperature method.
   2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Open control valves that were shut. Close enough control valves that were previously open to maintain diversity, and balance terminals that were just opened.

G. Prior to verifying final system conditions, determine system pressure-differential set point(s).

H. Mark final settings and verify that memory stops have been set.

I. Verify final system conditions as follows:
   1. Re-measure and confirm that total water flow is within design.
   2. Re-measure final pump operating data, TDH, volts, amps, and system pressure drop profile.
   3. Measure the differential-pressure-control-valve settings at conclusion of balancing.
   4. Check settings and operation of each safety valve. Record settings.
   5. Mark final settings.

J. Verify that memory stops have been set.

3.8 PROCEDURES FOR STEAM AND CONDENSATE SYSTEMS

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

D. Check settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

3.9 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.

3.10 PROCEDURES FOR AIR-COOLED CONDENSING UNITS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of compressor(s), fan(s), and motors.

3.11 PROCEDURES FOR AIR-COOLED CONDENSERS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of fan(s) and motor(s).

3.12 PROCEDURES FOR BOILERS

A. Hydronic Boilers:
1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Measure and record pressure drop.
4. Measure and record relief valve(s) pressure setting.
5. Capacity: Calculate in Btu/h (kW) of heating output.

6. Fuel Consumption: If boiler fuel supply is equipped with flow meter, measure and record consumption.
7. Efficiency: Calculate operating efficiency for comparison to submitted equipment.
8. Fan, motor, and motor controller operating data.

B. Boilers with Flue Gas Economizers:
1. Measure and record entering- and leaving-water temperature.
2. Measure and record water flow rate.
3. Measure and record water pressure drop.
4. Heat Recovered: Calculate in Btu/h (kW) of waste heat recovered.

3.13 DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.14 PIPE LEAKAGE TESTS

A. Witness the pipe pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.15 HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:
1. Verify HVAC control system is operating within the design limitations.
2. Confirm that the sequences of operation are operating in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.16 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

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

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

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

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

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

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

3.17 TOLERANCES

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

1. Air Systems:

a. Fans and Equipment with Fans: Plus or minus 10 percent. If design value is less than 100 cfm (47 L/s), within 10 cfm (4.7 L/s).
b. Air Outlets and Inlets: Plus or minus 10 percent

2. Hydronic Systems - Water Flow Rate: Plus or minus 5 percent. If design value is less than 10 gpm, within 10 percent

3.18 REPORTING

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

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

3.19 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.
15. Test conditions for fans and pump performance forms including the following:

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

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

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

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches (mm), and bore.
i. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.

d. Full-load amperage and service factor.
e. Sheave make, size in inches (mm), and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

3. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Filter static-pressure differential in inches wg (Pa).
f. Preheat-coil static-pressure differential in inches wg (Pa).
g. Cooling-coil static-pressure differential in inches wg (Pa).
h. Heating-coil static-pressure differential in inches wg (Pa).
i. Outdoor airflow in cfm (L/s).
j. Return airflow in cfm (L/s).
k. Outdoor-air damper position.
l. Return-air damper position.
m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch (mm) o.c.
f. Make and model number.
g. Face area in sq. ft. (sq. m).
h. Tube size in NPS (DN).
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Air flow rate in cfm (L/s).
b. Average face velocity in fpm (m/s).
c. Air pressure drop in inches wg (Pa).
d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
h. Water flow rate in gpm (L/s).
i. Water pressure differential in feet of head or psig (kPa).
j. Entering-water temperature in deg F (deg C).
k. Leaving-water temperature in deg F (deg C).
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig (kPa).
n. Refrigerant suction temperature in deg F (deg C).

o. Inlet steam pressure in psig (kPa).

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h (kW).
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches (mm), and bore.
n. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

2. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm (L/s).
b. Entering-air temperature in deg F (deg C).
c. Leaving-air temperature in deg F (deg C).
d. Air temperature differential in deg F (deg C).
e. Entering-air static pressure in inches wg (Pa).
f. Leaving-air static pressure in inches wg (Pa).
g. Air static-pressure differential in inches wg (Pa).
h. Low-fire fuel input in Btu/h (kW).
i. High-fire fuel input in Btu/h (kW).
j. Manifold pressure in psig (kPa).
k. High-temperature-limit setting in deg F (deg C).
l. Operating set point in Btu/h (kW).
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h (kW).

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches (mm), and bore.

h. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches (mm), and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Suction static pressure in inches wg (Pa).

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F (deg C).
d. Duct static pressure in inches wg (Pa).
e. Duct size in inches (mm).
f. Duct area in sq. ft. (sq. m).
g. Indicated air flow rate in cfm (L/s).
h. Indicated velocity in fpm (m/s).
i. Actual air flow rate in cfm (L/s).
j. Actual average velocity in fpm (m/s).
k. Barometric pressure in psig (Pa).

J. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft. (sq. m).

2. Test Data (Indicated and Actual Values):

   a. Air flow rate in cfm (L/s).
   b. Air velocity in fpm (m/s).
   c. Preliminary air flow rate as needed in cfm (L/s).
   d. Preliminary velocity as needed in fpm (m/s).
   e. Final air flow rate in cfm (L/s).
   f. Final velocity in fpm (m/s).
   g. Space temperature in deg F (deg C).

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

   a. System and air-handling-unit identification.
   b. Location and zone.
   c. Room or riser served.
   d. Coil make and size.
   e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

   a. Air flow rate in cfm (L/s).
   b. Entering-water temperature in deg F (deg C).
   c. Leaving-water temperature in deg F (deg C).
   d. Water pressure drop in feet of head or psig (kPa).
   e. Entering-air temperature in deg F (deg C).
   f. Leaving-air temperature in deg F (deg C).

L. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and size.
   e. Model number and serial number.
   f. Water flow rate in gpm (L/s).
   g. Water pressure differential in feet of head or psig (kPa).
   h. Required net positive suction head in feet of head or psig (kPa).
   i. Pump rpm.
   j. Impeller diameter in inches (mm).
   k. Motor make and frame size.
   l. Motor horsepower and rpm.
   m. Voltage at each connection.
   n. Amperage for each phase.
   o. Full-load amperage and service factor.
   p. Seal type.

2. Test Data (Indicated and Actual Values):

   a. Static head in feet of head or psig (kPa).
   b. Pump shutoff pressure in feet of head or psig (kPa).
   c. Actual impeller size in inches (mm).
   d. Full-open flow rate in gpm (L/s).
   e. Full-open pressure in feet of head or psig (kPa).
   f. Final discharge pressure in feet of head or psig (kPa).
   g. Final suction pressure in feet of head or psig (kPa).
   h. Final total pressure in feet of head or psig (kPa).
   i. Final water flow rate in gpm (L/s).
   j. Voltage at each connection.
   k. Amperage for each phase.

M. Boiler Test Reports
   1. Unit Data:
      a. System identification.
      b. Location.
      c. Boiler type.
      d. Make and model number.
   2. Test Data:
      a. Hot Water Boilers
         1) Entering water temperature.
         2) Leaving water temperature.
         3) Water flow
      b. Steam Boilers
         1) Entering water temperature.
         2) Entering water flow.
         3) Leaving-steam pressure.
         4) Leaving-steam temperature.
         5) Leaving-steam flow.]

N. Instrument Calibration Reports:

   1. Report Data:

      a. Instrument type and make.
      b. Serial number.
      c. Application.
      d. Dates of use.
      e. Dates of calibration.

3.20 INSPECTIONS

A. Initial Inspection:

   1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
   2. Check the following for each system:

a. Measure airflow of at least [**10**] <**Insert number**> percent of air outlets.
b. Measure water flow of at least [**5**] <**Insert number**> percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Verify that balancing devices are marked with final balance position.
e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by COR.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of COR.
3. COR hall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent 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 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. 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.

D. Prepare test and inspection reports.

3.21 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

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

END OF SECTION 230593

SECTION 230700 - MECHANICAL INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following duct services:

1. Combined Heating and Cooling Ducts – Climate Zones 5, 6, 7 and 8
2. Unconditioned Outside Air Intake Ducts/Plena and Exhaust Relief Duct and Plena Inside the Building Envelope – Climate Zones 2 through 8

B. Section includes insulating the following HVAC equipment that is not factory insulated:

1. Cooling Coil and Humidifier Drain Pans
2. Cooling System Equipment
3. Heating Hot Water Equipment

C. Section includes insulating the following HVAC piping systems

1. Heating Hot Water Systems: 141 deg F to 200 deg F
2. Cooling and Glycol Energy Recovery Systems 40 deg F to 65 deg F including free cooling tower/condenser water systems.
3. Cooling Coil Condensate Piping, Outdoor Cooling Tower Makeup Water Piping and Equipment Drain Piping
4. Air Conditioning Refrigerant Suction, Hot Gas, Outdoor Liquid Line and Hot Gas Piping

D. Section includes insulation for Outdoor, Underground Piping (excluding loose fill insulated piping).

E. Referenced Standards:

1. ASTM International (ASTM)
2. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE).
3. North American Insulation Manufacturers Association (NAIMA).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance, thickness, and jackets (both factory- and field-applied if any).

B. Sustainable Design Submittals

1. Adhesives:

a. Product Data for adhesives indicating VOC content.

2. Coatings

a. Product Data for coatings indicating VOC content.

b. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.

3. Sealants

a. Product Data for sealants indicating VOC content.

b. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of field-applied jackets.

2. Detail application at linkages of control devices.

3. Detail application of protective duct shields, saddles, and inserts at hangers for each type of insulation and hanger.

4. Detail insulation application at duct elbows, fittings, dampers, specialties and flanges for each type of insulation.

5. Detail attachment and covering of equipment heat tracing inside insulation.

6. Detail removable insulation at equipment connections.

7. Detail field application for each equipment type.

8. Detail application of protective piping shields, saddles, and inserts at hangers for each type of insulation and hanger.

9. Detail attachment and covering of piping heat tracing inside insulation.

10. Detail insulation application at pipe expansion joints for each type of insulation.

11. Detail insulation application at pipe elbows, fittings, flanges, valves, and specialties for each type of insulation.

12. Detail removable insulation at valves and piping specialties.

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Sheet Form Insulation Materials: 12 inches square.

2. Sheet Jacket Materials: 12 inches square.

3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

4. Preformed Pipe Insulation Materials: 12 inches long by NPS 2 Jacket Materials for Pipe: 12 inches long by NPS 2.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Coordination Documentation: Written documentation indicating specific sheet metal and hanger requirements from fire-rated duct insulation system UL Listing.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 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.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23.

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. , specific sheet metal joint construction requirements and specific hanger requirements.

D. Coordinate clearance requirements with equipment Installer for equipment insulation application. Coordinate installation and testing of equipment heat tracing.

E. Coordinate clearance requirements with piping Installer for piping insulation application. Coordinate installation and testing of piping heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure and leak testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation Non-Plenum Applications: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials and Type I for tubular materials. For indoor applications insulation meet ASTM E84 Flame Spread and Smoke Developed ratings of 25/50 for thickness required. For duct applications, color shall be selected by the architect from manufacturer standard color options.

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

a. Aeroflex USA, Inc.; Aerocel.

b. Armacell LLC; AP Armaflex and Armaflex FS.

c. K-Flex USA; Insul-Sheet and Insul-Tube.

G. Flexible Elastomeric Insulation in Supply, Return, Exhaust, Relief and Ventilation Air Plenums: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials and Type I for tubular materials. For indoor applications insulation shall be listed and labelled to UL 723 or ASTM E84 Flame Spread and Smoke Developed ratings of 25/50 for thickness required. For duct applications, color shall be selected by the architect from manufacturer standard color options.

1. Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

H. Armacell LLC; Armaflex ULTRA.Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

a. Pittsburgh Corning Corporation.

2. Block Insulation: ASTM C 552, Type I.

3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

I. Mineral-Fiber (Fiberglass) Blanket Duct Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I for insulation without jackets, Type II with factory-applied vinyl jacket, Type III with factory-applied FSK jacket or Type III with factory-applied FSP jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. CertainTeed Corp.; SoftTouch Duct Wrap.
   b. Johns Manville; Microlite.
   c. Knauf Insulation; Atmosphere Duct Wrap with ECOSE Technology.
   d. Manson Insulation Inc.; Alley Wrap.
   e. Owens Corning; SOFTR All-Service Duct Wrap.

J. Rigid Mineral-Fiber (Fiberglass) Board Duct Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB.

1. For duct and plenum applications in mechanical rooms and concealed locations, provide insulation with factory applied FSK jacket.
2. For duct and plenum applications exposed in occupied spaces, provide insulation with paintable factory applied ASJ jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Provide insulation with factory applied ASJ for equipment. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
4. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. CertainTeed Corp.; Commercial Board.
   b. Fibrex Insulations Inc.; FBX.
   c. Johns Manville; 800 Series Spin-Glas.
   d. Knauf Insulation; Earthwool Insulation Board with ECOSE Technology
   e. Manson Insulation Inc.; AK Board.
   f. Owens Corning; Fiberglas 700 Series.

K. Mineral-Fiber (Fiberglass), Preformed Pipe Insulation

1. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory and field installed jackets identified in pipe insulation schedules.

2. Type II, 1200 deg F (649 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory and field installed jackets identified in pipe insulation schedules.

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

   a. Johns Manville; a Berkshire Hathaway company.

   b. Knauf Insulation.

   c. Manson Insulation Inc.

   d. Owens Corning.

L. Polyisocyanurate: Prefabricated, rigid cellular polyisocyanurate material intended for use as piping thermal insulation. Comply with ASTM C591.

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

   a. Johns Manville; a Berkshire Hathaway company.

2. Prefabricated insulation, with factory-applied ASJ or with factory-applied ASJ-SSL. Provide with specified field applied jacket.

3. Type IV, except thermal conductivity (k-value) do not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.

4. Flame-spread index is 25 or less, and smoke-developed index is 50 or less for thicknesses of up to 1.5 inch as tested in accordance with ASTM E84.

5. Fabricated shapes in accordance with ASTM C450 and ASTM C585.

6. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

M. Semi-Rigid Mineral-Fiber (Fiberglass) Insulation

1. Duct Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semi-rigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Minimum nominal density is 2.5 lb/cu. ft.. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2. Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semi-rigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Minimum nominal density is 2.5 lb/cu. ft.. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

   a. CertainTeed Corp.; CrimpWrap.

   b. Johns Manville; MicroFlex.

   c. Knauf Insulation; Earthwool Pipe & Tank Insulation with ECOSE Technology.

d. Knauf Insulation: Kwik-Flex Pipe & Tank Insulation.

e. Manson Insulation Inc.; AK Flex.

f. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

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

a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

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

a. Ramco Insulation, Inc.; Thermokote V.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

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

a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

1. Adhesives shall have a VOC content of 250 g/L or less or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

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

a. Aeroflex USA, Inc.; Aeroseal Low VOC.

b. Armacell LLC; Armaflex 520BLV Adhesive.

c. K-Flex USA; 720-LVOC Contact Adhesive.

d. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
    b. Eagle Bridges - Marathon Industries; 225.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.

D. ASJ,and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
    b. Eagle Bridges - Marathon Industries; 225.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
    d. Mon-Eco Industries, Inc.; 22-25.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. Dow Corning Corporation; 739, Dow Silicone.
    b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
    c. P.I.C. Plastics, Inc.; Welding Adhesive.
    d. Speedline Corporation; Polyco VP Adhesive.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

F. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg FAvailable Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-97.
    b. Eagle Bridges - Marathon Industries; 290.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-27.
    d. Mon-Eco Industries, Inc.; 22-30.

e. Vimasco Corporation; 760.

G. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

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

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

1. VOC Content: 300 g/L or less.

2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

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

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.

b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F.

4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.

b. Eagle Bridges - Marathon Industries; 570.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.

3. Service Temperature Range: Minus 50 to plus 220 deg F.

4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.

5. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.

b. Eagle Bridges - Marathon Industries; 550.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.

d. Mon-Eco Industries, Inc.; 55-50.

e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F.

4. Solids Content: 60 percent by volume and 66 percent by weight.

5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.

b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.

c. Vimasco Corporation; 713 and 714.

2. Adhesives shall have a VOC content of 250 g/L or less.

3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

4. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.

5. Service Temperature Range: 0 to plus 180 deg F.

6. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

   b. Eagle Bridges - Marathon Industries; 405.

   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.

   d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F.

5. Color: Aluminum.

6. Sealant shall have a VOC content of 420 g/L or less.

7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

B. ASJ Flashing Sealants and PVC Flashing Sealants:

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.

4. Service Temperature Range: Minus 40 to plus 250 deg F.

5. Color: White.

C. Joint Sealants:

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

   b. Marathon Industries; 405.

   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.

d. Mon-Eco Industries, Inc.; 44-05.

e. Pittsburgh Corning Corporation; Pittseal 444.

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I. Permeance of jacket shall not exceed 0.02 perm.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I. Permeance of jacket shall not exceed 0.02 perm.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II. Permeance of jacket shall not exceed 0.02 perm.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas No. 5.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

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

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.

b. Vimasco Corporation; Elastafab 894.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

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

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

C. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

D. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

E. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches OC and at end joints.

F. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

G. PVC Jacket: 30 Mil, High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Johns Manville; Zeston.
   b. P.I.C. Plastics, Inc.; FG Series.
   c. Proto Corporation; LoSmoke.
   d. Speedline Corporation; SmokeSafe.
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated tank heads and tank side panels.

H. Metal Jacket:

1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
   b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.

c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Factory cut and rolled to size.

b. Finish and thickness are indicated in field-applied jacket schedules.

c. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.

d. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.

2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.

3) Tee covers.

4) Flange and union covers.

5) End caps.

6) Beveled collars.

7) Valve covers.

8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

I. Underground Direct-Buried Piping Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

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

a. Pittsburgh Corning Corporation; Pittwrap.

b. Polyguard Products, Inc.; Insulrap No Torch 125.

J. Self-Adhesive Outdoor Jacket: Minimum 12 mil thick, vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; UV resistant, zero permeability with white aluminum-foil facing, impact and tear resistant.

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

a. Polyguard Products, Inc.; Alumaguard CoolWrap.

b. Venture Tape Corporation; VentureClad (White Embossed).

2. Subject to compliance with requirements for thickness, UV resistance, tear resistance and permeability, flexible elastomeric insulation manufacturer cladding may be used for outdoor insulation in lieu of field installed jacketing.

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. ABI, Ideal Tape Division; 428 AWF ASJ.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
    c. Compac Corporation; 104 and 105.
    d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
    e. Knauf Insulation; EXPERT Tapes: ASJ+ Tape OR ASJ Tape.
2. Width: minimum 3 inches.
3. Thickness: minimum 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. ABI, Ideal Tape Division; 491 AWF FSK.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    c. Compac Corporation; 110 and 111.
    d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
    e. Knauf Insulation; EXPERT Tapes: FSK Tape.
2. Width: minimum 3 inches.
3. Thickness: minimum 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    a. ABI, Ideal Tape Division; 370 White PVC tape.
    b. Compac Corporation; 130.
    c. Venture Tape; 1506 CW NS.
2. Width: 2 inches.

3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. ABI, Ideal Tape Division; 488 AWF.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
   c. Compac Corporation; 120.
   d. Venture Tape; 3520 CW.
   e. Knauf Insulation; EXPERT Tapes: 2 MIL Foil Tape.
2. Width: minimum 2 inches.
3. Thickness: minimum 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:

1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
   a. ITW Insulation Systems; Gerrard Strapping and Seals.
   b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
   c. Wing seals are primarily used for fastening bands together. Closed seals are occasionally used for large, 84-inch- diameter applications and where fastening bands are used with springs. Wing seals are reusable; closed seals are not.
2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 1/2 inch wide with wing seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 1/2 inch wide with wing seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- or **0.135-inch-** diameter shank, length to suit depth of insulation indicated.

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

1) AGM Industries, Inc.; CWP-1.

2) GEMCO; CD.

3) Midwest Fasteners, Inc.; CD.

4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- or 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

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

1) AGM Industries, Inc.; CHP-1.

2) GEMCO; Cupped Head Weld Pin.

3) Midwest Fasteners, Inc.; Cupped Head.

4) Nelson Stud Welding; CHP.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:

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

1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.

2) GEMCO; Perforated Base.

3) Midwest Fasteners, Inc.; Spindle.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

c. Spindle: Copper- or zinc-coated, low-carbon steel, or Aluminum, or Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.

d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:

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

1) GEMCO; Nylon Hangers.

2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.

c. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.

d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:

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

1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.

2) GEMCO; Peel and Press.

3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.

c. Spindle: Copper- or zinc-coated, low-carbon steel, or Aluminum, or Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.

d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel, or aluminum, or stainless-steel sheet matching hanger materials, with beveled edge sized to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. Available Manufacturers: Subject to compliance with requirements,:

1) AGM Industries, Inc.; RC-150.

2) GEMCO; R-150.

3) Midwest Fasteners, Inc.; WA-150.

4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized to hold insulation securely in place but not less than 1-1/2 inches in diameter.

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

1) GEMCO.

2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

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

a. C and F Wire.

2.13 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances 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.

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

3.2 PREPARATION

A. Duct Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application including dirt, scale, oil, rust and other foreign matter.

B. Equipment Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

C. Piping Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

D. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

E. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Protect insulation from exposure to moisture prior to and after installation. All insulation other than flexible elastomeric that becomes wet shall be replaced at no cost to the project.

B. Install insulation after systems have been tested, proved tight. Remove dirt, scale, oil, rust and other foreign matter prior to installation of insulation.

C. Install insulation, mastics, adhesives, coatings, covers, weather-protection and other work in accordance with manufacturer's recommendations. 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.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic. Leakage in vapor barrier or voids in insulation will not be accepted.

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 insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied non-self-sealing jackets as follows:

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches OC

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at manufacturer recommended spacing but space no further than 4 inches OC

a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

L. Install insulation with self-sealing factory-applied jackets as follows:

1. Locate all longitudinal pipe insulation jacketing laps in least visible location.
2. Draw jacket tight and smooth.
3. For proper sealing, seal lap joints with reasonable pressure being applied with a plastic squeegee or sealing tool.
4. Vapor seal all circumferential joints with factory furnished matching pressure sensitive butt strips installed with reasonable pressure being applied with a plastic squeegee or sealing tool.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. 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.

P. Insulate flex connections to same thickness as material as adjoining system

Q. Duct Insulation Requirements:

1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
2. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
3. Insulate standing seams with same material and thickness as duct.
4. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
5. Insulate flex connections to same thickness as material as adjoining ductwork.

R. Equipment Insulation Requirements:

1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.
2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment as specified in insulation system schedules.
3. For above ambient services, do not install insulation to the following:
   a. Vibration-control devices.
   b. Testing agency labels and stamps.
   c. Nameplates and data plates.
   d. Manholes.
   e. Handholes.
   f. Cleanouts.

S. Piping Insulation Requirements:

1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
3. For piping systems operating below 60 deg F, seal ends of pipe insulation onto the jacket and seal insulation onto the pipe with approved fire-retardant vapor barrier mastic, at flanges, valves and fittings and at intervals of no more than every fourth section of pre-formed insulation or 20 feet on continuous runs of piping whichever is less.
4. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
5. Insulate flex connections to same thickness as material as adjoining piping.
6. For above ambient services, do not install insulation to the following:
   a. Vibration-control devices.
   b. Testing agency labels and stamps.
   c. Nameplates and data plates.
   d. Manholes.
   e. Handholes.
   f. Cleanouts.

3.4 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.
3. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   a. For insulated piping penetrating the building roof, insulate section of piping passing through from 6 inches inside the envelope to 6 inches above the end of the sleeve with a section of rigid polyisocyanurate pipe insulation with thickness to match outdoor insulation thickness. Provide section with field applied aluminum jacket with moisture barrier over entire section passing though the sleeve. Seal all insulation joints and section ends with vapor retarder mastic.
4. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
5. 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.

3. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

a. For insulated piping penetrating the building exterior walls, insulate section of piping passing through from 6 inches inside the envelope to 6 inches past the end of the sleeve with a section of rigid polyisocyanurate pipe insulation with thickness to match outdoor insulation thickness. Provide section with field applied aluminum jacket with moisture barrier over entire section passing though the sleeve. Seal all insulation joints and section ends with vapor retarder mastic.

4. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.

5. 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. Ductwork Insulation Installation at Fire-Rated Wall and Partition Penetrations: 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 07for firestopping and fire-resistive joint sealers.

F. Duct Insulation Installation at Floor Penetrations:

1. Duct: 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. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07.

G. Piping Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Division 07 for firestopping and fire-resistive joint sealers.

H. Piping Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.

2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties [**Except Steam Traps**]:

1. Install removable preformed valve covers and covers for specialties manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body or specialties. Arrange insulation to permit access to packing and to allow operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

E. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area recommended by the insulation manufacturer but no less than for 50 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches OC
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches OC each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not over compress insulation during installation. Maximum allowable compressions shall be as recommended by the insulation manufacturer.

e. Impale insulation over pins and attach speed washers.

f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch OC Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 deg F at 20-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches OC

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches OC

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area recommended by the insulation manufacturer but no less than for 50 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches OC.

b. On duct sides with dimensions larger than 18 inches, space pins 16 inches OC each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

d. Do not over-compress insulation during installation.

e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch OC Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches OC

C. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

3. For insulation with factory-applied jackets on above-ambient surfaces, secure using the self-seal system per manufacturer's recommendations or for non-self-seal systems, secure laps with outward-clinched staples at 6 inches OC

4. For insulation with factory-applied jackets on below-ambient surfaces, secure using the self-seal systems per manufacturer's recommendations, or for non-self-seal systems, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

D. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.

4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

E. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

F. Insulation Installation on Valves and Pipe Specialties:

1. Install removable preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed sections are not available, install mitered sections of pipe insulation to valve body and specialties.

3. Arrange insulation to permit access to packing and to allow operation without disturbing insulation.

4. Install insulation to flanges as specified for flange insulation application.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.

3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.

2. Install lap or joint strips with same material as jacket.

3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.

5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches OC and at end joints.

3.8 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area recommended by the insulation manufacturer but no less than for 50 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
   a. Do not weld anchor pins to ASME-labeled pressure vessels.
   b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
   c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches OC in both directions.
   d. Do not over-compress insulation during installation.
   e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
   f. Impale insulation over anchor pins and attach speed washers.
   g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch pre-stressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches OC Install a wire ring around each end and around outer periphery of center openings, and stretch pre-stressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches OC Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches.
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply manufacturer recommended coverage of adhesive but no less than 50% to surface with manufacturer's recommended adhesive.

2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch- diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.

2. Fabricate boxes from galvanized steel for indoor pumps and aluminum or stainless steel, at least 0.050 inch thick.

3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.9 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties (except steam traps)_with continuous thermal and vapor-retarder integrity unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves and specialties using removable preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating

cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.10 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Boiler Breechings, Flues and Connectors:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.

2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.

2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

4. Finish flange insulation same as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.

3. Finish fittings insulation same as pipe insulation.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install removable mitered segments of calcium silicate insulation to valve body and specialties. Arrange insulation to permit access to packing and to allow operation without disturbing insulation.

2. Install insulation to flanges as specified for flange insulation application.

3. Finish valve and specialty insulation same as pipe insulation.

3.11 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches OC
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install removable preformed sections of cellular-glass insulation to valve body and specialties.
2. Arrange insulation to permit access to packing and to allow operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.12 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 for exterior and interior painting.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
   a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating. Coating for outdoor insulation shall be UV resistant and waterproof.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.13 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to two location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to two location(s) for each type of equipment defined in the Part 3. For large equipment, remove only a portion adequate to determine compliance.

3. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.14 DUCT INSULATION SCHEDULE GENERAL

A. Items Not Insulated:

1. Fibrous-glass ducts.

2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA scheduled values below.

3. Factory-insulated flexible ducts.

4. Factory-insulated plenums and casings.

5. Vibration-control devices.

6. Factory-insulated access panels and doors.

3.15 DUCT AND PLENUM INSULATION SCHEDULE

A. Provide insulation materials and thicknesses identified below. If more than one material is listed for a duct location, selection from materials listed is Division 23 option.

B. Duct Insulation Schedules:

1. Where application of rigid versus blanket insulation on components such as coils and supply fans is to be based on the height of a component, height shall be determined based on the bottom of the component listed. Extend applicable insulation over the entire component before transitioning to alternate material. For ductwork, transition from blanket to rigid insulation shall occur no lower than height listed.
2. Exposed ductwork between air volume terminal or local heating or cooling unit mounted within the space served and associated diffusers or registers does not require external insulation. Where air volume terminal or local heating or cooling unit are mounted outside the space served, insulate ductwork between the air volume terminal or local heating or cooling unit and the wall of the space served.

Combined Heating and Cooling Supply, Return and Heat/Energy Recovery System Exhaust Ducts Climate Zone 5, 6, 7 and 8						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
All ductwork, plena, duct mounted coils and supply fans exterior to building envelope. For rectangular and flat oval ductwork taper top insulation to prevent water accumulation by increasing thickness 1/8" per foot up from minimum listed to high point for drainage.	R-12.0	Rigid Mineral-Fiber Board	3.0	6.0	FSK	Self-Adhesive Outdoor Jacket
		Semi-Rigid Mineral-Fiber Board	3.0	1.5	FSK	
		Flexible Elastomeric	3.0	N/A	N/A	
All concealed ductwork, plena, duct mounted coils and supply fans in unconditioned spaces including shafts, non-plenum return ceiling cavities and crawlspaces (ventilated and non- ventilated) and all exposed ductwork, plena, duct mounted coils and supply fans in mechanical rooms located more than 10 feet above finished floor.	R-6.0	Mineral-Fiber Blanket	2.0	1.0	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	N/A
All exposed ductwork, plena, duct mounted coils and supply fans in mechanical rooms 10 feet or less above finished floor.	R-6.0	Rigid Mineral-Fiber Board	1.5	6.0	FSK	N/A
Concealed supply ductwork, plena, duct mounted coils and supply fans in indirectly conditioned spaces including return air plenums with or without exposed roofs above and exposed ductwork in spaces having operable envelope elements (windows and doors) including loading dock areas.	R-1.9	Mineral-Fiber Blanket	1.5	0.75	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	N/A
		Listed and Labelled Flexible Elastomeric	0.5	N/A	N/A	N/A
All round ductwork and supply fans in mechanical rooms and all round ductwork in exposed location below 10 feet above finished floor.	R-6.0	Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	N/A

Combined Heating and Cooling Supply, Return and Heat/Energy Recovery System Exhaust Ducts Climate Zone 5, 6, 7 and 8						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
Backs of air outlets and outlet plenums with face area larger than 5 square feet that are exposed to unconditioned and indirectly conditioned spaces.	R-2.0	Mineral-Fiber Blanket	1.5	0.75	FSK	N/A
		Listed and Labelled Flexible Elastomeric	0.5	N/A	N/A	N/A
All exposed supply ductwork passing through occupied spaces from heating and cooling unit or shaft to the supply air terminal box inlet or wall of space served and ductwork between the terminal box and the wall of space served.	R-1.9	Rigid Mineral-Fiber Board	1.5	3.0	ASJ	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	ASJ	N/A
		Flexible Elastomeric	0.5	N/A	N/A	N/A

Unconditioned Outside Air Intake Ducts/Plena and Exhaust/Relief Duct/Plena Inside Building Envelope Climate Zones 2 Through 8						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
For outside air intakes, all ductwork and plena between the building envelope and the first system heating coil, cooling coil or air handling unit connection.	R-12.0	Rigid Mineral-Fiber Board	3.0	6.0	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	3.0	1.5	FSK	
For exhaust/relief ducts and plena, all ductwork and plena between the building envelope and first system isolation damper.	R-12.0	Rigid Mineral-Fiber Board	3.0	6.0	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	3.0	1.5	FSK	

3.16 BREECHING, FLUES AND CONNECTORS INSULATION SCHEDULE

A. Breeching, flues and connector insulation shall be one of the following:

1. Calcium Silicate: 4 inches thick.
2. High-Temperature Mineral-Fiber Blanket: 3 inches thick and 3-lb/cu. ft. nominal density.
3. High-Temperature Mineral-Fiber Board: 3 inches thick and 6-lb/cu. ft. nominal density.

3.17 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option. Refer to duct insulation tables for supply fan and duct mounted coils requirements.

B. Insulate indoor and outdoor equipment that is not factory insulated.

Cooling Coil and Humidifier Drain Pans		
Insulation Type	Minimum Thickness (inch)	Factory Applied Jacket
Rigid Mineral-Fiber Board: Minimum Density = 6 lb/cu.ft	1	FSK
Semi-Rigid Mineral-Fiber Board: Minimum Density = 1.5 lb/cu.ft		
Flexible Elastomeric - Provide listed and labelled insulation in active plenums.		N/A

Heating Hot Water Equipment Insulation Schedule					
Equipment Type	Insulation Type	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket – Outdoor Only
Heating-hot-water pumps Heating-hot-water air-separator Piping system filter-housing	Rigid Mineral-Fiber Board: Minimum Density = 6 lb/cu.ft Semi-Rigid Mineral-Fiber Board: Minimum Density = 1.5 lb/cu.ft	1	2	FSK	Self-Adhesive Outdoor Jacket
Heat-exchanger (water-to-water for heating service) Heating-hot-water system tanks, heat recovery tanks and thermal storage tanks	Rigid Mineral-Fiber Board: Minimum Density = 6 lb/cu.ft Semi-Rigid Mineral-Fiber Board: Minimum Density = 1.5 lb/cu.ft	2	4	FSK	Self-Adhesive Outdoor Jacket
Radiant Heating Panel and Exposed Bottom Surface of Radiant Floor Heating. Adjacent building envelope insulation counts towards the specified minimum R-Value.	Mineral-Fiber Blanket: Minimum Density = 0.75 lb/cu.ft, Minumum R-Value = 3.5.	1.5	N/A	N/A	N/A

3.18 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.

2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.19 PIPING INSULATION SCHEDULE

A. Provide insulation materials and thicknesses scheduled for each system type and pressure/temperature range. If more than one material is listed for a system, selection from materials listed is Division 23 option.

B. For dual temperature systems (heating and cooling), provide thickness equal to greater of heating or cooling scheduled value. Dual temperature piping shall also meet all vapor barrier requirements for cooling insulation (perm rating).

C. Insulation for pre-insulated piping shall meet all specified requirements.

D. Insulate piping operating at temperatures below 40 deg F and systems operating between 40 deg F to 65 deg F in accordance with NAIMA Guide to Insulating Chilled Water Piping Systems with Mineral Fiber Pipe Insulation. Comply with all recommendations including but not limited to the requirement for vapor dams every fourth section of insulation.

E. Outdoor piping insulation requirements apply to all piping outside the building envelope and including pipes in unconditioned piping vestibules connected to outdoor equipment.

F. Pipe Insulation Schedules:

Heating Hot Water Systems: 141 deg F to 200 deg F						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.25 to 0.29 at 125	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Pipe and Tank Insulation for 14" and Larger Pipe Size	Less than 1	1.5	3.0	ASJ or ASJ-SSL	Indoor: PVC for exposed piping in mechanical rooms when mounted 10 feet or lower above finished floor Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	1.5	3.0		
		1.5 to Less than 4	2.0	4.0		
		4 to Less than 8	2.0	4.0		
		8 and Larger	2.0	4.0		

Heating Hot Water Systems: 85 deg F to 140 deg F						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.22 to 0.28 at 100	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Pipe and Tank Insulation for 14" and Larger Pipe Size	Less than 1	1.0	2.0	ASJ or ASJ-SSL	Indoor: PVC for exposed piping in mechanical rooms when mounted 10 feet or lower above finished floor Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	1.0	2.0		
		1.5" to Less than 4	1.5	3.0		
		4 to Less than 8	1.5	3.0		
		8 and Larger	1.5	3.0		

3.20 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. This section does not apply where other Division 23 sections require the installation of loose-fill insulation for underground piping.

B. Schedule of field installed insulation for underground piping:

System Served	Insulation Type	Minimum Insulation Thickness (inches)
Chilled Water, Condenser Water, Heating Hot Water 200 deg F and Below, Dual Temperature (Heating/Cooling) Piping, All Sizes	Cellular Glass with Underground Direct-Buried Piping Jacket	2.0
Heating Hot Water All Sizes Above 200 deg F, All Sizes		3.0
Steam and Steam Condensate All Sizes, 140 psig/350 deg F and Below, All Sizes		4.0

3.21 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Refer to Duct, Plenum, Equipment and Pipe insulation schedules for outdoor field applied jacketing requirements. If more than one material is listed, selection from materials listed is Contractor's option.

C. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 230700

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

B. Related Sections:

1. Section 019113 "General Commissioning Requirements" for general commissioning process requirements.

1.3 DEFINITIONS

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

B. CxA: Commissioning Authority.

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

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

1.4 INFORMATIONAL SUBMITTALS

A. Certificates of readiness.

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

1.5 ALLOWANCES

A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Section 012100 "Allowances."

1.6 UNIT PRICES

A. Commissioning testing allowance may be adjusted up or down by the "List of Unit Prices" Article in Section 012200 "Unit Prices" when actual man-hours are computed at the end of commissioning testing.

1.7 CONTRACTOR'S RESPONSIBILITIES

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

B. Attend construction phase controls coordination meeting.

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

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

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

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

1.8 CxA'S RESPONSIBILITIES

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

B. Direct commissioning testing.

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

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

1.9 COMMISSIONING DOCUMENTATION

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

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.

5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
6. Test and inspection reports and certificates.
7. Corrective action documents.
8. Verification of testing, adjusting, and balancing reports.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

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

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

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

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

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

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

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

3.2 Testing AND BALANCING VERIFICATION

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

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

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

1. The CxA will notify testing and balancing Contractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
2. The testing and balancing Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.

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

D. The CxA along with the HVAC&R Contractor, testing and balancing Contractor, and HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

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

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

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

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

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

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

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

A. Boiler Testing and Acceptance Procedures: Testing requirements are specified in HVAC boiler Sections. Provide submittals, test data, inspector record, and boiler certification to the CxA.

B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC." Assist the CxA with preparation of testing plans.

C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment requirements are specified in HVAC piping Sections. HVAC&R **Contractor** shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:

1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
2. Description of equipment for flushing operations.
3. Minimum flushing water velocity.
4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

D. Energy Supply System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of gas and hot-water systems and equipment at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

E. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

F. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

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

END OF SECTION 230800

SECTION 230923 - HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

Complete automatic cloud-based control system as required for automatic operation of heating, ventilating and air conditioning systems including controllers, operators, dampers, and accessories.

1.2 QUALITY ASSURANCE

A. Electrical work shall comply with NFPA 70, National Electrical Code.

B. Submit documentation of contractor qualifications. Minimum qualifications include a minimum of 7 years furnishing and installing HVAC controls and building management systems.

C. The programmer responsible for programming digital controllers shall have a minimum of three years' experience programming digital controllers of the manufacturer.

D. All products of the system shall be provided with relevant agency approvals. Verification that the approvals exist for all submitted products shall be provided on request, with the submittal package.

E. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in the production and installation of HVAC control systems. Products shall be manufacturer's latest standard design and have been tested and proven in actual use.

F. Automatic control system subcontractor shall be responsible for providing quantity and type of transformers to make their system operational, except for where transformers are furnished and mounted by the equipment manufacturer.

1.3 SUBMITTALS

A. Submit in accordance with Division 01 and Sections 23 05 00.

B. Shop drawings of the control system shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers' catalog data sheets and installation instructions.

C. Shop drawings shall also contain complete wiring and schematic diagrams, sequences of operation, control system network riser diagram, floor plans and any other details required to demonstrate that the system has been coordinated and will properly function as specified.

D. Upon completion of the work, provide complete sets of 'as-built' drawings and other project-specific documentation.

E. Drawings

1. The Equipment Supplier shall submit engineered drawings using control sequences provided by Engineering Design Firm, and bill of materials for approval.
2. Drawings shall be available on web-based document storage site.

F. System Documentation

Include the following in submittal package:

1. System configuration diagrams in simplified block format.
2. All input/output object listings and an alarm point summary listing.
3. Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.
4. Complete bill of materials.
5. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
6. Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.

G. Damper schedule.

1.4 APPLICABLE PUBLICATIONS

The publications form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation.

1.5 WARRANTY

1. System installation and programming labor shall be warrantied for one year.
2. All Parts shall be warrantied against manufacturers defects for 3 years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

Manufacturers: Subject to compliance with requirements, provide products by the following: Siemens.

2.2 SYSTEM OVERVIEW

A. An open system architecture means each HVAC component (devices or applications) shall work together and deliver its specified level of performance with no loss. The following three layers are required:

1. Building Layer: On-premise master building controller and integrated device controllers.
2. Cloud Layer: Cloud computing architecture.
3. Application and Services: A web and mobile phone applications for operating, monitoring and controlling the system.

2.3 BUILDING LAYER

A. Support HVAC, energy and other industry protocol standards. Devices shall communicate with BACnet, Modbus or other open standard protocols.

B. The solution shall allow for selection of 3rd party devices (field controllers, thermostats, sensors) that are not limited to vendor branded devices.

C. There shall be no proprietary communication between the device and the building controller that is controlled solely by the vendor. Proprietary Gateways or Chip based protocols will not be permitted.

D. The master building controller shall have multi-protocol capabilities and shall perform control, scheduling, alarming, data logging, and have an onboard web server for local configuration and display.

E. The building controller shall not send BACnet data northbound (outside the network) to prevent security vulnerabilities. Any data sent outside the network must be encrypted using TLS version 1.2 or later.

F. Building Controller shall have contingencies available to handle a loss of network communication including local schedule, alarm detection and sequence of operations control, and at least two weeks of data and alarm data local storage.

G. The solution shall have a data model based on Project Haystack standards, conforming to the tagging found at this web page: https://project-haystack.org/tag. The data models shall be pre-built for rapid deployment.

H. The master building controller system will provide configurable notifications for alarms and alerts via email.

I. Hardware platform shall be based on Intel® reference architecture for IoT (version 2.0) and include an Intel® Processor-Based Solution (Intel® QuarkTM SoC, Intel® AtomTM Processor).

J. The building controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the local area network (LAN).

2.4 CLOUD LAYER

A. General: The System shall employ modern cloud applications designed for IoT and big data technologies. It shall be open at the cloud layer allowing for interaction with other cloud application via published APIs to support integration with other business application.

B. System management. The system shall have the ability to perform software updates in an automated fashion over the network. This includes updates of the master building controller Operating Systems and the application software loaded onto the master building controller. All updates should support a current form of digital signing to ensure the integrity of the software package.

C. Connectivity management. The solution should have the ability to detect communication failures both at the gateway level and downstream of the gateway.

D. Data collection, processing & management.

1. The system shall leverage a noSQL or equivalent distributed database. No additional database licenses shall be required.
2. Administrators and credentialed users shall be provided means to export customized data reports.

3. There shall be no limitation on the amount of data points stored over time.
4. Advanced analytics capabilities (AI & Machine learning, logic programming UI) shall be available.

2.5 APPLICATION LAYER

A. Web and mobile application: Web applications shall be HTML5, web browser-based and not require plug-ins. Mobile applications shall be native Apple iOS and Google Android, available for download at the respective app stores.

B. Monitor and Control: Application shall provide the ability to monitor and control the HVAC units and systems.

C. Notifications: Application shall provide the ability to send notifications via email and text and configure various escalations.

D. Canned and custom reporting: Application shall include a set of canned, existing reports and also allow for the user to create custom reports. Ad hoc trend graphing for all equipment and points shall be available.

E. Analytics. It shall be capable of performing advanced analytics and contain a library of fault detection and diagnostic algorithms specifically designed for HVAC systems.

F. Schedules: Application shall be able to view and adjust scheduled operating hours of each individual, schedulable piece of equipment on a weekly schedule display. Application shall be able to view and adjust exception schedules/holiday schedules on the schedule display. Application shall be able to create schedule groups and group like equipment schedules.

G. Graphics: Operator interface shall be accessible utilizing standard and supported web browser software. The graphical interface will display building locations on a geographic map, allowing for dynamic scaling. The equipment graphics user interface shall allow the operator to view system status and update control points for the most important data for each zone. A notification user interface shall allow for response to alarms and faults. Application shall include graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system.

H. Automated Demand Response/Utility services for HVAC (ADR) shall be Open ADR 2.0b certified and support functionality as a Virtual End Node (VEN) for Utility Demand Response. The OpenADR 2.0b profile specification is a flexible data model to facilitate common information exchange between electricity service providers, aggregators, and end users. The concept of an open specification is intended to allow anyone to implement the two-way signaling systems, providing the servers, which publish information (Virtual Top Nodes or VTNs) to the automated clients, which subscribe the information (Virtual End Nodes, or VENs). This OpenADR 2.0 profile specification covers the signaling data models between VTN and VEN (or VTN/VEN pairs) and does include information related to specific DR electric reduction or shifting strategies, which are taken at the facility or equipment level.

I. Global control, automation and commands. It shall allow for global set point management, control and schedules without the need to go site-by-site. It shall allow for grouping of points, devices, buildings or regions so that changes or rules may be applied accordingly.

J. User and systems management: System shall include a role-based permission structure for allowing multiple users to access the system. Logging of access for tracking authorized and unauthorized connections shall be included.

2.6 NETWORK COMMUNICATION AND SECURITY

A. The following networks (serial, IP, etc.) shall be communication capabilities of the system:

1. IP network for connecting the Building Layer to the Cloud Layer
2. IP network for connecting IP enabled devices to the Master Building Controller
3. MS/TP network for connecting serial devices to the Master Building Controller

B. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet network. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2004, BACnet.

1. Install new wiring and network devices as required to provide a complete and workable control network.
2. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.
3. Operator interface and value passing shall be transparent to architecture.
4. An operator interface connected to a controller shall allow the operator to interface with each integrated controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each controller.
5. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies as shown on the drawings. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

C. Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.

D. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

E. Network & Application Security

1. The system shall allow only secure remote access. It shall use an MQTT based communication channel where the master building controller initiates the communication so only outbound network access over a specific TCP port is required. This channel is encrypted and also includes facilities for bi-directional authentication and subsequent communication for a higher level of security than VPN based communication methods.
2. All communication shall be encrypted using TLS version 1.2 or later. The system should support role-based access control (RBAC) so different roles can be defined for users in according to their responsibilities, along with the corresponding applications and access rights.
3. A REST based API that is communicated with over HTTPS shall be available.

2.7 OPERATOR INTERFACE

A. A cloud-based internet appliance shall be used to provide Human to Machine interface with the CBMS. Provide:

1. Web client shall, at a minimum, support the following tablets:
   a. Android platform:
      1) Google Nexus
      2) Samsung Galaxy Note
   b. Apple platform
      1) Ipad
      2) Apple Ipad Mini
2. Smart mobile phone application shall, at a minimum, support the following platforms and download location:
   a. Android platform and Google Play Store
   b. Apple iOS platform and iOS App Store
3. Operator's workstation(s) shall be any laptop or desktop computer with the minimum requirements:
   a. Web Brower Application: Internet Edge, Firefox, Chrome, or Safari, with auto update enabled.
   b. Internet access

2.8 CONTROLLERS

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

B. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–10VDC, 4–20mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.

C. All program sequences shall be stored on board controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely through modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.

D. Application controller shall include support for intelligent room sensor. Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

E. Electric Duct Heater Control: Furnish step, SCR controllers to heater manufacturer for factory mounting in heater terminal box.

2.9 OPERATORS

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

B. Actuators.

1. Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation.
2. Spring-return Mechanism. Actuators used for all safety applications shall have an internal mechanical spring-return mechanism.
3. Signal and Range. Proportional actuators for modulating valve and damper service shall accept a 0-10 Vdc or a 0-20 mA input control signal and shall have a 0-10 Vdc or 4-20 mA operating range.
4. Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.
5. Analog Output: Actuators shall have an analog output to correlate to actual damper position.
6. Manual Override Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 60 in.-lb torque capacity shall have a manual crank.
7. Mechanical: Gear trains completely oil immersed and sealed.
8. Position Indicator: Actuators shall have a visible position indicator.
9. Actuators shall return to open or closed position as required to minimize possibilities of freezing, system malfunction or overheating upon system shutdown, changeover, or power failure.
10. Actuators shall be quiet and have ample power to provide smooth, repeatable proportional positioning under all operating conditions, and shall be rated to allow for motor, damper or valve deterioration.

2.10 DAMPERS

A. Construction

1. Blades: Reinforced or double panel galvanized steel or aluminum. Interlocking edges or compressible all-weather seals. Maximum blade width and length, 8 by 48 inches.
2. Bearings: Nylon or Oilite.
3. Frame: Heavy galvanized or aluminum channel braced at corners.
4. Linkages: Adjustable length with brass pin-clevis or ball-socket joints free of excessive play, accessible on front of damper.
5. Protect all steel parts with two coats rust inhibiting paint or galvanizing.
6. Construct duct-located dampers as specified with frames totally recessed out of the airstream. Pressure drop through full open damper shall not exceed 0.15-inch static pressure at 2000 FPM face velocity. Limit stop penetration into air stream to 1/2-inch.
7. Outdoor intake or duct shutoff dampers shall not leak more than 10 cfm per square foot at 4-inch w.g. pressure differential.

8. Dampers shall be structurally suitable for operation with pressure differentials encountered in system. See Section 23 31 13, "Ducts and Duct Accessories," for System Pressure Rating.
9. Dampers and frames in stainless steel ductwork shall be the same type stainless steel as the ductwork.
10. Select and arrange dampers for air mixing to provide convergent airflow to minimize stratification.

B. Characteristics

1. Flow characteristics with respect to operator travel shall approximate the following: Mixing Service: Linear
2. Characterized linkages shall be used where required to achieve these results.

2.11 TEMPERATURE SENSORS

A. Type. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.

B. Duct Sensors. Duct sensors shall be single point or averaging as required to meet performance requirements. Averaging sensors shall be used where ducts are larger than 9 sq. ft. or where prone to stratification, length as required.

C. Immersion Sensors. Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.

D. Space Sensors. Space sensors shall have setpoint adjustment and timed override pushbutton.

E. Outside Air Sensors: Watertight inlet fitting, shielded from direct sunlight where required and unshielded from sun where required by the drawings.

2.12 HUMIDITY SENSORS

1. Duct or plenum sensors shall have a sensing range of 20%-80%.
2. Duct or plenum sensors shall have a sampling chamber.
3. Outdoor air humidity sensors shall have a sensing range of 20%-95% RH and shall be suitable for ambient conditions of 40°F-170°F.
4. Humidity sensors shall not drift more than 1% of full scale annually
5. Humidity sensor shall have an accuracy of +/- 3%

2.13 END DEVICE AND HARDWARE

A. Relays

1. Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
2. Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

B. Override Timers

1. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0-12 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face.

C. Current Transmitters

1. AC current transmitters shall be self-powered, combination split-core or Rogowski current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
3. Unit shall be split-core type for clamp-on or Rogowski for installation on existing wiring.

D. Current Transformers

1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.
3. Use split-core or Rogowski transformers for existing wiring installation.

E. Voltage Transmitters

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.
2. Adjustable full-scale unit ranges shall be 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

F. Voltage Transformers

1. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.
2. Transformers shall be suitable for ambient temperatures of 40°F-130°F and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

G. Current Switches

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

H. Pressure Transducers

1. Transducers shall have linear output signal and field-adjustable zero and span.

2. Continuous operating conditions of positive or negative pressure 50% greater than calibrated span shall not damage transducer sensing elements.
3. Air differential pressure transducer shall be a direct reading device with a +/-1% accuracy of full scale. Unit shall provide a 4-20 mA output. Unit shall be Dwyer Series 616, with a range of 0-2 inches W.C.
4. Air differential pressure gage shall be a Dwyer Series 2000 Magnahelic Gage with an accuracy of +/- 2% of full scale. Range of gage shall be 0-2 inches W.C.
5. Differential Pressure Switches. Differential pressure switches shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

I. Local Control Panels

1. Indoor control panels shall be fully enclosed NEMA 1 construction with hinged door key-lock latch and removable sub-panels. A common key shall open each control panel and sub-panel.
2. Prewire internal and face-mounted device connections with color-coded stranded conductors tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring.
3. Each local panel shall have a control power source power switch (on-off) with overcurrent protection.

2.14 ELECTRIC WIRING AND CONTROL

A. Electrical work shall conform to the Electric Division requirements except as modified below.

B. Minimum wire size shall conform to NFPA 70 (National Electrical Code) requirements.

C. Minimum Conduit Size: Trade size 3/4-inch. Conduit mounted outdoors or in damp areas shall be rigid.

D. Class 1 Wiring (Greater than 30 volts): Install in conduit in accordance with NFPA 70 (National Electrical Code).

E. Class 2 Wiring (30 volts or less): Remote control and signal wiring may be run in multi-conductor cable with PVC insulation, Mylar binder and PVC jacket. Digital transmission shall be through twisted, shielded pair. Entire installation shall be in accordance with NFPA 70 (National Electrical Code), and shall meet additional requirements noted.

F. Cables carrying AC circuits sensitive to external fields shall be shielded.

G. Material installed in ceiling plenums used to transport air shall meet applicable code requirements.

H. Furnish control transformers with steel enclosures with separate primary and secondary compartments, each with conduit connections.

I. Secondary side of control transformer shall be fused.

J. Controllers and Operators

1. All controls shall be designed to function properly with a power source voltage variation of plus or minus 10 percent.
2. Operators shall be hydraulic, thermal or gear type, totally enclosed with oil immersed gear.
3. Select speed of operation to prevent hunting.

PART 3 - EXECUTION

3.1 AUTOMATIC CONTROL SYSTEM

A. Automatic control system subcontractor shall install and adjust entire control system and supervise initial operation with mechanics or subcontractors in his employ.

B. Identify gages and controls. Note normal conditions with permanent markings.

C. Control Diagrams

1. Submit in accordance with Section 23 05 00, “Basic Mechanical Materials and Methods,” black line schematic wiring and control piping diagrams including graphic system representation, operating sequence and control description for entire system.
2. Submit damper schedule.
3. Upon completion of work, mount one "as built" set of diagrams in control panel associated with diagram.

3.2 CONTROLLERS

A. Mount all controllers securely at accessible, vibration free locations.

B. Housings for controls inside ducts shall be streamlined. Location subject to COR’s approval.

C. Field check calibration and adjustment of all controllers.

D. Sensing Elements

1. Locate where responsive to representative temperatures or minimum temperature for low limit or freeze protection temperature sensors.
2. Provide elements with firm support and insulate from direct contact with coils or other heat conductors.
3. Provide immersion bulbs with brass or copper separable wells with extension necks where required for insulation.
4. Protect capillaries between element and controller where exposed to damage with flexible armor or conduit.

3.3 OPERATORS

Furnish operators for air terminal units to unit manufacturer if required for compatibility.

3.4 DAMPERS

A. Install in a manner to allow access to operators and linkages, and to provide the intended function.

B. Lubricate damper pivot points with graphite impregnated oil before system start-up and again before systems are turned over to the Owner. Maintain record of date of lubrication of each damper.

3.5 ELECTRIC WIRING AND CONTROL

A. Obtain control power from nearest power panel having 120 volts available. Provide branch circuit breaker in empty space in panel properly sized for load. Provide separate circuit breaker for each DDC cabinet.

B. Control power may be derived from line side of a starter provided circuit is fused and all controls so energized are associated only with this starter and motor.

C. Control transformer furnished as an integral part of a starter shall not be used as a power source for additional control.

D. Starter disconnect or separate switch immediately adjacent to starter shall disconnect power from all line voltage or 120-volt control wiring entering starter.

E. Furnish p.e. switches, step controllers, SCR controllers for control of electric duct heaters to heater manufacturer for installation in terminal box.

3.6 AUTOMATIC CLOUD-BASED CONTROL SYSTEM

Control of the primary equipment including items listed in the Input/Output (I/O) Summary Charts shall be performed by the Automatic Cloud-Based Control System.

3.7 COORDINATION WITH TESTING, ADJUSTING, AND BALANCING SUBCONTRACTOR

The Automatic Control System (ACS) Subcontractor shall put the system in the required mode of operation as requested by the Testing and Balancing (TAB) Subcontractor. All programming changes and reporting of data from the Building Automation System (BAS) needed to achieve proper performance shall be done by the ACS Subcontractor. The TAB Subcontractor shall be the lead Subcontractor in coordinating his work and the ACS Subcontractor's work. All work is by the TAB Subcontractor unless noted as being the responsibility of the ACS Subcontractor.

3.8 INPUT/OUTPUT (I/O) SUMMARY CHARTS

The control points on I/O Summary Charts are shown on the drawings.

END OF SECTION 23 09 23

SECTION 230993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the required sequence of operations for control of mechanical and domestic hot water systems. The points for remote monitoring are also identified herein. The control system requirements are identified in Section 230900 "Instrumentation and Control for HVAC".

PART 2 – NOT USED

PART 3 – EXECUTION

3.1 SEQUENCE OF OPERATIONS

A. Chimborazo Visitor Center
   1. DX Split System Heat Pump (HP-1A &2A, CU-1A &2A)
      a. The air source heat pump shall operate upon a call for heating or cooling from the associated manufacturer's 7-day programmable zone thermostat using the manufacturer's integral controls.
      b. Alarms and signals shall be monitored through the main centralized controller (see equipment schedules), located in basement mechanical room.
      c. On a call for heating or cooling from a zone thermostat, the integral refrigerant expansion valves will modulate as required to satisfy the space temperature set points:
         i. Heating Set Point - Occupied: 68°F, 55% RH (adjustable)
         ii. Heating Set Point - Unoccupied: 55°F (adjustable)
         iii. Cooling Set Point - Occupied: 74°F (adjustable)
         iv. Cooling Set Point - Unoccupied: 80°F (adjustable)

   2. Single Packaged Heat Pump (AHU-1A)
      a. The air source heat pump shall operate upon a call for heating or cooling from the associated manufacturer's 7-day programmable zone thermostat using the manufacturer's integral controls.
      b. Alarms and signals shall be monitored through the main centralized controller (see equipment schedules), located in basement mechanical room.
      c. On a call for heating or cooling from a zone thermostat, the integral refrigerant expansion valves will modulate as required to satisfy the space temperature set points:
         i. Heating Set Point - Occupied: 68°F, 55% RH (adjustable)
         ii. Heating Set Point - Unoccupied: 55°F (adjustable)
         iii. Cooling Set Point - Occupied: 74°F (adjustable)
         iv. Cooling Set Point - Unoccupied: 80°F (adjustable)

   3. Variable Air Volume Terminal Box (VAV)
      a. VAV boxes shall be controlled by local (box mounted) controller communicating the local thermostat and AHU controller.
      b. Set points and occupancy schedule shall be adjustable from the AHU manufactures controller. Local thermostats shall be capable of setpoint adjustments.
      c. All VAVs shall have a flow rate sensor that shall be maintained by the local controller.

d. Temperature Control: Heating Set Point: 68°F (adjustable)
   i. When the space temperature is above the heating setpoint and is less than the cooling setpoint, supply valve set to minimum airflow.
   ii. If any temperature sensor is calling for heating and the outside air temperature is below 50 deg f, the perimeter radiation heating valve shall fully open. when
   iii. If air flow is at minimum occupied flow setpoint and temperature continues to drop below setpoint, air flow control damper shall modulate open to maintain setpoint.
e. Temperature Control: Cooling Set Point: 74°F (adjustable)
   i. When the space temperature is above the heating setpoint and is less than the cooling setpoint, supply valve set to minimum airflow.
   ii. Upon a rise in temperature above the cooling setpoint, the supply valve shall modulate towards maximum airflow.
   iii. As the space temperature drops towards the cooling setpoint, the supply valve shall modulate towards minimum airflow.

4. Exhaust Fan (EF-1A)
   a. Fan shall run continuously during occupied hours.
   b. Occupied hours shall be determined by the park.
   c. Alarms and signals shall be monitored through the main centralized controller.

B. Cold Harbor Visitor Center
1. DX Split System Heat Pump (HP-1B, CU-1B)
   a. The air source heat pump shall operate upon a call for heating or cooling from the associated manufacturer's 7-day programmable zone thermostat using the manufacturer's integral controls.
   b. On a call for heating or cooling from a zone thermostat, the integral refrigerant expansion valves will modulate as required to satisfy the space temperature set points:
      i. Heating Set Point - Occupied: 68°F, 55% RH (adjustable)
      ii. Heating Set Point - Unoccupied: 55°F (adjustable)
      iii. Cooling Set Point - Occupied: 74°F (adjustable)
      iv. Cooling Set Point - Unoccupied: 80°F (adjustable)
2. Exhaust Fan (EF-1B)
   a. Fan shall run continuously during occupied hours.
   b. Occupied hours shall be determined by the park.
   c. Alarms and signals shall be monitored through the main centralized controller.

C. Watt House
1. DX Split System Heat Pump (HP-1E, 2E & 3E, CU-1E, 2E & 3E)
   a. The air source heat pump shall operate upon a call for heating or cooling from the associated manufacturer's 7-day programmable zone thermostat using the manufacturer's integral controls.
   b. On a call for heating or cooling from a zone thermostat, the integral refrigerant expansion valves will modulate as required to satisfy the space temperature set points:
      i. Heating Set Point: 68°F (adjustable)
      ii. Cooling Set Point: 74°F (adjustable)

D. Ranger Office, 1900 Maintenance Way
1. DX Split System Heat Pump (HP-1F & 2F, CU-1F & 2F)

a. The air source heat pump shall operate upon a call for heating or cooling from the associated manufacturer's 7-day programmable zone thermostat using the manufacturer's integral controls.
b. Alarms and signals shall be monitored through the main centralized controller (see equipment schedules), located in basement mechanical room.
c. On a call for heating or cooling from a zone thermostat, the integral refrigerant expansion valves will modulate as required to satisfy the space temperature set points:
   i. Heating Set Point - Occupied: 68°F, 55% RH (adjustable)
   ii. Heating Set Point - Unoccupied: 55°F (adjustable)
   iii. Cooling Set Point - Occupied: 74°F (adjustable)
   iv. Cooling Set Point - Unoccupied: 80°F (adjustable)

E. Maintenance Building
1. DX Split System Heat Pump (HP-1H, 2H, & 3H, CU-1H, 2H, & 3H)
   a. The air source heat pump shall operate upon a call for heating or cooling from the associated manufacturer's 7-day programmable zone thermostat using the manufacturer's integral controls.
   b. On a call for heating or cooling from a zone thermostat, the integral refrigerant expansion valves will modulate as required to satisfy the space temperature set points:
      i. Heating Set Point - Occupied: 68°F, 55% RH (adjustable)
      ii. Heating Set Point - Unoccupied: 55°F (adjustable)
      iii. Cooling Set Point - Occupied: 74°F (adjustable)
      iv. Cooling Set Point - Unoccupied: 80°F (adjustable)
2. Exhaust Fan (EF-1H, 2H, &3H)
   a. Fans shall be controlled by thermostat set to 85ºF.
   b. When space is above the set point, one fan shall turn on. If space temperature continues to rise, then the second fan shall turn on. This shall continue until all (3) fans are enabled.
   c. If space temperature is below 80ºF, for more than 10 consecutive minutes, the fans shall disengage, one at a time.

F. Auto Shop
1. Hot Water System
   a. System Operation:
      i. The heating hot water system shall be available 24 hours per day, 7 days per week.
      ii. The system temperature control shall be maintained to provide setpoint (140 degree F adjustable) supply water temperature.
      iii. Boiler controls by boiler manufacturer.
   b. Water Volume Control:
      i. The boiler pumps (P-1I) shall modulate motor speed to maintain the system differential pressure setpoint. Pump speed shall be increased in response to a decrease in system differential pressure. Pump speed shall be decreased in a response to an increase in system differential pressure.
   c. Boiler Control
      i. Upon a call for heating for any zone, P-I shall operate and B-1I shall stage as required to maintain 120ºF (adjustable) heating water supply temperature.
      ii. When a zone thermostat calls for heating, the circulator pump (P2I &3I) shall operate until the thermostat is satisfied.
   d. Space temperature set points:

i. Heating Set Point - Occupied: 68°F (adjustable)
ii. Heating Set Point - Unoccupied: 55°F (adjustable)

2. Packaged Terminal Air Conditioner (PTAC-1I)
   a. The PTAC shall operate upon a call for heating or cooling from the associated manufacturer's 7-day programmable zone thermostat using the manufacturer's integral controls.
   b. On a call for heating or cooling from a zone thermostat, the integral refrigerant expansion valves will modulate as required to satisfy the space temperature set points:
      i. Heating Set Point - Occupied: 68°F, 55% RH (adjustable)
      ii. Heating Set Point - Unoccupied: 55°F (adjustable)
      iii. Cooling Set Point - Occupied: 74°F (adjustable)
      iv. Cooling Set Point - Unoccupied: 80°F (adjustable)
3. Bathroom Exhaust Fan (EF-1I)
   a. Fan shall be controlled with a local switch.
4. Vehicle Extractor Exhaust Fan (EF-2I)
   a. Fan shall be controlled with local switch.
5. Exhaust Fan (EF-3I)
   a. Fan shall be controlled with an on/auto switch.
   b. Tie existing louver damper actuators into exhaust fan control. Damper shall be normally closed. When fan is in operation L-2 and L-3 damper shall open.
6. Air Cleaner (CL-1I)
   a. Fan shall be controlled with local switch.

G. Garthright House
1. DX Split System Heat Pump (HP-1D & 2D, CU-1D & 2D)
   a. The air source heat pump shall operate upon a call for heating or cooling from the associated manufacturer's 7-day programmable zone thermostat using the manufacturer's integral controls.
   b. On a call for heating or cooling from a zone thermostat, the integral refrigerant expansion valves will modulate as required to satisfy the space temperature set points:
      i. Heating Set Point: 68°F (adjustable)
      ii. Cooling Set Point: 74°F (adjustable)

H. Quarters 12, 1910 Maintenance Way
1. DX Split System Heat Pump (HP-1G, CU-1G)
   a. The air source heat pump shall operate upon a call for heating or cooling from the associated manufacturer's 7-day programmable zone thermostat using the manufacturer's integral controls.
   b. On a call for heating or cooling from a zone thermostat, the integral refrigerant expansion valves will modulate as required to satisfy the space temperature set points:
      i. Heating Set Point: 68°F (adjustable)
      ii. Cooling Set Point: 74°F (adjustable)

I. Fort Harrison Visitor Center

1. Single Packaged Heat Pump (AHU-1C)
   a. The air source heat pump shall operate upon a call for heating or cooling from the associated manufacturer's 7-day programmable zone thermostat using the manufacturer's integral controls.

b. Alarms and signals shall be monitored through the main centralized controller (see equipment schedules), located in basement mechanical room.
c. On a call for heating or cooling from a zone thermostat, the integral refrigerant expansion valves will modulate as required to satisfy the space temperature set points:
   i. Heating Set Point - Occupied: 68°F, 55% RH (adjustable)
   ii. Heating Set Point - Unoccupied: 55°F (adjustable)
   iii. Cooling Set Point - Occupied: 74°F (adjustable)
   iv. Cooling Set Point - Unoccupied: 80°F (adjustable)

2. DX Split System Heat Pump (HP-1C &2C, CU-1C)
   a. The air source heat pump shall operate upon a call for heating or cooling from the associated manufacturer's 7-day programmable zone thermostat using the manufacturer's integral controls.
   b. Alarms and signals shall be monitored through the main centralized controller (see equipment schedules), located in basement mechanical room.
   c. On a call for heating or cooling from a zone thermostat, the integral refrigerant expansion valves will modulate as required to satisfy the space temperature set points:
      i. Heating Set Point - Occupied: 68°F, 55% RH (adjustable)
      ii. Heating Set Point - Unoccupied: 55°F (adjustable)
      iii. Cooling Set Point - Occupied: 74°F (adjustable)
      iv. Cooling Set Point - Unoccupied: 80°F (adjustable)

3. Energy Recovery Unit (ERV-1C)
   a. The ERV system shall be configured to run continuously with a wall mounted control panel during occupied hours.
   b. Occupied hours shall be determined by the park.
   c. When outside air temperatures are below 45°F. Electric reheat coil shall be enabled.

4. Unit Heater (UH-1C)
   a. Temperature Sensor shall cause fan to start and electrical coil to turn on.
   b. When temperature rises above set point fan and electric coil shall turn off.
   c. Heating Set Point: 55°F (adjustable)

END OF SECTION 230923

SECTION 232100 HYDRONIC PIPING

PART 1 GENERAL

1.1 SUMMARY

A. The Contractor shall furnish and install all HVAC piping and accessories as shown on the Drawings and in accordance with the Specifications.

B. Section includes:
   1. Hydronic system pumps
   2. Hydronic piping materials and fittings
   3. Hydronic system valves and accessories
   4. Hydronic piping system air control devices.
   5. Hydronic system meters and gauges
   6. Hydronic piping specialties and components
   7. Piping insulation

C. Requirements apply to the following hydronic systems:
   1. Hot-water heating piping.
   2. Chilled-water piping.
   3. Glycol cooling or heating-water piping.
   4. Makeup-water piping.
   5. Condensate-drain piping.
   6. Blowdown-drain piping.
   7. Air-vent piping.
   8. Safety-valve-inlet and -outlet piping.

1.2 Submittals:

A. Product Data: For each type of the following:
   1. Hydronic pumps
      a. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
   2. Indicate pump's operating point on curves.
   3. Pipe, fittings and joining materials.
   4. Bypass chemical feeder.
   5. Expansion joints, alignment guides, and anchors.
   6. Thermometers, thermowells, pressure gages, and test plugs
   7. Thermal-energy meters
   8. Ball valves, butterfly valves, check valves, and globe valves
   9. Strainers
   10. Suction diffusers

11. Hydronic specialty valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
    a. Calibrated balancing valves
    b. Automatic flow control valves
12. Pressure reducing valves
13. Triple duty valves
14. Chainwheel operators
15. Air-control devices.
16. Flexible connectors and expansion fittings.
17. Sleeves
18. Sleeve-seal systems.
19. Grout
20. Escutcheons.

B. Shop Drawings: For each pump.
    1. Show pump layout and connections.
    2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
    3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal:
    1. Design calculations and detailed fabrication and assembly of hangers and supports for multiple pipes and attachments of the same to the building structure.
    2. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
    3. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.
    4. Expansion fittings and loops: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
    5. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections. Design and prepare drawings and calculations for restraint of pipe expansion loops, joints, pipe alignment guides, and pipe anchors, supports and attachments of the same to the building structure. Include seal and signature of Registered Engineer, licensed in jurisdiction where Project is located, certifying compliance with specifications. Submit maximum anchor reaction loads for review and approval to the Structural Engineer.
    6. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
    7. Alignment Guide Details: Detail field assembly and attachment to building structure.
    8. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
    9. Locations: Indicate locations of pipe anchors, alignment guides, and expansion joints and loops.

1.3 QUALITY ASSURANCE

A. All welding processes (including, but not limited to, procedures and welding operator qualifications) shall be in strict accordance with the requirements of Section IX of the ASME Boiler and Pressure Vessel Code (edition, including any addenda, in effect at the time of contract execution). On butt weld joints, provide full penetration welds. On socket weld fittings it is required that the toe of weld blends smoothly with no undercut in pipe wall.

B. Installations, equipment and material provided shall comply with federal, state and local laws, regulations, codes, specifications and standards. In the event of any apparent conflict among standards, codes or this specification, refer conflict to the Owner for written resolution. If work is performed or installation is completed in variance with applicable codes and regulations, remove and replace work to rectify the installation.

C. Welding of stanchions, brackets, anchors and other welding not performed on pipe joints shall be in accordance with requirements of AWS specifications and requirements.

D. Welder Qualification:

1. Test welders to demonstrate ability to make acceptable welds. Tests conducted for qualification of welder for work under one Division or Section shall not qualify welder for work under another Division or Section.

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

3. Pipe Welding Qualifications: Qualify procedures and personnel according to Section IX ASME Boiler and Pressure Vessel Code.

4. Records of tests shall be as follows: Each welder shall be assigned an identifying number, letter or symbol. Identifying mark shall be stamped adjacent to welds made by this welder. Identification shall be at top of horizontal piping and at front of vertical piping.

5. Maintain record of welders employed, showing dates and results of tests and identifying mark assigned to each welder. Certify records and make them accessible to Owner's project representative and/or project manager. Before completion of project, one copy of records

6. No qualification shall be older than three years when welder commences work on this project. If welder has not welded in required welding process for a period of six months, he shall be re-certified.

E. 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.

F. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

G. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

2. ASME B31.1 for power piping valves.

3. ASME B31.9 for building services piping valves.

1.4 COORDINATION

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

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08.

PART 2 PRODUCTS

2.1 HYDRONIC DISTRIBUTION PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Armstrong Pumps, Inc.
2. Bell & Gossett a Xylem Brand
3. Grundfos Pumps Corporation.
4. Taco Comfort Solutions, Inc.

B. General Requirements:

1. Source Limitations: Except automatic condensate pump units, obtain pumps from single source from single manufacturer.

2. Description: Factory-assembled and -tested, centrifugal, pump as defined in HI-1.1, HI-1.2 and HI-1.3.

3. Pump Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 23.

a. Enclosure Type: Totally enclosed, fan cooled.

b. NEMA Premium Efficient motors as defined in NEMA MG 1.

c. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor.

d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

e. Variable-speed motor. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.

f. Electrical Characteristics: Refer to schedules on drawings.

C. Inline Pumps:

1. Pump Type: Match scheduled equipment pump type.

a. Close-coupled in-line pumps shall be designed for installation with pump and motor shafts mounted horizontally or vertically.

b. Split-coupled pumps shall be designed for installation pump and motor shafts mounted vertically.

c. Maximum Operating Conditions: 225 deg F and 175 psig] working pressure.

2. Pump Construction:

a. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, and threaded companion-flange connections.

b. Impeller: Cast bronze or stainless-steel; statically and dynamically balanced, and keyed to shaft.

c. Pump Shaft: Carbon or alloy steel, with copper-alloy shaft sleeve.

d. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat rated for a minimum of 250 deg F.

e. Pump Bearings: Permanently lubricated ball bearings.

f. Shaft Coupling: Molded rubber insert with interlocking spider or interlocking frame with interconnecting springs capable of absorbing vibration.

g. Provide integral pump motor variable-speed controller.

D. End Suction Pumps, Base Mounted:

a. General

i. The pump internals shall be capable of being services without disturbing piping connections, electrical motor, connections or pump to motor alignment. Pump shall be designed to allow for true back pull-out allowing access to the pump's working components for ease of maintenance.

ii. The pumps shall be composed of three separable components a motor, bearing assembly, and pump end (wet end). The motor shaft shall be connected to the pump shaft via a replaceable flexible coupling.

iii. Maximum Operating Conditions: 225 deg F and 175 PSIG working pressure.

iv. Base plate shall be of structural steel or fabricated steel channel with fully open grouting area (for field grouting). The minimum base plate stiffness shall conform to ANSI/HI 1.3.8-2019 for grouted Horizontal Baseplate Design standards.

b. Pump Type: Match scheduled equipment pump type

i. Flex-coupled pumps shall be designed for installation with pump and motor shafts mounted horizontally.

c. Pump Construction:

i. Casing: Vertically split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gauge tappings at inlet and outlet, and flanged connections.

1. Pump volute shall be of a cast iron design with integrally cast pedestal volute support with integral cast iron flanges. Volute shall include gauge ports at nozzles, and vent and drain ports.

ii. Impeller: Cast bronze or stainless-steel; statically and dynamically balanced to ANSI/HI 9.6.4-2016, balance grade G6.3, keyed to shaft, and secured with a stainless-steel locking cap screw or nut.

iii. Pump Shaft and Sleeve: The pump shall incorporate a dry shaft design to prevent the circulating fluid from contacting the shaft. The pump shaft shall be of carbon or stainless steel with field replaceable bronze or stainless-steel sleeve covering all wetted areas under the sleeve. Shaft sleeve shall be slip on (press on not allowable) and must be easily replaced in the field.

iv. Pump Stub Shaft: Where manufacturer uses a stub shaft, shaft shall be type 304 stainless steel.

v. Coupling: Capable of absorbing torsional vibration, between the pump and motor. Pumps for variable speed application shall be provided with a manufacturer recommended coupling sleeve. Coupling shall allow for removal of

pump wetted end without disturbing pump volute or movement of the pump motor and electrical connections.

vi. An ANSI and OSHA rated coupling guard shall shield the coupling during operation. Coupling guard shall be dual rated ANSI B15.1 and OSHA 1910.219 compliant and contain viewing windows for inspection of the coupling. No more than 0.25 inches of either rotating assembly shall be visible beyond the coupling guard.

vii. A bearing assembly shall support the shaft via two heavy-duty re-greaseable ball bearings or permanently sealed bearings with an L10 life of 60,000 hours. Bearing assembly shall be replaceable without disturbing the system piping and shall have foot support at the coupling end. Pump bearings shall be re-greaseable without removal of the bearings from the bearing assembly.

viii. Thermal expansion of the shaft toward the impeller shall be prevented via an inboard thrust bearing.

ix. Seal: Manufacturer recommended mechanical seal selected to meet pressure and temperature rating based on system fluid (water or glycol). Seal shall consist of rotating ring against a seat held by a stainless-steel spring, bellows and seat gasket. Include water slinger on shaft between motor and seal.

x. Pump shall be equipped with either an internally flushed mechanical seal

xi. assembly installed in an enlarged tapered seal chamber or manufacturer optional external seal flush line assembly.

1. For pumps used on open systems (cooling towers) include manufacturer recommended replaceable cartridge filter or separator with shut-off isolation valve installed in the seal flushing line. The filter shall have the ability to remove particles down to five microns in size.

xii. Provide integral pump motor variable-speed controller.

2.2 HYDRONIC PIPING MATERIALS AND FITTINGS

A. Copper Tube and Fittings

1. Drawn-Temper Copper Tubing Above Ground: ASTM B 88, Type L (ASTM B 88M, Type B).

2. Brazed Joint Fittings

a. Wrought-Copper Fittings, Unions and Couplings: ASME B16.22

3. Press Joint Fittings (125 psig pressure rated systems only):

a. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

i. Anvil International
ii. NIBCO
iii. Viega ProPress
iv. Apollo

b. Wrought-Copper Fittings, Unions and Couplings: ASME B16.51

c. EPDM Gasket: Manufacturer standard O-rings for specific application. Provide o-ring and indicator lubricant. Manufacturer shall verify water quality at the site will not negatively affect O-ring or lubricant.

B. Steel Pipe and Fittings

1. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping, Specialty and Valve Applications" Article.

2. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping, Specialty and Valve Applications" Article.

3. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping, Specialty and Valve Applications" Article.

4. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping, Specialty and Valve Applications" Article.

5. 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 "Piping, Specialty and Valve Applications" Article.

6. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

7. 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:
   a. Material Group: 1.1.
   b. End Connections: Butt welding.
   c. Facings: Raised face.

8. Grooved Mechanical-Joint Fittings and Couplings:

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

i. Anvil International, Inc.
ii. Star Pipe Products.
iii. Victaulic Company.

b. 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/A 106M, 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.

c. Couplings: Ductile- or malleable-iron housing and EPDM gasket rated for minimum 230 deg F and of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings. Couplings used for expansion compensation including loops shall be flexible type couplings.

9. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

C. Joining Materials

1. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to:
i. Grafoil
ii. Flexitallic

b. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless otherwise indicated.
i. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

c. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

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

4. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

5. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

a. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

D. Transition Fittings

1. Plastic-to-Metal Transition Fittings:

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

i. Charlotte Pipe and Foundry Company.

ii. IPEX Inc.

iii. KBI (King Bros. Industries).

b. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

2. Plastic-to-Metal Transition Unions:

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

i. Charlotte Pipe and Foundry Company.

ii. IPEX Inc.

iii. KBI (King Bros. Industries).

iv. NIBCO INC; Model #T/S-1710.

b. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

E. Flexible Hose Connectors - Maximum Pipe Size 1 inch NPS.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. IMI Flow Design
   b. Macon
   c. Nexus

2. Minimum Operating Pressure Rating: 225 psig at 230 deg F.

3. 304 stainless steel braided hose with EPDM core.

4. End connections: Match piping and equipment connections.

5. Maximum length: 18 inches unless noted otherwise.

F. Dielectric Fittings

1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

2. Dielectric Unions:

   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      i. A.Y. McDonald Mfg. Co.
      ii. Capitol Manufacturing Company.
      iii. Central Plastics Company.
      iv. Hart Industries International, Inc.
      v. Jomar International, Ltd.
      vi. Matco-Norca.
      vii. Watts Regulator Co.
      viii. Zurn Industries, LLC; AquaSpec Commercial Faucet Products.

   b. Description:
      i. Standard: ASSE 1079.
      ii. Refer to Part 3 for pressure and temperature rating.

   c. End Connections: Solder-joint copper alloy and threaded ferrous.
      i. Fittings in "Dielectric Flanges" Paragraph below are available in NPS 1-1/2 to NPS 4 (DN 40 to DN 100).

3. Dielectric Flanges:

   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      i. Capitol Manufacturing Company.
      ii. Central Plastics Company.
      iii. Matco-Norca.
      iv. Watts Regulator Co.
      v. Zurn Industries, LLC; AquaSpec Commercial Faucet Products.

   b. Description:
      i. Standard: ASSE 1079.
      ii. Factory-fabricated, bolted, companion-flange assembly.
      iii. Refer to Part 3 for pressure and temperature rating.
      iv. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

G. Bypass Chemical Feeder

1. Provide bypass feeder(s) with a 5-gallon capacity. The feeder shell and tank heads shall be constructed of steel.

2. Bypass feeder at a minimum shall be rated at same pressure and temperature as system served.

3. The tank shall have a wide mouth, to allow chemical addition without the need of a funnel. The bypass feeder shall have a continuous threaded closure requiring multiple turns to close and seal. Closures using partial threads or lugs shall not be considered.

4. Cap shall be constructed of cast iron with manufacturer recommended treatment of underside to prevent corrosion. Provide with gasket seal.

5. Bypass feeder shall be provided with legs to elevate the feeder off the floor. The legs shall have holes to allow mounting by anchor bolts.

H. Expansion Loops, Joints, Swing Connections, Alignment Guides and Anchors

1. Field Fabricated Expansion Loops: Fabricate expansion loops using piping materials and fittings to dimensions shown on the approved shop drawings. Loop sizes shown on the contract drawings are for bid purposes only. Sizes must be confirmed using actual field location of anchors and guides.

2. Factory Fabricated Expansion Joints and Loops (Stainless Steel Hose)
   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      i. Flex-Hose Co., Inc.
      ii. Hyspan
      iii. Linetics Noise Control
      iv. Metraflex, Inc.
      v. U-shaped or V-shaped subject to meeting expansion requirements and space limitations of the project.
      vi. Connections to match system.
      vii. Class: 150
      viii. 300 Series Stainless Steel or Bronze Hose and Braid
      ix. 90 and 180 degree turns: Carbon steel schedule 40

3. Metal Externally Pressurized Bellows Packless Expansion Joints
   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      i. Adsco Manufacturing LLC.
      ii. American BOA, Inc.
      iii. Expansion Joint Systems, Inc.
      iv. Flex-Hose Co., Inc.
      v. Metraflex, Inc.

vi. U.S. Bellows, Inc.

4. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

5. Type: Circular, externally pressurized corrugated bellows.

6. Refer to Part 3 for pressure and temperature rating.

7. Configuration: Single joint class(es) unless otherwise indicated.

8. Expansion Joints for Copper Tubing: Multi-ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
   a. End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint.

9. Expansion Joints for Steel Piping: Multi-ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.
   a. End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
   b. End Connections for Steel Pipe NPS 2-1/2 (DN 65) and Larger: Flanged or Weld.

10. Alignment Guides and Anchors

    a. Alignment Guides:

       i. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
          1. Adsco Manufacturing LLC.
          2. Advanced Thermal Systems, Inc.
          3. Flex-Hose Co., Inc.
          4. Flexicraft Industries.
          5. Flex-Weld, Inc.
          6. Hyspan Precision Products, Inc.
          7. Metraflex, Inc.
          8. Senior Flexonics Pathway.
          9. Unisource Manufacturing, Inc.
          10. U.S. Bellows, Inc.

       ii. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

       iii. Anchor Materials:
          1. Steel Shapes and Plates: ASTM A 36/A 36M.
          2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
          3. Washers: ASTM F 844, steel, plain, flat washers.

4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened Portland cement concrete, with tension and shear capacities appropriate for application.
5. Stud: Threaded, zinc-coated carbon steel.
6. Expansion Plug: Zinc-coated steel.
7. Washer and Nut: Zinc-coated steel.

b. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

c. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

2.3 HYDRONIC SYSTEM METERS AND GAUGES

A. Liquid-in-glass Thermometers

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Flo Fab Inc.
   b. Miljoco Corporation.
   c. Palmer Wahl Instrumentation Group.
   d. Tel-Tru Manufacturing Company.
   e. Trerice, H. O. Co.
   f. Weiss Instruments, Inc.
   g. Winters Instruments - U.S.

2. Standard: ASME B40.200.
3. Case: Cast aluminum or plastic; 9-inch (229-mm) nominal size unless otherwise indicated.

4. Case Form:
   a. When mounted between 3 and 7 feet above the floor: straight.
   b. When mounted at all other heights: adjustable angle

5. Tube: Glass with magnifying lens and blue or red organic liquid.

6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C).

7. Window: Glass or plastic.

8. Stem: Aluminum, brass, or stainless steel and of length to suit installation.
   a. Design for Air-Duct Installation: With ventilated shroud.

b. Design for Thermowell Installation: Bare stem.

9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.

10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Thermowells

1. Standard: ASME B40.200.

2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.

3. Material for Use with Copper Tubing: CNR or CUNI.

4. Material for Use with Steel Piping: CRES or CSA.

5. Type: Stepped shank unless straight or tapered shank is indicated.

6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.

7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.

8. Bore: Diameter required to match thermometer bulb or stem.

9. Insertion Length: Length required to match thermometer bulb or stem.

10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

12. Heat-Transfer Medium: Mixture of graphite and glycerin.

C. Pressure Gages

1. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
i. Ernst Flow Industries.
ii. Flo Fab Inc.
iii. Marsh Bellofram.
iv. Trerice, H. O. Co.
v. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.

vi. Weiss Instruments, Inc.

b. Standard: ASME B40.100.

c. Case: Liquid-filled Sealed type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter.

d. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.

e. Pressure Connection: Brass, with NPS 1/2 (DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.

f. Movement: Mechanical, with link to pressure element and connection to pointer.

g. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) psi and kPa.

h. Pointer: Dark-colored metal.

i. Window: Glass.

j. Ring: Metal.

k. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   i. Ernst Flow Industries.
   ii. Flo Fab Inc.
   iii. Marsh Bellofram.
   iv. Trerice, H. O. Co.
   v. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   vi. Weiss Instruments, Inc.
b. Standard: ASME B40.100.
c. Case: Liquid-filled Sealed type; cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter with back flange and holes for panel mounting.
d. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
e. Pressure Connection: Brass, with NPS 1/2 (DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
f. Movement: Mechanical, with link to pressure element and connection to pointer.
g. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa).
h. Pointer: Dark-colored metal.
i. Window: Glass.

j. Ring: Metal.
k. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

D. Gage Attachments

1. Snubbers: ASME B40.100, brass; with NPS 1/2 (DN 15), ASME B1.20.1 pipe threads and piston or porous-metal-type surge-dampening device. Include extension for use on insulated piping.

2. Siphons: Loop-shaped section of stainless-steel pipe with NPS 1/2 (DN 15) pipe threads.

3. Valves: Brass or stainless-steel needle, with NPS 1/2 (DN 15), ASME B1.20.1 pipe threads.

E. Test Plugs

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Flow Design, Inc.
   b. Miljoco Corporation.
   c. National Meter, Inc.
   d. Peterson Equipment Co., Inc.
   e. Sisco Manufacturing Company, Inc.
   f. Trerice, H. O. Co.
   g. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   h. Weiss Instruments, Inc.

2. Description: Test-station fitting made for insertion into piping tee fitting.

3. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

4. Thread Size: NPS 1/2 (DN 15), ASME B1.20.1 pipe thread.

5. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).

6. Core Inserts: Chloro-sulfonated polyethylene synthetic and EPDM self-sealing rubber.

F. Flow and Thermal-Energy Meters

1. Full-Bore Magnetic Flow Meters:

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

      i. Onicon Inc.

ii. Foxboro by Schneider Electric.

iii. Siemens.

b. Description: Meter with flow sensor, transmitter, indicator, and connecting wiring. Sensor shall be a magnetic flowmeter, which utilizes Faraday's Law to measure volumetric fluid flow through a pipe. The flow meter shall consist of two elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.

c. Flow Sensor: Full-bore magnetic type with transmitter.

d. Electric replacement shall not affect meter accuracy (electric units are not matched with specific sensors).

e. Four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). BACnet compatible 4-20mA or 0-10Vdc output signal provided accuracy is as specified.

f. Flow tube

i. ANSI class 1034 kPa (150 psig) steel

ii. ANSI flanges

iii. Protected with PTFE, PFA, or ETFE liner rated for 118.3 deg C (245 deg F) minimum fluid temperature.

g. Electrode and grounding material:

i. 316L stainless steel or Hastelloy C

ii. Electrodes shall be fused to ceramic liner and not require O-rings.

h. Electrical enclosure. NEMA 4 or 7.

i. Approvals:

i. UL or CSA

j. Indicator: Solid-state, integrating-type meter.

i. Data Output: Electromechanical counter with readout in gallons per minute (liters/second.

k. Accuracy: Plus or minus 0.5 percent.

l. Performance

i. Accuracy shall be plus or minus 0.5 percent of actual reading from 3 to 30ft/s flow velocities, and 2 percent from 0.04 to 3 ft/s.

ii. Stability. 0.1 percent of rate over six months.

iii. Meter repeatability shall be plus or minus 0.1 percent of rate at velocities greater than3 ft/s.

iv. Maximum pressure loss: 0.5 psi.

m. Display: Visually indicates total fluid flow in gallons per minute.

n. Operating Instructions: Include complete instructions with each flow meter system.]

2.4 Additional Requirements for Thermal-Energy Meters:

a. Description: Meter with flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.

b. Flow Sensor: Full-Bore Magnetic Flow Meter as specified.

c. Temperature Sensors: Matched RTD, solid-state, or thermistor temperature sensors with a differential temperature accuracy of plus or minus 0.15 deg F.

d. Indicator: Solid-state, integrating-type meter.

e. Accuracy: Plus or minus 1 percent factory calibrated, traceable to NIST with certification.

f. NEMA 1 enclosure.

g. Panel mounted display.

h. UL listed.

i. Isolated 4–20 mA signals for energy rate and supply and return temperatures and flow.

j. Energy meter shall be equipped with an instantaneous flow and a totalized flow with a totalizer that can hold one month of data.

i. Data Output: Electromechanical counter with instantaneous readout in British thermal units per hour.

ii. Provide totalizer to indicate energy use in British thermal units or thousand British thermal units (MBTU)

k. Operating Instructions: Include complete instructions with each thermal-energy meter system.

2.5 HYDRONIC SYSTEMS VALVES AND ACCESSORIES

A. General Valve Requirements

1. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures. Valves shall have name of manufacturer and guaranteed working pressure cast or stamped on bodies. Gaskets and packings shall not contain asbestos.
2. Valve Sizes: Same as upstream piping unless otherwise indicated.
3. Valve Actuator Types:
   a. Gear Actuator: For quarter-turn valves NPS 8 DN 200 and larger.
   b. Handwheel: For valves other than quarter-turn types.
   c. Handlever: For quarter-turn valves NPS 6 DN 150 and smaller except plug valves.
   d. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.
   e. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.
4. Valves in Insulated Piping: With 2-inch 50-mm stem extensions and the following features:

a. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
b. Butterfly Valves: With extended neck.

5. Valve-End Connections:
   a. Flanged: With flanges according to ASME B16.1 for iron valves.
   b. Threaded: With threads according to ASME B1.20.1.
6. Valve Bypass and Drain Connections: MSS SP-45.

B. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Cannon
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. Crane Co.; Crane Valve Group; Crane Valves.
   d. Grinnell
   e. Hammond Valve.
   f. Kitz
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Rockwell
   j. Stockham
   k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   a. Standard: MSS SP-110.
   b. Stem: Stainless steel.
   c. Ball: Stainless steel, vented.
   d. Refer to schedules in Part 3 for specific application requirements.

C. Cast Steel Ball Valves, Flanged (2.5 inch and larger)

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Apollo: 88A-200 Series
   b. Bray
   c. Keckley
2. Description:
   a. Class: 150.
   b. Stem: Carbon Steel
   c. Ball: Stainless steel, vented.
   d. Seal: PTFE
   e. Refer to schedules in Part 3 for specific application requirements.

D. Iron General Service Butterfly Valves

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
   b. Centerline
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. DeZurik Water Controls.
   f. Grinnell
   g. Hammond Valve.
   h. Jomar
   i. Keystone
   j. Milwaukee Valve Company.
   k. NIBCO INC.
   l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   a. Standard: MSS SP-67, Type I
   b. Stem: One- or two-piece stainless steel.
   c. Disc: Aluminum bronze.
   d. Refer to schedules in Part 3 for specific application requirements.

E. Carbon Steel High-Performance Butterfly Valves

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
   b. Bray Controls; a division of Bray International.
   c. DeZurik Water Controls.
   d. Flowseal
   e. Jomar
   f. Keystone
   g. NIBCO INC.
   h. Posi-Seal
2. Description:
   a. Standard: MSS SP-68
   b. Stem: Stainless steel; offset from seat plane.
   c. Disc: 316 stainless steel.
   d. Service: Bidirectional.
   e. Refer to schedules in Part 3 for specific application requirements.

F. Bronze Globe Valves

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division (Class 125).
c. Grinnell
d. Hammond Valve.
e. Jomar.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Walworth

2. Description:
   a. Standard: MSS SP-80, Type 1 (Class 125).
   b. Standard: MSS SP-80, Type 2 (Class 150)
   c. Packing: Asbestos free.
   d. Handwheel: Malleable iron or bronze.
   e. Refer to schedules in Part 3 for specific application requirements.

G. Iron Globe Valves

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Grinnell
   e. Hammond Valve.
   f. Milwaukee Valve Company.
   g. NIBCO INC. (Class 125)
   h. Walworth
2. Description:
   a. Standard: MSS SP-85, Type I
   b. Packing and Gasket: Asbestos free.
   c. Refer to schedules in Part 3 for specific application requirements.

H. Eccentric Plug Valves

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. DeZurik Water Controls.
   b. Mueller
   c. Rockwell
   d. Stockham
   e. Walworth
2. Description:
   a. Standard: MSS SP-108.
   b. Bearings: Oil-impregnated bronze or stainless steel.
   c. Stem-Seal Packing: Asbestos free.

d. Plug, Resilient-Seating Material: Suitable for potable-water service unless otherwise indicated.
e. Refer to schedules in Part 3 for specific application requirements.

I. Bronze Silent Check Valves (Pump Discharge)

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Milwaukee Valve Company.
   e. Mueller Steam Specialty; a division of SPX Corporation.
2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. Disc: BUNA/TFE.
   c. Refer to schedules in Part 3 for specific application requirements.

J. Iron, Globe Silent Check Valves (Pump Discharge)

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Milwaukee Valve Company.
   e. Mueller Steam Specialty; a division of SPX Corporation.
2. Description:
   a. Standard: MSS SP-125.
   b. Disc: Bronze.
   c. Refer to schedules in Part 3 for specific application requirements

K. Bronze Swing Check Valves

1. Bronze Swing Check Valves with Nonmetallic Disc:
   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      i. Crane Co.; Crane Valve Group; Crane Valves.
      ii. Crane Co.; Crane Valve Group; Jenkins Valves.
      iii. Crane Co.; Crane Valve Group; Stockham Division.
      iv. Hammond Valve.
      v. Kitz Corporation.
      vi. Milwaukee Valve Company.
      vii. NIBCO INC.

viii. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
b. Description:
i. Standard: MSS SP-80, Type 4.
ii. Body Design: Horizontal flow.
iii. Disc: PTFE unless indicated otherwise in table.
iv. Refer to schedules in Part 3 for specific application requirements.

2. Bronze Swing Check Valves with Bronze Disc:
a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
i. Crane Co.; Crane Valve Group; Crane Valves.
ii. Crane Co.; Crane Valve Group; Jenkins Valves.
iii. Crane Co.; Crane Valve Group; Stockham Division.
iv. Kitz Corporation.
v. Milwaukee Valve Company.
vi. NIBCO INC.
b. Description:
i. Standard: MSS SP-80, Type 3.
ii. Body Design: Horizontal flow.
iii. Refer to schedules in Part 3 for specific application requirements.

L. Iron Swing Check Valves

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Kitz Corporation (Class 125).
f. Legend Valve (Class 125).
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Powell Valves (Class 125).
2. Description:
a. Standard: MSS SP-71, Type I.
b. Body Design: Clear or full waterway.
c. Gasket: Asbestos free.
d. Refer to schedules in Part 3 for specific application requirements.

M. Strainers

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

a. Sarco
b. Mueller
c. Watts
d. Armstrong
e. Jomar

2. Description:
   a. For water service, strainers shall be full size of entering pipe size and have a maximum clean pressure drop of one psi.
   b. Pump start up strainer screens shall be used for cleaning and removed afterwards.
   c. Provide blow-off valve on each strainer.
      i. Provide bronze strainers with end cap with threaded connection for blow off valve.
   d. Provide iron valves with bolted cover with threaded connection for blow off valve.
3. Refer to schedules in Part 3 for specific application requirements.

N. Suction Diffusers

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Armstrong
   b. Bell & Gossett
   c. Mueller
   d. Watts
2. Suction diffuser/strainers shall have 200 psi cast iron body and stainless-steel sleeve with 5/32" perforations. Units shall include flanged connections, removable gasketed cover and straightening vanes.
3. Provide 16 mesh start-up strainer.
4. Provide blow off tapping on bottom of unit.
5. Provide full pipe size inlet and outlet (reducing suction diffusers are not acceptable).

O. Hydronic Specialty Valves

1. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23.

2. Brass or Bronze, Calibrated-Orifice, Balancing Valves:
   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      i. Armstrong Pumps, Inc.
      ii. Bell & Gossett Domestic Pump.
      iii. Flow Design Inc.
      iv. Gerand Engineering Co.
      v. Griswold Controls.
      vi. Macon
      vii. NuTech Hydronic Specialty Products

viii. Nexus Valve, Inc.
ix. Taco.
x. Tour & Andersson; available through Victaulic Company.

b. Valves shall perform the following functions:
   i. Flow balancing
   ii. Flow measurement
   iii. Positive shut-off
c. Valves type shall be one of the following:
   i. Ball or plug type with calibrated orifice or venturi.
   ii. Y-pattern globe style.
d. Body: Brass, bronze or copper alloy.
e. Ball: Brass or stainless steel.
f. Plug: Resin.
g. Seat: PTFE, stainless steel or cast copper alloy.
h. End Connections: Threaded or socket.
i. Pressure Gage Connections: Integral seals for portable differential pressure meter.
j. Handle Style: Lever or knob, with memory stop to retain set position.
k. Provide removable pre-formed insulation to permit access for balancing and readouts.
l. Refer to Part 3 for pressure and temperature rating.

3. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      i. Armstrong Pumps, Inc.
      ii. Bell & Gossett Domestic Pump.
      iii. Flow Design Inc.
      iv. Gerand Engineering Co.
      v. Griswold Controls.
      vi. Macon
      vii. NuTech Hydronic Specialty Products
      viii. Nexus Valve, Inc.
      ix. Taco.
      x. Tour & Andersson.
   b. Valves shall perform the following functions:
      i. Flow balancing
      ii. Flow measurement
      iii. Positive shut-off
   c. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
   d. Ball: Brass or stainless steel.
   e. Stem Seals: EPDM O-rings.
   f. Disc: Manufacturer standard construction.
   g. Seat: PTFE or EPDM.
   h. End Connections: Flanged.
   i. Pressure Gage Connections: Integral seals for portable differential pressure meter.

j. Handle Style: Lever or knob, with memory stop to retain set position.
k. Provide removable pre-formed insulation to permit access for balancing and readouts.
l. Refer to Part 3 for pressure and temperature rating.

4. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      i. AMTROL, Inc.
      ii. Armstrong Pumps, Inc.
      iii. Bell & Gossett Domestic Pump.
      iv. Conbraco Industries, Inc.
      v. Spence Engineering Company, Inc.
      vi. Watts Regulator Co.
   b. Body: Bronze or brass.
   c. Disc: Glass and carbon-filled PTFE.
   d. Seat: Brass.
   e. Stem Seals: EPDM O-rings.
   f. Diaphragm: EPT.
   g. Low inlet-pressure check valve.
   h. Inlet Strainer: 304 or 316 stainless steel, removable without system shutdown.
   i. Valve Seat and Stem: Noncorrosive.
   j. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

5. Diaphragm-Operated Safety Valves: ASME labeled.

   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      i. AMTROL, Inc.
      ii. Armstrong Pumps, Inc.
      iii. Bell & Gossett Domestic Pump.
      iv. Conbraco Industries, Inc.
      v. Spence Engineering Company, Inc.
      vi. Watts Regulator Co.
   b. Body: Bronze or brass.
   c. Disc: Glass and carbon-filled PTFE.
   d. Seat: Brass.
   e. Stem Seals: EPDM O-rings.
   f. Diaphragm: EPT.
   g. Wetted, Internal Work Parts: Brass and rubber.
   h. Inlet Strainer: 304 or 316 stainless steel, removable without system shutdown.
   i. Valve Seat and Stem: Non-corrosive.
   j. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV for heating hot water boilers and piping up to 160

psig and Section VIII for heat exchangers and higher-pressure applications, selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

6. Automatic Flow-Control Valves:

    a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
        i. Flow Design Inc.
        ii. Griswold Controls.
        iii. Hays Fluid Controls
        iv. Macon
        v. NuTech Hydronic Specialty Products
        vi. Nexus Valve, Inc.
    b. Body: Brass, bronze or ferrous metal.
    c. Flow Limiting Assembly: Corrosion resistant stainless-steel piston/spring or elastomeric diaphragm, tamper proof, self-cleaning, and removable.
    d. Combination Assemblies: Include bronze or brass ball valve.
    e. Identification Tag: Marked with zone identification, valve number, and flow rate.
    f. Size: Same as pipe in which installed.
    g. Performance: Maintain constant flow, plus or minus 10 percent over system pressure fluctuations.
    h. Factory set range: 2 to 80 psid.
    i. Refer to Part 3 for pressure and temperature ratings.

7. Triple Duty Valves:

    a. Angle or straight pattern.
    b. 175-psig (1204-kPa) pressure rating, cast or ductile-iron body, pump-discharge fitting.
    c. Valve with multi-turn stem and memory stop to allow valve to be returned to its original position after shutoff.
    d. Brass valve disc with EPDM rubber seat.
    e. Type 304 stainless steel valve stem.
    f. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
    g. Brass gauge ports with integral check valve and orifice for flow measurement.

2.6 HYDRONIC PIPING SYSTEM AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    a. AMTROL, Inc.
    b. Armstrong Pumps, Inc.

c. Bell & Gossett Domestic Pump.
d. Nexus Valve, Inc.
e. NuTech Hydronic Specialty Products
f. Taco, Inc.
2. Body: Brass or stainless steel.
3. Internal Parts: Non-ferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Refer to Part 3 for pressure and temperature rating.

B. Automatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. AMTROL, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Nexus Valve, Inc.
   e. Taco, Inc.
2. Body: Brass, stainless steel or cast iron.
3. Internal Parts: Non-ferrous.
4. Operator: Non-corrosive metal float.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Refer to Part 3 for pressure and temperature rating.

C. Bladder-Type Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. AA Tanks
   b. AMTROL, Inc.
   c. Armstrong Pumps, Inc.
   d. Bell & Gossett Domestic Pump
   e. Taco, Inc.
2. Tank: Welded steel. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Refer to Part 3 Piping and Specialty for system pressure and temperature rating required
4. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
5. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats

D. In-Line Air Separators:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. AMTROL, Inc.
   b. Armstrong Products, Inc.
   c. Bell & Gossett Domestic Pump.
   d. Taco, Inc.

2. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.

2.7 HYDRONIC PIPING SPECIALTIES

A. Stainless-Steel Bellow, 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 (20-mm) misalignment.

B. Spherical, Rubber, Flexible Connectors:
1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.

C. Sleeves

1. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
2. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
3. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set screws.

D. Sleeve Seal Systems

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Advance Products & Systems, Inc.
   b. CALPICO, Inc.
   c. Metraflex Company (The).
   d. Pipeline Seal and Insulator, Inc.
   e. Proco Products, Inc.

2. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

    a. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
    b. Pressure Plates: Carbon steel, plastic, or stainless steel.
    c. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating or stainless steel of length required to secure pressure plates to sealing elements.

E. Grout

1. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Non-shrink; recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

F. Escutcheons

1. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
2. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
3. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
4. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.
5. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
6. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.
7.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the 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.

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

E. Equipment Mounting: Install base-mounted pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases specified in Division 03. Comply with requirements for vibration isolation devices specified in Division 23.

1. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install on 4-inch- (100-mm-) high concrete base[designed to withstand, without damage to equipment, seismic force required by code].

F. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and of size required to support weight of in-line pumps. Provide vibration isolators specified in Division 23.

1. Comply with requirements for seismic-restraint devices specified in Division 23.
2. Comply with requirements for hangers and supports specified in Division 23.

G. Alignment

1. Engage a factory-authorized service representative to perform alignment service.
2. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
3. Comply with pump and coupling manufacturers' written instructions.
4. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with non-shrink, non-metallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

H. Pump Connections

1. Comply with requirements for piping specified in Division 23, Steam and Condensate Heating Piping. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Where installing piping adjacent to pump, allow space for service and maintenance.
3. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
4. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
5. Install check, shutoff, and throttling valves or triple-duty valve on discharge side of pumps as indicated on drawings.
6. Install Y-type strainer or suction diffuser and shutoff valve on suction side of pumps as indicated on the drawings.
7. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
8. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.
9. Connect wiring according to Division 26, Low-Voltage Electrical Power Conductors and Cables.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Piping locations and arrangements indicated were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Verify final equipment locations for roughing-in.

C. Installation of piping must allow for expansion using offsets, loops, swing joints or expansion joints to prevent undue strain.

1. Mains and risers with loops or offsets shall be securely anchored to structure so as to impart expansion towards loops or offsets. Anchors shall be constructed of heavy forged wrought iron, secured to pipe and to structure. Provide vibration isolation.
2. Provide pipe alignment guides to guide expanding pipe to move freely from anchor points toward expansion joints, offsets, etc.

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

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

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

G. Install piping to permit valve servicing.

H. Install piping at indicated slopes.

I. Install piping free of sags and bends.

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

K. Install piping to allow application of insulation.

L. Select system components with pressure rating equal to or greater than specified system pressure rating.

M. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

N. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

O. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

P. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

Q. Install branch connections to mains using 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.

R. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

S. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

T. Install shutoff valve immediately upstream of each dielectric fitting.

U. Comply with requirements in Division 23 for HVAC piping and equipment identification.

V. Install expansion loops and expansion loops.

3.4 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. Align components. No strain shall be placed on weld during welding. No part of pipe shall be offset more than 20 percent of thickness. Set flanges and branches properly.

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

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

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

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

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

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

I. Pressed Joints: Assemble joints in strict accordance with manufacturer written instructions including but not limited to cutting pipe to square the end, removal of burrs from cut inside and outside, restoration of full inside diameter and a smooth, chamfered exterior surface, marking of insert depth on the pipe, inspection of gasket to ensure proper seating all prior to clamping and pressing. Maintain manufacturer minimum distance between press type fittings and brazed fittings. Press-connect joints shall be made using a press-connect tool and jaws approved for use for the manufacturer’s specific fitting configuration.

J. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts in accordance with manufacturer written instructions. Cut or roll grooves in ends of pipe based on pipe wall thickness per coupling installation instructions. Use grooved-end fittings and grooved-end-pipe couplings. Grooved couplings used at expansion devices shall be flexible type, all others shall be rigid type.

3.5 CORE DRILLING

A. Core drilling shall be avoided in new construction. Set sleeves prior to installation of structure for passage of pipes, conduit and ducts. Where core drilling is unavoidable (e.g. when individual sleeves are not installed or incorrectly located) or required by renovation projects, locate required openings prior to coring and submit locations for review.

B. Coordinate openings with other Divisions.

C. Do not disturb existing systems. Protect areas from damage.

D. Thoroughly investigate existing conditions in vicinity of required opening prior to coring.

3.6 PIPING, SPECIALTIES AND VALVE APPLICATIONS

A. Hydronic piping components and installation shall be rated for the following minimum pressures and temperatures unless otherwise indicated:

CHILLED WATER/ GLYCOL, AND CONDENSER WATER PIPING AND SPECIALTIES - Table 1 of 2 Minimum Component Rating2 - 125 psig at 150 deg F for NPS 1/2 - NPS 24			
Size	Pipe Material	Joints	Fittings and Flanges
NPS 2	Type L , drawn-temper copper tubing	Brazed or high temperature silver soldered	Wrought copper
	Schedule 40 steel, Grade B, CW	Threaded	Class 125 cast-iron
NPS 2-1/2 NPS 10	Schedule 40 steel, Grade B, ERW	Welded	Wrought-steel
		Flanged	Class 150 Wrought-cast or forged-steel
		Flanged	Class 125 cast-iron
NPS 12	Standard weight steel. Grade B, ERW	Welded	Wrought-steel
		Flanged	Class 150 Wrought-cast or forged-steel
		Flanged	Class 125 cast-iron
NPS 14 - and larger	Standard weight steel. Grade B, ERW	Welded	Wrought-steel
		Flanged	Class 150 Wrought-cast or forged-steel

1. Minimum rating for all piping specialties shall be 125 psig at 150 deg F. Piping specialties include: dielectric unions; dielectric flanges; test plugs; packless expansion joints; brass or bronze, calibrated orifice, balancing valves; cast iron or steel, calibrated orifice, balancing valves; automatic flow control valves; manual air vents; automatic air vents; air separators; expansion tanks, stainless-steel bellows flexible connectors; spherical, rubber, flexible connectors.

CHILLED WATER/ GLYCOL AND CONDENSER WATER SYSTEM VALVES - Table 2 of 2
Maximum 150 deg F and 125 psig for NPS 1/2 - NPS 24

Specialty	Application	Type	Size (inches)	Body/Seat Body/Trim	Connection	Minimum Rating1,2
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 2 pc.	1/2 - 2	Bronze/Teflon	Threaded	400 psig WOG
Globe Valve	ATC Modulation	Control Valve	1/2 - 2	Bronze/Metal	Threaded	400 psig WOG
			2-1/2 - 6	Bronze/Metal	Flanged	400 psig WOG
Butterfly Valve	Isolation and Modulation	General Service	2-1/2 - 6	Ductile Iron/EPDM	Threaded Lug	175 psig CWP 150 psig bi-directional shutoff 150 psig dead end service
		High Performance	8 - 24	Ductile Iron/EPDM	Threaded Lug	150 psig CWP 150 psig bi-directional shutoff 150 psig dead end service
Check Valve	Pumps	Silent	1/2 - 2	Bronze/Bronze	Threaded	200 psig WOG
		Silent Globe	2-1/2 - 24	Iron/Bronze	Flanged	Class 125
	Piping	Y-Pattern Swing	1/2 - 2	Bronze/Bronze	Threaded	200 psig WOG
			2-1/2 - 24	Iron/Bronze	Flanged	Class 125
Strainer	Control Valves and Flow Meters	Y-Type	1/2 -2	Bronze/Stainless (1/16 inch dia.)	Threaded	200 psig WOG
			2-1/2 - 4	Iron/Stainless (1/16 inch dia.)	Flanged	Class 125
			5 - 24	Iron/Stainless (1/8 inch dia.)	Flanged	Class 125
	Pump Suction	In-Line Y-Type	1/2 - 2	Bronze/Stainless (1/16 inch dia.)	Threaded	200 psig WOG
			2-1/2 - 4	Iron/Stainless (3/16 inch dia.)3	Flanged	Class 125
			5 - 24	Iron/Stainless (1/4 inch dia.)3	Flanged	Class 125
		Angle Suction Diffuser End Suction Pumps	2 - 12	Iron/Stainless (3/16 inch dia.)3 Start Up Strainer = 16 Mesh Bronze	Flanged	Class 125

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves and strainers.
2. CWP=Cold Water Working Pressure; WOG=Water, Oil or Gas; Class=ANSI Standard;
3. Use 1/8 inch diameter for plate heat exchanger application.

HOT WATER/GLYCOL AND DUAL TEMPERATURE PIPING AND SPECIALTIES - Table 1 of 2 Minimum Component Rating[2] - 125 psig at 250 deg F for NPS 1/2 - NPS 24			
Size	Pipe Material	Joints	Fittings
NPS 2	Type L, drawn-temper copper tubing	Brazed or high temperature silver soldered	Wrought copper
	Schedule 40 steel, Grade B, Seamless	Threaded	Class 125 cast-iron
NPS 2-1/2 NPS 12	Schedule 40 steel, Grade B, ERW	Welded	Wrought steel
		Flanged	Class 150 Wrought-cast or forged-steel
		Flanged	Class 125 cast-iron
NPS 12	Standard weight steel, Grade B, ERW	Welded	Wrought steel
		Flanged	Class 150 Wrought-cast or forged-steel
		Flanged	Class 125 cast-iron
NPS 14 - and larger	Standard weight steel, Grade B, ERW	Welded	Wrought steel
		Flanged	Class 150 Wrought-cast or forged-steel

1. Minimum rating for all piping specialties shall be 125 psig at 250 deg F (121 deg C). Piping specialties include: dielectric unions; dielectric flanges; test plugs; packless expansion joints; brass or bronze, calibrated orifice, balancing valves; cast iron or steel, calibrated orifice, balancing valves; automatic flow control valves; manual air vents; automatic air vents; air separators; expansion tanks, stainless-steel bellows flexible connectors; spherical, rubber, flexible connectors.
2. For copper piping, press-joints and fittings meeting system pressure and temperature requirements may be used in lieu of brazed or high temperature solder and threaded joints.
3. For steel pipe system grooved mechanical joint fittings and joints meeting system pressure and temperature requirements may be used in lieu of welded or flanged joints ONLY IN ACCESSIBLE LOCATIONS. Locations prohibited from using grooved joints of any type include shafts, chases, and above ceiling installations.

HOT WATER/ GLYCOL AND DUAL TEMPERATURE SYSTEM VALVES- Table 2 of 2 Maximum 250 deg F and 125 psig for NPS 1/2 - NPS 24						
Specialty	Application	Type	Size (inches)	Body/Seat, Body/Trim	Connection	Minimum Rating1,2
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 2 pc.	1/2 - 2	Bronze/Teflon	Threaded	400 psig WOG
Globe Valve	ATC Modulation	Control Valve	1/2 - 2	Bronze/Metal	Threaded	400 psig WOG
			2-1/2 - 6	Bronze/Metal	Flanged	400 psig WOG
Butterfly Valve	Isolation and Modulation	General Service	2-1/2 - 6	Ductile Iron/EPDM	Threaded Lug	200 psig CWP 200 psig bi-directional shutoff 200 psig dead end service
		High Performance	8 - 24	Ductile Iron/EPDM	Threaded Lug	150 psig CWP 150 psig bi-directional shutoff 150 psig dead end service
Check Valve	Pumps	Silent	1/2 - 2	Bronze/Bronze	Threaded	200 psig WOG
		Silent Globe	2-1/2 - 24	Iron/Bronze	Flanged	Class 125
	Piping	Y-Pattern Swing	1/2 - 2	Bronze/Bronze	Threaded	200 psig WOG
			2-1/2 - 24	Iron/Bronze	Flanged	Class 125
Strainer	Control Valves and Flow Meters	Y-Type	1/2 - 2	Bronze/Stainless (1/16" dia.)	Threaded	200 psig WOG
			2-1/2 - 4	Iron/Stainless (1/16" dia.)	Flanged	Class 125
			5 - 24	Iron/Stainless (1/8" dia.)	Flanged	Class 125
	Pump Suction	In-Line Y-Type	1/2 - 2	Bronze/Stainless (1/16" dia.)	Threaded	200 psig WOG
			2-1/2 - 4	Iron/Stainless (3/16" dia.)[3]	Flanged	Class 125
			5 -24	Iron/Stainless (¼" dia.)[3]	Flanged	Class 125
		Angle Suction Diffuser End Suction Pumps	2 - 12	Iron/Stainless (3/16" dia.)[3] Start Up Strainer = 16 Mesh Bronze	Flanged	Class 125

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves and strainers. 2. CWP=Cold Water Working Pressure; WOG=Water, Oil or Gas; Class=ANSI Standard; Use 1/8 inch diameter for plate heat exchanger application. 3. For copper piping, press-joint valves manufactured by the press-joint fitting manufacturer meeting system project specifications and pressure/temperature requirements may be used in lieu of sweat or threaded valves.] 4. For steel pipe systems, grooved valves manufactured by the grooved joint manufacturer meeting system project specifications and pressure/temperature requirements may be used in lieu of welded or flanged joints ONLY IN ACCESSIBLE LOCATIONS. Locations prohibited from using grooved joints of any type include shafts, chases, and above ceiling installations.

B. Miscellaneous Piping and Valve Applications

1. Makeup-water piping shall be the following:
   a. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered or high temperature soldered joints.
   b. System Rating: 125 psig at 150 deg F

2. Condensate-Drain Piping: Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered or high temperature soldered joints.
   a. System Rating: 125 psig at 150 deg F

3. Humidifier-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
   a. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
   b. System Rating: 125 psig at 150 deg F

4. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
   a. System Rating: 125 psig at 150 deg F

5. Air-Vent Piping:
   a. Inlet: Same as service where installed according to piping manufacturer's written instructions.
   b. Outlet: Type L (Type B), annealed-temper copper tubing with soldered or flared joints.
   c. System Rating: 125 psig at 150 deg F

6. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed according to valve manufacturer's written instructions.

3.7 VALVE EXAMINATION

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

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

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

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

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

3.8 VALVE INSTALLATION

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

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

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

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for ball, butterfly, and globe valves NPS 3 DN 75 and larger and more than 84 inches 2100 mm above floor. Extend chains to 60 inches 1520 mm above finished floor.

F. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Silent Check Valves: In horizontal or vertical position, between flanges.

3.9 VALVE ADJUSTMENT

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.10 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. Valves on condenser water, chilled water, hot water and glycol services shall be as shown in the above application tables. If valve applications are not indicated, use the following:

   1. Shutoff Service: Ball or butterfly valves
   2. Butterfly Valve Dead-End Service: Single-flange (lug) type
   3. Modulating Service: Globe valves

4. Pump-Discharge Check Valves:
   a. NPS 2 DN 50 and Smaller: Spring wafer check valve with bronze disc.
   b. NPS 2-1/2 DN 65 and Larger: Iron, center-guided, metal -seat check valves.

B. If valves with specified CWP ratings are not available, the same types of valves with higher CWP ratings may be substituted.

C. Select valves with end connections as indicated in the tables. For applications not listed in the tables select valves, except wafer types, with the following end connections
   1. For Copper Tubing, NPS 2 DN 50 and Smaller: Threaded ends
   2. For Steel Piping, NPS 2 DN 50 and Smaller: Threaded ends
   3. For Steel Piping, NPS 2-1/2 DN 65 and larger: Flanged ends.

3.11 VALVE APPLICATIONS

A. Install shut off-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install calibrated-orifice, balancing valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

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 required by ASME Boiler and Pressure Vessel Code. 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.

3.12 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 and larger (DN 65 to DN 100): Use dielectric flanges or dielectric flange kits.

3.13 HYDRONIC PIPING HANGERS AND SUPPORTS

A. Comply with requirements in Division 23 for hanger, support, anchor devices and vibration isolation. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Division 23 for seismic restraints.

C. Install the following pipe attachments:

Nominal Pipe Size (inches)	Maximum Horizontal Span (feet)	Minimum Rod Size (inches)	Hanger Type
1/2	5	0.375	Clevis Hanger
3/4	5	0.375	Clevis Hanger
1	6	0.375	Clevis Hanger
1.25	7	0.375	Clevis Hanger
1.5	8	0.375	Clevis Hanger
2	8	0.375	Clevis Hanger
2.5	11	0.5	Clevis Hanger
3	12	0.5	Clevis Hanger
4	12	0.625	Single Rod Roller Hanger
5	12	0.625	Single Rod Roller Hanger
6	12	0.75	Single Rod Roller Hanger
8 to 12	12	Two at 0.875	Dual Rod Roller Hanger
14 to 18	12	Two at 1	Dual Rod Roller Hanger
20	12	Two at 1.25	Dual Rod Roller Hanger
24	12	Two at 1.5	Dual Rod Roller Hanger

D. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

E. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

F. Provide spring hangers to support vertical runs. Vertical supports shall be spaced to prevent the pipe from being overstressed from the combination of all loading effects including the entire weight of the riser, and adjacent piping, hydrostatic test load conditions, line temperature, other live load conditions, and available supporting structure. On a riser subject to expansion, only one support of the rigid type shall be used.

G. Riser clamps shall have a positive means of engagement (i.e. shear lugs) between the pipe and the clamp.

H. Rigid riser clamps, when used for deadweight purposes, shall be sized for two times the calculated load.

3.14 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 bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections.

E. For local terminal units with rotating components (e.g. fan coils, heat pumps, fan powered boxes) and where indicated on drawings, provide flexible hose connectors between unit and supply and return valve assemblies. Connector length shall no longer than 12 inches for chilled beam applications or 18 inches for other applications.

3.15 EXPANSION JOINT AND LOOP INSTALLATION

A. Install expansion joints and loops of sizes matching sizes of piping in which they are installed.

B. Install expansion loops in accordance with approved delegated design submittal.

C. Install manufactured flexible hose loops and joints in accordance with manufacturer installation instructions.

D. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

E. Install rubber packless expansion joints according to FSA-NMEJ-702.

F. Install grooved-joint expansion joints to grooved-end steel piping

3.16 PIPING SWING CONNECTION INSTALLATION

A. Connect risers and branch connections to mains with at least three elbows.

B. Connect risers and branch connections to terminal units with at least three elbows.

C. Connect mains and branch connections to terminal units with at least three elbows.

3.17 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one guide on each side of pipe expansion fittings and loops. Per ASHRAE Handbook, distance for guides is “2H” for expansion loops and “L” for Z-bends. At expansion joints, alignment guide locations shall be in accordance with joint manufacturer recommendations.

C. Attach guides to pipe and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.

2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

H. Concrete inserts shall be iron or steel of type to receive machine bolt head or nut after installation. Inserts shall permit adjustment of bolt in one horizontal direction and shall develop strength of bolt when installed in properly cured concrete.

3.18 SLEEVE INSTALLATION

A. General

1. Lay out penetration and sleeve openings in advance, to permit provision in work. Coordinate work carefully with architectural and structural work. Set sleeves and conduit in forms before concrete is poured. Provide remedial work where sleeves and conduits are omitted or improperly placed. Remedial work includes core drilling (see requirements below) for penetrations if walls are poured, or otherwise constructed, without required sleeves. Provide core drilling (see requirements below) of existing construction. Do not penetrate structural members without Structural Engineer’s/Architect's written approval.

2. Provide sleeves and packing materials at penetrations of foundations, walls, basement floors, slabs (except on grade), partitions and floors. Sleeve installation shall meet NFPA 101 requirements, UL rated assembly requirements, and materials requirements of these specifications. Submit a list of the UL listed details that the Contractor intends on using on this project in all rated assemblies.

3. Sleeves that penetrate outside walls, basement slabs, footings and beams shall be waterproof. Sleeves that penetrate floors shall be fireproof and waterproof.

4. Sleeves for insulated pipe and duct in non-fire rated construction shall accommodate continuous insulation without compression. Sleeves and/or penetrations in fire rated construction that do not require fire dampers shall be packed with fire rated material that shall maintain the fire rating of the wall. Seal ends of penetrations to provide continuous vapor barrier where insulation is interrupted. Where fire dampers are required, install sleeve and damper assembly in accordance with damper listing.

5. Where pipes passing through openings are exposed in finished rooms, finishes of filling materials shall match and be flush with adjoining floor, ceiling, and wall finishes.

6. Identify unused sleeves and slots for future installation. Fill slots, sleeves and other openings in floors or walls if not used. Fill spaces in openings after installation of pipe, duct, conduit or cable. Fill for floor penetrations shall prevent passage of water, smoke, fire, and fumes. Fill shall be fire resistant in fire floors and walls, and shall prevent passage of air, smoke and fumes.

7. Do not support piping risers or conduit on sleeves.

8. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 7 for materials.

9. Verify final equipment locations for roughing-in.

10. Installation Testing, Listings and Approvals

    a. Installation of sleeves, fill and packing shall meet material manufacturer's recommendations exactly, particularly as regards safety, ventilation, removal of foreign materials and other details of installation. Dam openings as recommended. Remove flammable materials used for damming and forming seals in fire-rated construction.
    b. Sleeve penetration methods shall be water- and gas-tight and shall meet requirements of ASTM E-119 Standard Methods of Fire Tests of Building Construction and Materials.
    c. Fire-stop penetration seal methods and materials shall be FM-approved and UL-listed as applicable. They shall have the same rating as the structure penetrated. Submit manufacturer's detail sheet indicating assembly rating.
        i. Inspect foamed sealants to ensure manufacturer's optimum cell structure and color ranges.
        ii. Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07.

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

C. Sleeves are not required for slab-on-grade floors.

D. Sleeves are required for core-drilled holes on any floor.

E. Install sleeves in new walls and slabs as new walls and slabs are constructed.

F. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.

G. Cut sleeves to length for mounting flush with both surfaces.
   1. 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 to secure clamping ring if ring is specified.

H. Install sleeves that are large enough to provide 0.25-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

   1. Steel Pipe Sleeves: For pipes smaller than NPS 6.

   2. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.

   3. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashings and Trim" for flashing.
      a. Seal space outside of sleeve fittings with grout.

   4. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.

   5. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07, Joint Sealants.

I. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 for materials and installation.

J. Install sleeve seals for piping penetrations of exterior concrete walls and slabs.

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

L. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

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

3.19 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.20 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:
   1. Exterior Concrete Walls above Grade: Galvanized-steel-pipe sleeves.
   2. Exterior Concrete Walls below Grade: Galvanized-steel-pipe sleeves with sleeve-seal system.
      a. Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
   3. Concrete Slabs-on-Grade:
      a. Galvanized-steel-pipe sleeves with sleeve-seal system.
         i. Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
   4. Concrete Slabs above Grade:
      a. Galvanized-steel-pipe sleeves.
   5. Interior Partitions:
      a. Piping Smaller Than NPS 6 (DN 150): Galvanized-steel-pipe sleeves.
      b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-sheet sleeves.

3.21 ESCUTCHEON INSTALLATION

A. Install escutcheons at piping penetrations of walls, ceilings, and finished floors exposed to view in finished spaces (not required in utility spaces or mechanical rooms).

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

   1. New Piping: Use the following:
      a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      b. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type.

c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type.

2. Existing Piping: Use the following:
   a. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
   b. Insulated Piping: Split-plate, stamped-steel type hinge
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   e. Bare Piping in Unfinished Service Spaces: Split-casting, cast-brass type.
   f. Bare Piping in Equipment Rooms: Split-casting, cast-brass type.
   g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

3.22 METER AND GAGE INSTALLATION

A. Install all meters and gauges in locations readable from the floor without the use of a ladder.

B. Install meters and gages where indicated on plans and details.

C. Install thermowells with socket extending 2 inches (51 mm) into fluid or one-third of pipe diameter, whichever is shorter. Socket shall be installed in vertical position in piping tees.

D. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

E. Install thermowells with extension on insulated piping.

F. Fill thermowells with heat-transfer medium.

G. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids.

K. Install test plugs in piping tees.

L. Install flow indicators in piping systems in accessible positions for easy viewing.

M. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
   1. Install flowmeter elements in accessible positions in piping systems.
   2. Install flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.
   3. Install permanent indicators on walls or brackets in accessible and readable positions.
   4. Install connection fittings in accessible locations for attachment to portable indicators.
   5. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

N. Install thermometers in the following locations:
   1. Inlet and outlet of each hydronic zone.
   2. Inlet and outlet of each major hydronic coil bank (10 gpm or more)
   3. Inlet and outlet of each hydronic boiler.
   4. Two inlets and two outlets of each chiller.
   5. Inlet and outlet of each hydronic coil in air-handling units.
   6. Two inlets and two outlets of each hydronic heat exchanger.
   7. Inlet and outlet of each thermal-storage tank.
   8. At inlet and outlet of each bridge in primary/secondary systems.

O. Install pressure gages in the following locations:
   1. Inlet and outlet of each major hydronic coil bank (10 gpm or more)
   2. Discharge of each pressure-reducing valve.
   3. Inlet and outlet of each chiller chilled-water and condenser-water connection.
   4. Suction and discharge of each pump.
   5. Expansion tank connections.
   6. Makeup water connections.

P. Meter and Gage Connections
   1. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.
   2. Connect flowmeter-system elements to meters.
   3. Connect flowmeter transmitters to meters and DDC system.
   4. Connect thermal-energy meter transmitters to meters and DDC system.

Q. Meter and Gage Adjustment
   1. After installation, calibrate meters according to manufacturer's written instructions.
   2. Adjust faces of meters and gages to proper angle for best visibility.

3.23 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C).

B. Scale Range for Condenser-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C).

C. Scale Range for Heating, Hot-Water and Dual Temperature Piping: 30 to 240 deg F (0 to plus 115 deg C).

3.24 PRESSURE-GAGE SCALE-RANGE SCHEDULES

A. Scale Range for Chilled-Water Piping: 0 to 100 psi (0 to 600 kPa).

B. Scale Range for Condenser-Water Piping: 0 to 100 psi (0 to 600 kPa).

C. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi (0 to 600 kPa).

3.25 FLOW AND THERMAL-ENERGY METER SCHEDULE

A. Flow and Thermal-Energy Meters for Chilled-Water Piping: Full-bore Magnetic type.

B. Flow and Thermal-Energy Meters for Condenser-Water Piping: Full-bore Magnetic type.

C. Flow and Thermal-Energy Meters for Heating Hot-Water and Dual Temperature Piping: Full-bore Magnetic type.

3.26 HYDRONIC PIPING 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. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install piping from boiler air outlet, air separator, to expansion tank with a 2 percent upward slope toward tank.

D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.

E. Install expansion tanks. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
   1. Install tank fittings that are shipped loose.
   2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

F. Vent and purge air from hydronic system.

3.27 PIPING INSULATION SCHEDULE

A. Provide insulation materials and thicknesses scheduled for each system type and pressure/temperature range. If more than one material is listed for a system, selection from materials listed is Division 23 option.

B. Insulation for pre-insulated piping shall meet all specified requirements.

C. Insulate piping operating at temperatures below 40 deg F and systems operating between 40 deg F to 65 deg F in accordance with NAIMA Guide to Insulating Chilled Water Piping Systems with Mineral Fiber Pipe Insulation. Comply with all recommendations including but not limited to the requirement for vapor dams every fourth section of insulation.

D. Outdoor piping insulation requirements apply to all piping outside the building envelope and including pipes in unconditioned piping vestibules connected to outdoor equipment.

E. Cooling and Glycol Energy Recovery Systems: 40 deg F to 65 deg F
   1. Applies to the Following Systems: Chilled Water, Refrigerant, Brine, Glycol Energy Recovery Systems (winter mode), Cooling Tower/Condenser Water Piping When Used for Winter Free Cooling and All Outdoor Heat Traced Piping

F. Insulation Conductivity (Btu-in/hr-deg F-SF): 0.21 to 0.27 at 7 deg F

G. Insulation Type: Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Pipe and Tank Insulation for 14” and Larger Pipe Size.

H. Outdoor-Minimum Thickness: 3”

I. Factory Applied Jacket: ASJ or ASJ-SSL

J. Field Applied Jacket: Aluminum UV protective covering with Moisture Barrier

3.28 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 percent of specified minimum yield strength or 1.7 times the "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.

D. Replace broken and damaged escutcheons using new materials.

3.29 PUMP 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.

3.30 DEMONSTRATION

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

END OF SECTION 236423

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Refrigerant pipes and fittings.
2. Refrigerant piping valves and specialties.
3. Refrigerants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty.

1. Include pressure drop, based on manufacturer's test data, for the following:

a. Thermostatic expansion valves.
b. Solenoid valves.
c. Hot-gas bypass valves.
d. Filter dryers.
e. Strainers.
f. Pressure-regulating valves.

B. Shop Drawings:

1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
2. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
3. Show interface and spatial relationships between piping and equipment.
4. Shop Drawing Scale: **1/4 inch equals 1 foot (1:50)**

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-134a:

1. Suction Lines for Air-Conditioning Applications: 115 psig (793 kPa).
2. Suction Lines for Heat-Pump Applications: 225 psig (1551 kPa).
3. Hot-Gas and Liquid Lines: 225 psig (1551 kPa).

B. Line Test Pressure for Refrigerant R-407C:

1. Suction Lines for Air-Conditioning Applications: 230 psig (1586 kPa).
2. Suction Lines for Heat-Pump Applications: 380 psig (2620 kPa).
3. Hot-Gas and Liquid Lines: 380 psig (2620 kPa).

C. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: **ASTM B 88, Type K or L (ASTM B 88M, Type A or B)**.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8/A5.8M.

F. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
4. Working Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as selected in piping application articles.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

E. Flanged Unions:

1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 (DN 25 to DN 40) and ductile iron for NPS 2 to NPS 3 (DN 50 to DN 80). Apply rust-resistant finish at factory.
2. Gasket: Fiber asbestos free.
3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
6. Pressure Rating: Factory test at minimum 400 psig (2760 kPa).
7. Maximum Operating Temperature: 330 deg F (165 deg C).

F. Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket.
2. End Connections:

a. NPS 2 (DN 50) and Smaller: With threaded-end connections.
b. NPS 2-1/2 (DN 65) and Larger: With flanged-end connections.

3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.4 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 275 deg F (135 deg C).

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig (3450 kPa).
8. Maximum Operating Temperature: 275 deg F (135 deg C).

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig (3.4 kPa).
8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 275 deg F (135 deg C).

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.

5. Working Pressure Rating: 500 psig (3450 kPa).

E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and **24**-V ac coil.
6. Working Pressure Rating: 400 psig (2760 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

F. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig (2760 kPa).
6. Maximum Operating Temperature: 240 deg F (116 deg C).

G. Thermostatic Expansion Valves: Comply with AHRI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: **40 deg F (4.4 deg C)**.
6. Superheat: A**djustable**.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: **450 psig (3100 kPa)**.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: **Internal**.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter and **24**-V ac coil.
8. End Connections: Socket.
9. Throttling Range: Maximum 5 psig (34 kPa).
10. Working Pressure Rating: 500 psig (3450 kPa).
11. Maximum Operating Temperature: 240 deg F (116 deg C).

I. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig (3450 kPa).
5. Maximum Operating Temperature: 275 deg F (135 deg C).

J. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig (3450 kPa).
6. Maximum Operating Temperature: 275 deg F (135 deg C).

K. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in parts per million (ppm).
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

L. Replaceable-Core Filter Dryers: Comply with AHRI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated **alumina**.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: **2 psig (14 kPa)**
8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 240 deg F (116 deg C).

M. Permanent Filter Dryers: Comply with AHRI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated **alumina**.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.

7. Maximum Pressure Loss: **2 psig (14 kPa)**
8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 240 deg F (116 deg C).

N. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

O. Receivers: Comply with AHRI 495.

1. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 275 deg F (135 deg C).

P. Liquid Accumulators: Comply with AHRI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

2.5 REFRIGERANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines **NPS 1-1/2 (DN 40) and Smaller** for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with **brazed or soldered** joints.

B. Safety-Relief-Valve Discharge Piping: Copper, **Type ACR**, annealed- or drawn-temper tubing and wrought-copper fittings with **brazed or soldered** joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install **diaphragm packless** or **packed-angle** valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install [**diaphragm packless**] [**packed-angle**] valves on inlet and outlet side of filter dryers.

E. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

F. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

G. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

H. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

I. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

J. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

K. Install receivers sized to accommodate pump-down charge.

L. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

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

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

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

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

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

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

J. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:

1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 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. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

F. Threaded Joints: Thread steel 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 to restore full ID. Join pipe fittings and valves as follows:

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

G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

H. Welded Joints: Construct joints according to AWS D10.12M/D10.12.

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

3.5 HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:

1. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod, 1/4 inch (6.4 mm).
2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod, 1/4 inch (6.4 mm).
3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod, 1/4 inch (6.4 mm).
4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod, 3/8 inch (9.5 mm).
5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod, 3/8 inch (9.5 mm).
6. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod, 3/8 inch (9.5 mm).
7. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod, 3/8 inch (9.5 mm).

8. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod, 3/8 inch (9.5 mm).
9. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod, 1/2 inch (13 mm).

D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod, 3/8 inch (9.5 mm).
2. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod, 3/8 inch (9.5 mm).
3. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod, 3/8 inch (9.5 mm).
4. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod, 1/2 inch (13 mm).

E. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.

   a. Fill system with nitrogen to the required test pressure.
   b. System shall maintain test pressure at the manifold gage throughout duration of test.
   c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
   d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Drain Pans
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233116 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
3. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment**,** seismic restraints, and vibration isolation.

C. Delegated-Design Submittal:

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

1.5 INFORMATIONAL SUBMITTALS

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

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to **AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.**

B. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 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."

2.2 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. 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).

C. 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 Ducts Larger Than **60 Inches (1524 mm)**

2. in Diameter: Flanged.

D. 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. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

E. 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."

2.3 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. 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.

D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.4 DRAIN PANS

A. General Fabrication Requirements: Drain pans, including their outlets and seals, shall be designed and constructed in accordance with this section and ASHRAE 62.1-2019.

B. Drain pans shall be aluminum or 304L stainless steel construction. Pans shall be seamless construction or joints soldered or welded liquid tight. Minimum depth shall be 2 inches.

C. Drain Pan Slope. Pans shall be sloped at least 0.125 in./ft (10 mm/m) from the horizontal toward the drain outlet such that water drains freely from the pan whether the fan is ON or OFF.

D. Drain Outlet. The drain pan outlet shall be located at the lowest point(s) of the drain pan.

1. Drain pan outlet shall be as follows:

Drain Line Size (inches)	Approximate Equivalent Unit Cooling Coil Airflow (cfm)	Approximate Cooling Capacity for Unit Cooling Coil (tons)
0.75	1,500	15
1	3,850	35
1.25	6,900	65

2. Steam humidifier drain pan outlet shall be 0.75 inches.

E. Drain Seal. For configurations that result in negative static pressure at the drain pan relative to the drain outlet (such as a draw-through unit), the drain line shall include a P-trap or other sealing device designed to maintain a seal against ingestion of ambient air, while allowing complete drainage of the drain pan under any normally expected operating condition, whether the fan is ON or OFF.

F. Pan Size. The drain pan shall be located under the water producing device. Drain pan width shall be sized to collect water droplets across the entire width of the water producing device or assembly.

1. For horizontal airflow configurations, cooling coil drain pan length shall begin at the leading face or edge of the water producing device or assembly and extend downstream from the leaving face or edge to a distance of either:

   a. one half of the installed vertical dimension of the water producing device or assembly or

   b. as necessary to limit water droplet carryover beyond the drain pan to 0.0044 oz/ft2 (1.5 mL/m2) of face area per hour under peak sensible and peak dew-point design conditions, accounting for both latent load and coil face velocity.

2. Secondary (supplemental) drain pans for terminal units shall expend the full with of unit and shall extend under the cooling coil and 1 foot beyond the main drain pan pipe connection.

3. Duct mounted steam humidifiers shall be installed in an aluminum or 304L stainless steel section of ductwork with the bottom 2 inches of the duct section seamless or welded liquid tight. Humidifier drain pan section shall be 8 feet minimum and shall extend from 2 feet upstream of the humidifier to 3 feet downstream of the provided humidifier dispersion distance.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: **4 inches (102 mm)**.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
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 (2500 Pa), positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
11. Service: Indoor or outdoor.

12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for10-inch wg (2500-Pa) 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.

2.6 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 (Table 5-1M), "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

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. **Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."**

3.2 INSTALLATION OF EXPOSED DUCTWORK

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

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

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

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

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.

4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) 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 (5 m).

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.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

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

3.6 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. Test the following systems:

   a. Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. 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.
6. Give [**seven**] <**Insert number**> days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 DUCT CLEANING

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

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, 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, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; 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 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.8 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.9 DUCT SCHEDULE

A. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units.

   a. Pressure Class: Positive **2-inch wg (500 Pa)**.
   b. Minimum SMACNA Seal Class: **A**.

2. Ducts Connected to Variable-Air-Volume Air-Handling Units:

   a. Pressure Class: Positive **4-inch wg (1000 Pa)**.
   b. Minimum SMACNA Seal Class: A.

3. Ducts Connected to Equipment Not Listed Above:

   a. Pressure Class: Positive **2-inch wg (500 Pa)**.
   b. Minimum SMACNA Seal Class: **A**.

B. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units :

   a. Pressure Class: Positive or negative **2-inch wg (500 Pa)**.
   b. Minimum SMACNA Seal Class: **A**.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative **4-inch wg (1000 Pa)**.
b. Minimum SMACNA Seal Class: **A**.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative **2-inch wg (500 Pa)**.
b. Minimum SMACNA Seal Class: **A**.

C. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Positive or negative **2-inch wg (500 Pa)**.
b. Minimum SMACNA Seal Class: A.

D. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 4-inch wg (1000 Pa).
b. Minimum SMACNA Seal Class: A.

E. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel,

2. Stainless-Steel Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Galvanized.

3. Aluminum Ducts: Aluminum.

F. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm (5 m/s) or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

      1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Radius-to Diameter Ratio: 1.5.

   b. Round Elbows, **12 Inches (305 mm)** and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, **14 Inches (356 mm)** and Larger in Diameter: **Standing seal**.

G. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: 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 (5 m/s) or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Combination fire and smoke dampers.
6. Flange connectors.
7. Turning vanes.
8. Duct-mounted access doors.
9. Flexible connectors.
10. Flexible ducts.
11. Duct accessory hardware.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control-damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Duct security bars.
f. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90 (Z275).
2. Exposed-Surface Finish: Mill phosphatized.

B. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

C. Extruded Aluminum: Comply with ASTM B 221 (ASTM B 221M), Alloy 6063, Temper T6.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

E. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. American Warming and Ventilating.
   2. Greenheck Fan Corporation.
   3. Nailor Industries, Inc.
   4. Ruskin Company
   5. Vent Products Company, Inc.

B. Description: Gravity balanced.

A. Maximum Air Velocity:

   1. For duct systems that do not include air volume control terminals and ductwork between room inlets or outlets and associated air volume terminals, provide backdraft damper with a minimum velocity rating of 1250 fpm (6.4 m/s).

   2. For ductwork between air volume control terminals and equipment (e.g. fan or air handling unit) provide backdraft damper with a minimum velocity rating of 2000 fpm (10 m/s).For fan inlets or outlets provide backdraft damper with a minimum velocity rating of 3000 fpm (15 m/s)

B. Maximum System Back Pressure:

   1. Backdraft Dampers

      1. For duct systems that do not include air volume control terminals and ductwork between room inlets or outlets and associated air volume terminals, provide backdraft damper with a maximum system backpressure rating of 2 inch water column (0.5 kPa)

      2. For ductwork between air volume control terminals and equipment (e.g. fan or air handling unit) and for fan inlets or outlets provide backdraft damper with a maximum system backpressure rating of 10 inch water column (2.5 kPa)Pressure Relief Dampers

      1. For pressure relief dampers with a setpoint of 0.1 to 2 inches water column, dampers shall be rated for a maximum backpressure of 8.5 inches water column.

      2. For pressure relief dampers with a setpoint of 2.1 to 4 inches water column, dampers shall be rated for a maximum backpressure of 13.5 inches water column.

      3. For pressure relief dampers with a setpoint of 4.1 to 6 inches water column, dampers shall be rated for a maximum backpressure of 20 inches water column.

C. Backdraft Damper Maximum Start-Open Pressure:

   1. For duct systems that do not include air volume control terminals and ductwork between room inlets or outlets and associated air volume terminals, provide backdraft damper with a maximum start open pressure of 0.05 inch water column when installed vertically and when installed horizontally with upward airflow. Provide damper with 0.075 inch water

column maximum start-open pressure for dampers mounted horizontally with downward airflow.

2. For ductwork between air volume control terminals and equipment (e.g. fan or air handling unit) and for fan inlets or outlets provide backdraft damper with a maximum start open pressure of 0.05 inch water column when installed vertically and when installed horizontally with upward airflow. Provide damper with 0.075 inch water column maximum start-open pressure for dampers mounted horizontally with downward airflow.

D. Maximum Leakage Rate:

1.

E. Frame: Manufacturer standard shape, minimum 0.05-inch- (1.3-mm-) thick (18 gage), galvanized sheet steel, minimum 0.063-inch- (1.6-mm-) thick extruded aluminum (14 gage) or minimum 0.05-inch- (1.3-mm-) thick stainless steel (18 gage), with welded corners or mechanically attached and mounting flange. Material to match associated duct material.

F. Blades: Multiple single-piece blades, center pivoted or end pivoted, maximum 6-inch (150-mm) width, minimum 0.03-inch- (0.6-mm-) thick, roll-formed aluminum with sealed edges. Orientation of blades for backdraft dampers located on fan discharge shall be selected to minimize system effect pressure drop.

G. Blade Action: Parallel.

H. Blade Seals: Extruded vinyl, mechanically locked or neoprene, mechanically locked.

I. Blade Axles:

1. Material: Nonferrous metal, galvanized steel, plated steel, stainless steel or aluminum and shall be compatible with blade material and frame material.

2. Diameter: Minimum 0.20 inch (5 mm).

J. Tie Bars and Brackets: Aluminum or galvanized steel and shall be compatible with blade and frame material.

K. Return Spring: Adjustable tension.

L. Bearings: Steel ball or synthetic pivot bushings.

M. Accessories:
1. Provide adjustment device to permit setting of varying differential static pressure.
2. Provide counterweights or spring-assist to assist in opening damper blades.
3. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Shop Fabricated Volume Dampers:
   a. Dampers shall meet the requirements of SMACNA Duct Construction Manual Section 7.1.

2. Factory Fabricated Volume Dampers:

a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1) American Warming and Ventilating; a Mestek Architectural Group company.
   2) Flexmaster U.S.A., Inc.
   3) Greenheck Fan Corporation.
   4) McGill AirFlow LLC.
   5) Nailor Industries Inc.
   6) Ruskin Company.
   7) Trox USA Inc.
   8) Vent Products Co., Inc.

3. Standard leakage rating, with linkage outside airstream.
4. Suitable for horizontal or vertical applications.
5. Frames:
   a. Frame: Manufacturer standard shape, minimum 0.0396-inch (20 gage) thick, galvanized sheet steel or stainless steel. Material shall match connecting duct materials.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.

6. Blades:

   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized or stainless-steel, minimum 0.0635-inch (16 gage) thick. Material shall match connecting duct materials
7. Blade Axles: Galvanized steel, plated steel or stainless steel.
8. Bearings:
   a. Oil-impregnated bronze or oil-impregnated stainless-steel sleeve.
   b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Tie Bars and Brackets: Galvanized steel.

2.5 FIRE DAMPERS

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

1. American Warming and Ventilating; a Mestek Architectural Group company.
2. Arrow United Industries.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Pottorff.
6. Prefco.

7. Ruskin Company.

8. Vent Products Co., Inc.

B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class (differential pressure) and minimum 2000-fpm (10-m/s) velocity.

D. Fire Rating: 1-1/2 hour rated damper for walls rated for less than 3 hours and 3 hour rated damper for walls with higher fire rating. Refer to architectural drawings for wall fire ratings.

E. Frame: For duct mounted dampers provide curtain type with blades outside air stream or multiple opposed blade type with blades in air stream. For dampers located behind grilles curtain type dampers, blades inside airstream are acceptable. Fabricate with hat channel of galvanized steel or stainless steel to match duct material with thickness (gage) required by the damper U.L. listing.

1. Curtain type fire dampers shall be Case 2 or 3 with blades out of airstream Type "B or C" as defined in SMACNA "Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems – 5th Edition" pages 5.8, 5.11, and 7.2.

2. Where duct dimensions require multiple damper sections, provide curtain type identified above with dampers arranged out of airstream (limited to two stacked dampers with blades on perimeter) or provide multiple opposed blade type dampers.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: Thickness (gage) required by the damper U.L. listing.

2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, galvanized or stainless steel sheet steel to match duct construction in thickness required by damper U.L. listing. Blades shall be one of the following:

1. Interlocking blade, or

2. Constructed with full-length blade connectors matching blade material.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

2.6 COMBINATION FIRE AND SMOKE DAMPERS

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

1. American Warming and Ventilating; a Mestek Architectural Group company.

2. Cesco Products; a divsion of MESTEK, Inc.

3. Greenheck Fan Corporation.

4. Nailor Industries Inc.

5. Pottorff.
6. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 2000-fpm (10-m/s) velocity.

D. Fire-Smoke Damper Fire Rating: 1-1/2 hour rated damper for walls rated for less than 3 hours and 3 hour rated damper for walls with higher fire rating. Refer to architectural drawings for wall fire ratings.

E. Frame: Fabricate with hat channel of galvanized steel or stainless steel to match duct material with thickness (gage) required by the damper U.L. listing. Frame shall have welded, interlocking gusseted or reinforced mechanically attached corners and mounting flange.

F. Blades: Roll-formed galvanized sheet steel or extruded aluminum in thickness (gage) required by the damper U.L. listing.

G. Leakage: Class I.

H. Rated pressure and velocity to exceed design airflow conditions.

I. Mounting Sleeve: Factory-installed, galvanized sheet steel in thickness required by the damper U.L. listing; length to suit wall or floor application with factory-furnished silicone calking.

J. Master control panel for use in dynamic smoke-management systems.

K. Damper Actuators: Provide two-position action unless modulating type action is indicated otherwise on the drawings.

1. Actuators shall be provided by and factory mounted by the damper manufacturer in accordance with the damper U.L Listing.
2. Actuators shall be electric unless noted otherwise.
3. Electrical Connection: 115 V, single phase, 60 Hz.

L. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).

5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
7. Electrical Connection: 115 V, single phase, 60 Hz.

M. Accessories:
1. Auxiliary switches for position indication. Provide additional switches for signaling and fan control where indicated on drawings.
2. Test and reset switches with red (closed) and green (open) LED indicator lights, remote mounted.

2.7 FLANGE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Hardcast, Inc.
3. Nexus PDQ.
4. Ward Industries; a brand of Hart & Cooley, Inc.

2. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.8 TURNING VANES

A. Provide short radius (full length splitter) vanes for elbows with a centerline radius less than 1.5 times the duct width in the plane of the elbow.
1. Comply with SMACNA Duct Construction Manual; Chart 4-1 and Figure 4-2 (Type RE-3) elbows for spacing of vanes and figure 4-9 for construction of short radius full length splitter vanes. Refer to detail on drawings for quantity of full length splitter vanes required based on ratio of centerline to duct width dimensions.

2.9 DUCT-MOUNTED ACCESS DOORS

A. Available Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Aire Technologies.
2. Ductmate Industries, Inc.

3. Nailor Industries Inc.
4. Ward Industries; a brand of Hart & Cooley, Inc.

B. Duct Mounted Sandwich (Clamp) Type Access Doors – Ductwork and Plena Greater Than 2 inch Pressure Class.

1. Duct-Mounted Access Doors: Factory fabricated, leak free insulated sandwich (clamp) type access door with minimum pressure rating equal to or greater than the attached ductwork. Material shall match connecting ductwork.

2. Provide with manufacturer standard gasket, bolts and springs between inner and outer door.

3. Provide wing nuts or molded knobs for low temperature applications and wing nuts for high temperature applications.

C. SMACNA Access Doors – Ductwork and Plena 2" and Lower Pressure Class.

1. Fabricate access panels according to SMACNA Duct Construction Manual, Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

1) Double wall, rectangular.

2) Galvanized sheet metal with insulation fill and thickness for duct pressure class.

3) Vision panel.

4) Hinges and Latches: 1-by-1-inch (25mm-by-25-mm) butt or piano hinge and cam latches.

5) Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:

1) Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.

2) Access Doors up to 18 Inches (460 mm) Square: Continuous hinge and two sash locks.

3) Access Doors up to 24 by 48 Inches (600 by 1200 mm): Continuous hinge and two compression latches with outside and inside handles.

4) Access Doors Larger than 24 by 48 Inches (600 by 1200 mm): Continuous hinge and two compression latches with outside and inside handles.

2.10 FLEXIBLE CONNECTORS

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

1. CL WARD & Family Inc.

2. Ductmate Industries, Inc.

3. Duro Dyne Inc.
4. Elgen Manufacturing.
5. Hardcast, Inc.
6. JP Lamborn Co.
7. Ventfabrics, Inc.
8. Ward Industries; a brand of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches (146 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).

2.11 FLEXIBLE DUCTS

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

1. Buckley Associates, Inc.
2. Flexmaster U.S.A., Inc.
3. JP Lamborn Co.
4. McGill AirFlow LLC.
5. Thermaflex; a Flex-Tek Group company.
6. Ward Industries; a brand of Hart & Cooley, Inc.

B. Non-Insulated Flexible Duct

1. Performance:
   a. UL 181, Class 1.

b. Pressure Rating: Minimum 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
c. Maximum Air Velocity: 4000 fpm (20 m/s).
d. Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).

C. Insulated Flexible Ducts

1. Performance:
a. UL 181, Class 1, fibrous-glass insulation, vapor-barrier film.
b. Pressure Rating: Minimum 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
c. Maximum Air Velocity: 4000 fpm (20 m/s).
d. Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).
e. Insulation R-Value: Comply with ASHRAE/IES 90.1.

D. Flexible Duct Connectors:
1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.

2.12 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.

2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. Control devices requiring inspection.
8. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
5. Body Access: 25 by 14 inches (635 by 355 mm).
6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Connect terminal units with fans to supply and return ducts with flexible connectors. Do not use flexible connectors to change directions.

O. Connect diffusers or light troffer boots to ducts directly or with maximum 6 foot lengths of flexible duct clamped or strapped in place.

P. Connect flexible ducts to metal ducts with ty-wrap tool or reusable stainless steel draw bands.

Q. Install duct test holes where required for testing and balancing purposes.

R. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233416 - CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes: For each product.
   1. Backward-inclined centrifugal fans.

1.3 ACTION SUBMITTALS

A. Product Data:

   1. Include rated capacities, furnished specialties, and accessories for each fan.
   2. Certified fan performance curves with system operating conditions indicated.
   3. Certified fan sound-power ratings.
   4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
   5. Material thickness and finishes, including color charts.
   6. Dampers, including housings, linkages, and operators.

B. Shop Drawings:

   1. Include plans, elevations, sections, and attachment details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.
   4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. AMCA Compliance:

1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
2. Operating Limits: Classify according to AMCA 99.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

D. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Startup."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, supports, including comprehensive engineering analysis by a qualified professional engineer, using performance and design criteria indicated.

F. Wind Performance: Fans shall withstand the effects of wind determined in accordance with to ASCE/SEI 7. See Division 23 for vibration and seismic requirements where applicable.

G. Capacities and Characteristics: Refer to schedules on drawings.

2.2 BACKWARD-INCLINED CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Twin City Fan Companies, Ltd.
2. Greenheck Fan Corporation.
3. Loren Cook Company.

B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. Housings:

1. Formed panels to make curved-scroll housings with shaped cutoff.
2. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
3. Horizontally split, bolted-flange housing.
4. Spun inlet cone with flange.
5. Outlet flange.

D. Backward-Inclined Wheels:

1. Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades, and fastened to shaft with set screws.
2. Welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate.

E. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Bearings:

1. Heavy-duty regreasable ball or roller type in a cast iron self-aligning pillow block housing.
2. Ball-Bearing Rating Life: ABMA 9, L(50) of 200,000 hours
3. Roller-Bearing Rating Life: ABMA 11, L(50) of 200,000 hours.
4. Extend grease fitting to accessible location outside of unit.
5. Where fans are required to be spark resistant, bearing shall be located outside the airstream.

G. Accessories:

1. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
3. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
4. Discharge Dampers: Assembly with opposed blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Spark-Resistant Construction: AMCA 99.
8. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

9. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.4 SOURCE QUALITY CONTROL

A. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:
1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Unit Support: Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

F. Install units with clearances for service and maintenance.

G. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
10. Remove and replace malfunctioning units and retest as specified above.

D. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 DEMONSTRATION

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

END OF SECTION 233416

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bypass, single-duct air terminal units.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.

1. Air terminal units.
2. Liners and adhesives.
3. Sealants and gaskets.
4. Seismic-restraint devices.

B. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated-Design Submittal:

1. Materials, fabrication, assembly, and spacing of hangers and supports.
2. Design Calculations: Calculations**, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation** for selecting hangers and supports.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling 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. Ceiling suspension assembly members.
2. Size and location of initial access modules for acoustic tile.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan-Powered-Unit Filters: Furnish **one** spare filter(s) for each filter installed.

1.7 QUALITY ASSURANCE

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

2.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 BYPASS, SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

1. Carnes.
2. Carrier Corporation.
3. Titus.

B. Configuration: Diverting-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: **0.034-inch (0.85-mm) steel**, **single** wall.

1. Casing Lining: Adhesive attached, **3/4-inch- (19-mm-)** thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

   a. Cover liner with nonporous foil.
   b. Cover liner with nonporous foil and perforated metal.

2. Casing Lining: Adhesive attached, [**1/2-inch- (13-mm-)**] [**3/4-inch- (19-mm-)**] [**1-inch- (25-mm-)**] thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
3. Air Inlet: Round stub connection for duct attachment.
4. Air Outlet: S-slip and drive connections.
5. Access: Removable panels for access to diverting damper and other parts requiring service, adjustment, or maintenance; with airtight gasket.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Electric Controls: Damper actuator and thermostat.

1. Damper Actuator: 24 V, powered closed, powered open
2. Thermostat: Wall-mounted electric type with temperature display in Fahrenheit and Celsius, and space temperature set point.
3. Changeover Thermostat: Duct-mounted, field-adjustable, electric type reverses action of zone thermostat when air temperature reaches 70 deg F (21 deg C).

E. Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat. Control devices shall be compatible with temperature controls specified in Section 230900 "Instrumentation and Control for HVAC" and shall have the following features:

1. Damper Actuator: 24 V, powered closed, powered open.
2. Thermostat: Wall-mounted electronic type with the following features:

   a. Temperature set-point display in Fahrenheit and Celsius.
   b. Auxiliary switch to energize heating control circuit.
   c. Changeover thermistor to reverse action.

2.4 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. Steel Cables: **Galvanized steel complying with ASTM A 603**.

D. 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.

E. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

3.2 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches (100 mm) thick.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. 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.

3.3 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.

B. Hot-Water Piping: In addition to requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Connect ducts to air terminal units according to **Section 233113 "Metal Ducts."**

D. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: **Engage** a qualified testing agency to perform tests and inspections.

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

C. Perform tests and inspections.

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

D. Tests and Inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Air terminal unit will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. **Perform** startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

A. **Train** park's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes gas-fired, fire-tube condensing boilers, trim, and accessories for generating hot water.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For each boiler.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For boiler, accessories, and components, from manufacturer.

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

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Pulse-Combustion Boilers:

   a. Heat Exchanger Damaged by Thermal Shock: 10 years from date of Substantial Completion.
   b. Heat-Exchanger Corrosion: Prorated Nonprorated for five years from date of Substantial Completion.

2. Warranty Period for Fire-Tube Condensing Boilers:

   a. Leakage and Materials: 10 years from date of Substantial Completion.
   b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated for five years from date of Substantial Completion.

3. Warranty Period for Water-Tube Condensing Boilers: 20 years from date of Substantial Completion.
4. Warranty Period for Water-Jacketed Condensing Boilers:

   a. Leakage and Materials: Eight years from date of Substantial Completion.
   b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated for five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N.

E. UL Compliance: Test boilers for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

F. CSA Compliance: Test boilers for compliance with CSA B51.

G. Mounting Base: For securing boiler to concrete base.

2.2 FIRE-TUBE CONDENSING BOILERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings:
1. Lochinvar

B. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water-heating service only.

C. Heat Exchanger: Nonferrous, corrosion-resistant combustion chamber.

D. Pressure Vessel: Carbon steel with welded heads and tube connections.

E. Burner: [Natural] [Propane] gas, forced draft.

F. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

G. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

H. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

I. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Baked-enamel protective finish.
4. Insulation: Minimum 2-inch- (50-mm-) thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

2.3 TRIM

A. Include devices sized to comply with ASME.

B. Safety Relief Valve: ASME rated.

C. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

D. Boiler Air Vent: Automatic.

E. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.

F. Circulation Pump: Nonoverloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

2.4 CONTROLS

A. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Boiler operating controls shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.
3. Operating Pressure Control: Factory wired and mounted to cycle burner.
4. Low-Water Cutoff and Pump Control: Cycle feedwater pump(s) for makeup water control.
5. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.

    a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

C. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. Hardwired Points:

a. Monitoring: On/off status, common trouble alarm, low-water-level alarm
b. Control: On/off operation, hot-water-supply temperature set-point adjustment

2. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.5 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface shall be to fused disconnect switch.
5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
6. Provide each motor with overcurrent protection.

2.6 VENTING KITS

A. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.

B. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.7 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

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

3.2 BOILER INSTALLATION

A. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

2. Retain one of two subparagraphs below. Retain first for projects in seismic areas; retain second for projects not in seismic areas. Indicate vibration isolation and seismic-restraint device type and minimum deflection in supported equipment schedule on Drawings.
3. Comply with requirements for vibration isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 "Hydronic Piping Specialties."

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Boiler Venting:

1. Install flue venting kit and combustion-air intake.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and [water temperature] [steam pressure].
b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Boiler will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

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

G. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.

3. Perform field performance tests to determine capacity and efficiency of boilers.

    a. Test for full capacity.
    b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
7. Notify COR 24 hours minimum in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235216

SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.7 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: **Five** year(s) from date of Substantial Completion.
b. For Parts: **Five**> year(s) from date of Substantial Completion.
c. For Labor: **Five** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

1. Carrier Corporation; Home Comfort and HVAC Building & Industrial Systems.
2. Mitsubishi Electric & Electronics USA, Inc.; HVAC Advanced Products Division.
3. Trane; a business of American Standard companies.
4. YORK; a Johnson Controls company.

2.2 INDOOR UNITS (5 TONS (18 kW) OR LESS)

A. Concealed Evaporator-Fan Components:

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
4. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; with a two-position control valve.
5. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
6. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
7. Fan Motors:
   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Division 23, Common Motor Requirements for HVAC Equipment.
   b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
   c. Wiring Terminations: Connect motor to chassis wiring with plug connection.
8. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
9. Filters: Permanent, cleanable.
10. Condensate Drain Pans:
    a. Fabricated with **one** percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
       1) Length: Extend drain pan downstream from leaving face **to comply with ASHRAE 62.1**.
       2) Depth: A minimum of **2 inches (50 mm)** deep.
    b. Single-wall, **galvanized**-steel sheet.
    c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on **one end** of pan.
       1) Minimum Connection Size: **NPS 1 (DN 25)**.
    d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
    e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

B. Floor-Mounted, Evaporator-Fan Components:
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect.
   a. Discharge Grille: [Steel with surface-mounted frame] [Welded steel bars forming a linear grille and welded into supporting panel].
   b. Insulation: Faced, glass-fiber duct liner.
   c. Drain Pans: Galvanized steel, with connection for drain; insulated.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
3. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; with a two-position control valve.

4. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
5. Fan: Direct drive, centrifugal[**, with power-induced outside air**].
6. Fan Motors:
   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Division 23, Common Motor Requirements for HVAC Equipment.
   b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
7. Air Filtration Section:
   a. General Requirements for Air Filtration Section:
      1) Comply with NFPA 90A.
      2) Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
      3) 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 lifted out from access plenum.
   b. Disposable Panel Filters:
      1) Factory-fabricated, viscous-coated, flat-panel type.
      2) Thickness: [**1 inch (25 mm)**] [**2 inches (50 mm)**].
      3) Dust-Holding Capacity: <**Insert lb (kg)**>.
      4) Initial Resistance: <**Insert inches wg (Pa)**>.
      5) Recommended Final Resistance: <**Insert inches wg (Pa)**>.
      6) Arrestance according to ASHRAE 52.1: [**80**] <**Insert value**>.
      7) Merv according to ASHRAE 52.2: [**5**] <**Insert value**>.
      8) Media: Interlaced glass fibers sprayed with nonflammable adhesive[**and antimicrobial agent**].
      9) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.
   c. Extended-Surface, Disposable Panel Filters:
      1) Factory-fabricated, dry, extended-surface type.
      2) Thickness: [**1 inch (25 mm)**] [**2 inches (50 mm)**] [**4 inches (100 mm)**].
      3) Dust-Holding Capacity: <**Insert lb (kg)**>.
      4) Initial Resistance: <**Insert inches wg (Pa)**>.
      5) Recommended Final Resistance: <**Insert inches wg (Pa)**>.
      6) Arrestance according to ASHRAE 52.1: [**90**] <**Insert value**>.
      7) Merv according to ASHRAE 52.2: [**7**] <**Insert value**>.
      8) Media: Fibrous material formed into deep-V-shaped pleats[**with antimicrobial agent**] and held by self-supporting wire grid.
      9) Media-Grid Frame: [Nonflammable cardboard] [Galvanized steel] [Fire-retardant, **3/4-inch (20-mm)** particleboard with gaskets].
      10) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

C. Wall-Mounted, Evaporator-Fan Components:
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.

3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
4. Fan: Direct drive, centrifugal.
5. Fan Motors:
   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Division 23, Common Motor Requirements for HVAC Equipment.
   b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
   c. Enclosure Type: Totally enclosed, fan cooled.
   d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
   e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
   f. Mount unit-mounted disconnect switches on e**xterior** of unit.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
7. Condensate Drain Pans:
   a. Fabricated with **one** percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
      1) Length: Extend drain pan downstream from leaving face **to comply with ASHRAE 62.1**.
      2) Depth: A minimum of [**1 inch (25 mm)**] deep.
   b. Single-wall, **galvanized**-steel sheet.
   c. Double-wall, **galvanized**-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
   d. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on **one end** of pan.
      1) Minimum Connection Size: **NPS 1 (DN 25)**
   e. Pan-Top Surface Coating: Asphaltic waterproofing compound.

2.3 OUTDOOR UNITS (5 TONS (18 kW) OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

   a. Compressor Type: Scroll.
   b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
   c. Refrigerant Charge: **R-410A**
   d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).
7. Mounting Base: Polyethylene.

2.4 ACCESSORIES

A. Control equipment and sequence of operation are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence and Operations for HVAC Controls."

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

C. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:

1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.

D. Automatic-reset timer to prevent rapid cycling of compressor.

E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

F. Drain Hose: For condensate.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s).
2. Install ground-mounted, compressor-condenser components on polyethylene mounting base.

3. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.3 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 components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

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.

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

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. **Perform** startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

A. **Train** Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 238126

SECTION 238143 - AIR-SOURCE UNITARY HEAT PUMP

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes air-source unitary heat-pump units consisting of evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
   1. Performance Rating: Submit catalog selection data showing equipment ratings and compliance with required cooling and heating capacities EER and COP values as applicable.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

D. Heating Performance shall conform to ASHRAE requirements when tested in accordance with AHRI 210/240 and UL 1995.

1.7 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: **Five** year(s) from date of Substantial Completion.
b. For Parts: **Five**>year(s) from date of Substantial Completion.
c. For Labor: **Five** year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, **provide products by one of the following**:

1. Carrier Corporation; Home Comfort and HVAC Building & Industrial Systems.
2. Mitsubishi Electric & Electronics USA, Inc.; HVAC Advanced Products Division.
3. Trane; a business of American Standard companies.
4. YORK; a Johnson Controls company.

2.2 UNITARY HEAT PUMPS, AIR TO AIR

A. Units shall comply with Fed Spec A-A-50502 Type II, (Split System) having remote outdoor section separate from indoor Section Class 1, "Department of Energy" (DOE) covered products
   1. Unitary heat pumps shall bear the United States Environmental Protection Agency, Energy Star label and shall have a minimum Heating Season Performance Factor (HSPF) of 8.2 and a minimum Seasonal Energy Efficiency Ratio (SEER) of 27.

B. Applicable AHRI Standards: Units shall be listed in the corresponding ARI Directory of Certified products shown in paragraph, APPLICABLE PUBLICATIONS:
   1. Air Source Unitary heat pumps with capacity less than 19 KW (65,000 Btu/hr), Comply with AHRI 210/240.
   2. Air Source heat pump with capacity above 19KW (above 65,000 Btu/hr, Comply with AHRI 340/360.

C. Casing:
   1. Unit shall be constructed of zinc coated, galvanized steel. Exterior surfaces shall be cleaned, phosphatized, and finished with a weather-resistant baked enamel finish.
   2. Unit surfaces shall be tested 500 hours in a salt spray test in compliance with ASTM B117.
   3. Cabinet panels shall have lifting handles and shall be water- and air-tight seal.
   4. All exposed vertical, top covers and base pan shall be insulated with 25-mm (1-inch) matt-faced, fire-resistant, odorless, glass fiber material.
   5. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2010.
   6. The base of the unit shall have provisions for forklift and crane lifting.

D. Filters:
   1. One inch, MERV 7, throwaway filter shall be standard on all units below 19kW (6 Tons). Filter rack can be converted to two inch capability.
   2. Two inch, MERV 8, throwaway filters shall be factory supplied on all units above 19 kW (6 Tons).

E. Compressors:
   1. Compressors shall be direct-drive, hermetic scroll type with centrifugal type oil pumps. Motor shall be suction gas-cooled.
   2. Internal overloads and crankcase heaters shall be utilized with all compressors.

F. Refrigerant Circuit:
   1. A minimum of two circuits is required. Each refrigerant circuit shall have independent fixed orifice or thermostatic expansion devices, service pressure ports, and refrigerant line filter driers factory installed as standard.
   2. An area shall be provided for replacement suction line driers.

G. Evaporator and Condenser Coils:
   1. Internally finned, DN 10 (NPS 3/8) copper tubes mechanically bonded to a configured aluminum plate fin shall be standard.
   2. The evaporated coil and condenser coil shall be leak tested at the factory to 1378 kPa (200 psig) and pressure tested to 2756 kPa (400 psig).
   3. All dual compressor units shall have intermingled evaporator coils. Sloped condensate drain pans shall be provided.

H. Outdoor fans:
   1. Direct driven, statically and dynamically balanced, draw-through in the vertical discharge position.
   2. The fan motors shall be permanently lubricated and shall have built-in thermal overload protection.

I. Indoor Fan:
   1. Forward-Curved, Centrifugal Fan: Motors shall be thermally protected. Provide oversized motors for high static application. Motors shall meet the U.S. Energy Policy Act of 2005 (EPACT).
   2. Plenum Fans Provide direct-drive, Arrangement 4, plenum fan(s) equipped with variable-speed drives.

J. Defrost Controls:
   1. A time initiated, temperature terminated defrost system shall ship with a setting of 70-minute cycle, with a choice of 50- or 90-minute cycle.
   2. Timed override limits defrost cycle to 10 minutes shall be available on units from 35- to 70-kW (10 to 20 tons).
   3. Adaptive demand defrost shall be provided on units below 35 kW (10 Tons).

K. Unit Electrical
   1. Provide single point unit power connection.
   2. Unit control box shall be located within the unit and shall contain controls for compressor, reversing valve and fan motor operation and shall have a 50 VA 24-volt control circuit transformer and a terminal block for low voltage field wiring connections.
   3. Safety Controls - High pressure, low temperature, and low pressure safety switches shall be wired through a latching lockout circuit to hold the conditioner off until it is reset electrically be interrupting the power supply to the conditioner. All safety switches shall be normally closed, opening upon fault detection.

L. Operating Controls
   1. Provide unit with low voltage electric controls.
   2. Low voltage, adjustable room thermostat to control heating and cooling in sequence with delay between stages, compressor and supply fan to maintain temperature setting. Include system selector switch off-heat-auto-cool)and fan control switch (auto-on).

M. Accessories:
   1. Electric Heater:
      a. Constructed of heavy-duty nickel chromium elements. Staging shall be achieved through the unit control processor.
      b. Each heater shall have automatically reset high limit control. Heaters shall be individually fused from the factory and shall comply with NEC and CEC requirements.
      c. Power assemblies shall provide single point connection. Electric heat modules shall be listed and labeled by a national recognized testing laboratory acceptable to authorities having jurisdiction. Electric heater controls shall confirm the supply fan is operating before electric elements are energized.
      d. Operate electric heater in 2 stages when outdoor ambient is too low to maintain space thermostat setting with compressor operation.
   2. Mounting Base: Polyethylene.

3. Control equipment and sequence of operation are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence and Operations for HVAC Controls."
4. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
5. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
   a. Compressor time delay.
   b. 24-hour time control of system stop and start.
   c. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
   d. Fan-speed selection including auto setting.
6. Automatic-reset timer to prevent rapid cycling of compressor.
7. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
8. Drain Hose: For condensate.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s).
2. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
3. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.3 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 components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

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.

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

E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. **Perform** startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

A. **Train** Park's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 238126

SECTION 26 00 10 - GENERAL ELECTRICAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section and all other Division 26 Sections included herein.

1.2 DESCRIPTION

A. This section includes basic requirements of a common or administrative nature that pertain to all electrical work.

1.3 WORK INCLUDED

A. As specified and as shown, furnish, install, test, and place in satisfactory and successful operation all equipment, materials, devices, and necessary appurtenances to provide the following:

1. Remove wiring, raceway and devices associated with HVAC equipment to be removed.
2. Provide wiring, raceway and devices associated with HVAC equipment to be furnished and installed, including VFD's.
3. Provide new cover for existing Panel MDP.

B. Work shall be completed as shown on the Drawings, as specified herein, and as required by job conditions.

1.4 QUALITY ASSURANCE `

A. Worker's Qualifications: All electrical work shall be performed by licensed electricians or under the direct supervision of a licensed electrician.

B. Manufacturer Qualifications: All materials shall be provided by firms regularly engaged in the manufacture of products and systems required, whose products have been in satisfactory use in similar service for not less than 10 years old.

C. Codes and Regulations:

1. All work shall meet requirements of governing codes and regulations, NFPA 70, latest edition.
2. Advise the Contracting Officer of conflicting codes or conflicts between codes and drawings and specifications.
3. When the requirements of specifications or drawings are more stringent than the codes, regulations, or standards, the specifications or drawings shall prevail.
4. The electrical installation shall meet the requirements of NECA Standard of Installation, except where otherwise specified.

D. UL Listing:

1. All electrical materials and equipment shall meet requirements of the applicable standards of UL if UL standards exist for such materials and equipment.

2. The UL authorized listing mark is acceptable as evidence that the materials meet this requirement.

3. In lieu of UL authorized listing mark, the Contractor may submit independent proof satisfactory to the Contracting Officer that the materials meet the standards.

4. Materials and equipment shall be installed only for their intended operational purpose.

E. Standard Products: Provide only new electrical equipment of current standard design.

F. Finished Surfaces:

1. Finished surfaces of existing facilities that are marred, scratched, or damaged shall be refinished to match original condition.

2. Building surfaces that have been altered for the proper installation of electrical equipment shall be restored by skilled personnel of the trades involved at no additional expense to the Government.

G. Polychlorinated Biphenyl (PCB): Equipment containing PCB is not acceptable.

1.5 INTENT OF CONSTRUCTION DRAWINGS

A. Electrical drawings do not attempt to show complete details of building construction that affect installation. Diagrams are schematic only and do not necessarily show physical arrangement of equipment. Refer to drawings of other trades for additional details which affect work.

B. Conduit, conductor, and ground connections are shown diagrammatically only. Layout does not necessarily show total number of conduits or conductors for circuits required and should not be used for obtaining quantities for linear runs of conduits or wires. Locations of indicated runs are not intended to show actual routing of conduits. Provide additional conduits and wire wherever needed to complete installation of specific equipment furnished.

C. Locations of outlets on drawings are approximate and may be distorted for clarity in representation.

D. Install electrical outlets and other equipment clear of and in proper relation to radiators, ducts, grilles, pipes, and other equipment, and items such as cabinets and counters.

E. Changes such as offsetting conduit runs, moving outlets, or other minor changes necessary to facilitate installation shall be made at no additional expense to the Government.

1.6 COORDINATION OF WORK

A. Coordinate electrical work with the National Park Service operations and the work of various other trades that may be on site.

1.7 SUBMITTALS

A. As specified in Section 013323 Submittal Procedures.

B. Submit manufacturer's literature for items listed below.

1. Control panels and all control accessories.

2. Batteries and battery chargers.

3. Central Station communicators and accessories.

4. Intrusion detection devices.

5. Intrusion detection notification appliances.

1.8 CLOSEOUT SUBMITTALS

A. As specified in Section 017700 Closeout Procedures.

B. Record Drawings.

1.9 PROJECT CLOSEOUT

A. As specified in Section 011770.

PART 2 - PRODUCTS NOT USED.

PART 3 - EXECUTION

3.1 INSPECTION

A. Demonstrate that electrical work operates satisfactorily and in accordance with the requirements of the drawings and specifications. Before final inspection, remove the front covers on all panelboards and wire gutters. Replace covers after the final inspection is completed.

3.2 TESTING

A. General:

1. Make all specified tests in the presence of the Contracting Officer's Representative or other authorized representative.

2. Furnish all instruments and provide qualified personnel to perform all tests in accordance with the drawings and specifications.

3. Perform all tests at no additional expense to the Government.

4. Operate all electrical equipment within the ranges specified by manufacturer.

5. Correct defects revealed by the tests.

B. Balance Test: Test for proper load balance on the system and make adjustments as required.

C. Conductors: Prior to energizing and circuitry, test installed wires and cables to ensure that insulation resistance levels are adequate, test wires and cables for electrical continuity and for short-circuits.

D. Wiring devices: Ensure proper polarity of connections. Prior to energizing the system, test wiring devices in accordance with manufacturer's recommendations.

END OF SECTION 26 00 10

SECTION 260519 - ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

B. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN-2-THWN-2.

C. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for armored cable, Type AC with ground wire.

2.2 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper, solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-2-THWN-2, single conductors in Armored cable.

D. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-2-THWN-2, single conductors in raceway.

E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Armored cable, Type AC.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductors at each outlet, with at least 6 inches (150 mm).

3.5 IDENTIFICATION

A. Identify and color-code conductors.

B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

   a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
   b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

B. Test and Inspection Reports: Prepare a written report to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 26 05 19

SECTION 26 05 33 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

1.2 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. RSC: Comply with ANSI C80.1 and UL 6.

C. RMC: Comply with ANSI C80.5 and UL 6A.

D. IMC: Comply with ANSI C80.6 and UL 1242.

E. EMT: Comply with ANSI C80.3 and UL 797.

F. FMC: Comply with UL 1; aluminum.

G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:
   a. Material: Steel.
   b. Type: Setscrew.
3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 BOXES, ENCLOSURES, AND CABINETS

A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: RMC

2. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.

3. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated.

1. Exposed, Not Subject to Physical Damage: EMT

2. Exposed and Subject to Severe Physical Damage: RGC.

3. Concealed in Ceilings and Interior Walls and Partitions: FC

4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.

5. Damp or Wet Locations: GRC.

6. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 nonmetallic in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.

2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.

3. EMT: Use setscrew, steel fittings. Comply with NEMA FB 2.10.

4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface raceways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.

D. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

E. Support conduit within 12 inches (300 mm) of enclosures to which attached.

F. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

G. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

H. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

I. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35-mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

J. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

K. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m).

2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.

b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.

c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.

d. Attics: 135 deg F (75 deg C) temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per degree F (0.06 mm per meter of length of straight run per degree C) of temperature change for PVC conduits.

4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.

5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

L. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.

2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

M. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.

B. Install firestopping at penetrations of fire-rated floor and wall assemblies.

3.4 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 05 33

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Enclosures.

1.2 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7] <Insert requirement>.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified [and the unit will be fully operational after the seismic event]."

1.4 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Siemens Energy & Automation, Inc.

4. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 240V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

4. Lugs: Suitable for number, size, and conductor material.

5. Service-Rated Switches: Labeled for use as service equipment.

2.2 NONFUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.

3. Siemens Energy & Automation, Inc.

4. Square D; a brand of Schneider Electric.

B. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Single Throw, 600V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Lugs: Suitable for number, size, and conductor material.

2.3 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

D. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I^2t response.

E. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

F. Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.2 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 26 28 16

SECTION 31 00 00 -- EARTHWORK

PART 1 – GENERAL

1.1 DESCRIPTION

A. Provide facilities, labor, materials, tools, equipment, appliances, transportation, supervision, and related work necessary to complete the work specified in this section, and as shown on the Drawings.

B. Work performed under this Section of the Specifications shall be subject to the General Conditions, Supplementary Conditions and Division 01 General Requirements Division 1 - General Provisions of the Contract Documents.

C. The work of this section includes but is not necessarily limited to:

1. Excavation, fill, and backfill, as indicated or required, including compaction.

2. Excavation, as required, to the lines and grades indicated on the Drawings.

3. Rough grading, including placement, moisture conditioning, and compaction of fills and backfill.

4. Placement of base and subbase course materials under pavements including compaction.

6. Protect and preserve all existing buildings, pavements, and utilities to remain.

D. Contractor shall be responsible for notifying all affected utility companies before starting work.

1.2 RELATED SECTIONS

A. Carefully examine all of the Contract Documents for requirements which affect the work in this Section. Other Specification Sections which directly relate to the work of this Section include, but are not limited to, the following:

1. Section 32 11 00 – BASE COURSES

2. Section 32 91 19 – LANDSCAPE GRADING

3. Section 32 92 05 - TOPSOIL

1.3 LAWS AND REGULATIONS

A. Work shall be accomplished in accordance with regulations of local, county, state and federal agencies or utility company standards as they apply.

1.4 QUALITY ASSURANCE

A. The Contractor shall make provisions for allowing observations and testing of Contractor's work by the independent testing and inspection firm and/or the Geotechnical Consultant.

1. The presence of the independent testing and inspection firm and/or the Geotechnical Consultant does not include supervision or direction of the actual work of the Contractor, and his employees or agents. Neither the presence of the independent testing and inspection firm and /or the Geotechnical Consultant, nor any observations and testing performed by them, nor failure to give notice of defects shall excuse the Contractor from defects discovered in his work.

B. Costs related to retesting due to unacceptable qualities of work and failures discovered by testing shall be paid for by the Contractor at no additional expense to Government, and the costs thereof will be deducted by the Government from the Contract Sum.

1.5 SUBMITTALS

A. Submit the name of each material supplier and specific type and source of each material. Any change in source throughout the project requires approval of the CO.

1.6 COORDINATION

A. Prior to start of earthwork the Contractor shall arrange an on-site meeting with the CO and/or the Geotechnical Consultant for the purpose of establishing the Contractor's schedule of operations and scheduling observation and testing procedures and requirements.

B. As construction proceeds, the Contractor shall be responsible for notifying the CO prior to the start of earthwork operations requiring observation and/or testing.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials shall comply with the Virginia Department of Transportation Road and Bridge Specifications (Latest Edition):

1. Subbase and Aggregate Base Material

2. Topsoil

PART 3 - EXECUTION

3.1 EXCAVATIONS

A. <u>General Definitions</u>

1. Unclassified Materials

Unclassified excavation includes the satisfactory removal and disposal of all materials encountered regardless of the nature of the materials and shall be understood to include, but not be limited to earth, pavements, abandoned drainage and utility structures, and debris.

B. Site General Requirements

1. Control the grading so that ground is pitched to prevent water from running to excavated areas, damaging other structures, or adjacent properties.

2. Where soil has been softened or eroded by flooding, equipment, traffic, or placement during unfavorable weather, or such other conditions, it shall be removed and replaced by the Contractor with suitable material, and at no cost to the Government.

3. Exercise care to preserve the material below and beyond the lines of excavation. Where excavation is carried out below indicated grade or beyond the lines of excavation, Contractor shall backfill and compact the over excavation with structural fill to the indicated grade, at no additional cost to the Government.

4. Limits of excavation are such that all unsuitable material shall be removed to firm natural ground in the manner specified below.

5. Unsuitable materials which are classified as organics such as peat, trash, fill, roots, debris, and topsoil and subsoil when determined by CO to be unacceptable for incorporation into the work.

6. All suitable material, as determined by the CO, may be reused on the site provided it meets the gradation requirements for the given materials in the information of embankments, subgrades, backfills, topsoil, etc.

3.3 PREPARATION OF EXCAVATION BOTTOMS

A. Compaction equipment for fill shall be accomplished by means of drum-type, power-driven, hand-guided vibratory compactors operating at 2,000 cycles per minute, or by hand-guided vibratory plate tampers.

3.4 BACKFILLING AND PLACEMENT OF FILL MATERIALS

A. Site

1. Dewater subgrade areas prior to filling.

2. Compaction by puddling or jetting is prohibited.

3. Control groundwater and surface runoff to minimize disturbance of exposed natural ground surface, previously placed and compacted fill and material being placed.

4. Soil fill moisture shall be maintained at an acceptable working range to allow for proper compaction.

5. Do not place fill on frozen ground.

6. Do not place frozen fill.

7. Place fill in uniform horizontal layers and compact immediately after placement.

8. To the extent that is practical, each layer of fill shall be compacted to the specific density the same day it is placed.

9. Protect pipes from damage during backfilling operations. Repair damage at no cost to Government.

10. Placement of fill shall not begin prior to observation and approval of subgrade conditions by CO.

11. Upon completion of the work, the final ground surface shall be left in a firm, unyielding, true, uniform condition free from ruts. Repair disturbed areas caused equipment traffic at no cost to the Government.

B. Equipment

1. Compaction equipment used in open areas where space permits shall consist of vibratory rollers weighing at least 15,000 lbs., pneumatic compactors, or other similar equipment.

2. Compaction equipment for fill against foundation walls and in other confined areas shall be accomplished by means of drum-type, power-driven, hand-guided vibratory compactors operating at 2,000 cycles per minute, or by hand-guided vibratory plate tampers.

C. Placing Fill

1. Fill sections and embankments shall be constructed of earth, or granular fill deposited in successive lifts.

2. During fill and embankment construction operations, earth moving equipment shall be routed as evenly as possible over the entire width of the work.

3. At the close of each day's work the working surface shall be crowned, shaped, and rolled with smooth steel or pneumatic tired rollers to ensure proper drainage.

3.5 BACKFILLING AGAINST STRUCTURES

A. Backfilling against concrete shall only be done when approved. The Contractor shall not place backfill against or on structures until they have attained sufficient strength to support the loads (including construction loads) to which they will be subjected, without distortion, cracking or other damage. As soon as practicable after the structures are structurally adequate and other necessary work has been satisfactorily completed, or other testing of the

structures shall be made by the Contractor, as required by the CO, at the Contractor's expense.

1. After the satisfactory completion of any other required work in connection with the structures, the backfilling around the structures shall proceed using suitable and approved excavation material. The best of the backfill material shall be used for backfilling within 2 feet (2') of the structure. Just prior to placing backfill, the areas shall be cleaned of all excess construction material and debris and the bottom of excavations shall be in a thoroughly compacted condition.

B. Symmetrical backfill loading shall be maintained. Special care shall be taken to prevent any wedging action or eccentric loading upon or against the structures.

1. During backfilling operations, care shall be exercised that the equipment used will not overload the structures in passing over and compacting these fills. Except as otherwise specified or directed, backfill shall be placed in layers not more than 12 inches (12") in loose depth and each layer of backfill shall be compacted thoroughly and evenly using approved types of mechanical equipment. Each pass of the equipment shall cover the entire area of each layer of backfill.

C. In compacting and other operations, the Contractor shall conduct his operations in a manner to prevent damage to structures due to passage of heavy equipment over and adjacent to structures. Repair damage made by the Contractor, at no additional cost to the Government.

D. After backfilling the Contractor shall maintain the surfaces of backfill areas in good condition to present a smooth surface at all times level with adjacent surfaces. The Contractor shall repair any subsequent settling over backfilled areas immediately, in a manner satisfactory to the CO, and such maintenance shall be provided by the Contractor for the life of this Contract, at no additional cost to the Government.

E. The finished subgrade of the filled excavations upon which pavements are to be constructed shall not be disturbed by traffic of other operations and shall be maintained in a satisfactory condition until the finished courses are placed. The storage or stockpiling of materials on finished subgrade will not be permitted.

F. Uniformly smooth grade all areas to be graded, as indicated including excavated sections and all areas disturbed because of the Contractor's operations. The finished surfaces shall be reasonably smooth, compacted and free from surface irregularities.

3.7 COMPACTION

A. <u>Compaction Requirements</u>

1. The degree of compaction is expressed as a percentage of the maximum dry density at optimum moisture content as determined by ASTM D1557, Method C. The compaction requirements are as follows:

Area	Minimum Degree of Compaction
Pavement base course	95%
Pavement subbase	95%
General fill below pavement subbase	90%
Trench backfill	92%
Lawn areas	90%

2. Compaction percentages are based on the laboratory derived Maximum Density Values.

B. Moisture Control

1. Fill that is too wet for proper compaction shall be dried to a proper moisture content to allow compaction to the required density. If fill cannot be dried within 24 hours of placement, it shall be removed and replaced with drier fill.

2. Fill that is too dry for proper compaction shall receive water uniformly applied over the surface of the loose layer. Sufficient water shall be added to allow compaction to the required density.

3. In no case shall fill be placed over material that is frozen. No fill material shall be placed, spread, or rolled during unfavorable weather conditions. When work is interrupted by heavy rains, fill operations shall not be resumed until the moisture content and the density of the previously placed fill are as specified.

C. Lift Thickness of Material

1. Select Fill and Sand Borrow. Place in layers not to exceed 6 inches (6") when utilizing light hand-operated compaction equipment.

2. Common Fill. Place in layers not to exceed 8 inches (8") when utilizing light hand-operated compaction equipment.

3. Crushed Aggregate, Gravel, Dense, Graded Crushed Aggregate for Subbase. Place in layers not to exceed 6 inches (6") when utilizing light hand-operated compacted equipment. Compact with a minimum of four (4) coverages of acceptable compaction equipment.

D. Placing Fill

1. Fill sections and embankments shall be constructed of earth or granular fill deposited in successive lifts.

2. During fill and embankment construction operations, earth moving equipment shall be routed as evenly as possible over the entire width of the work.

3. At the close of each day's work the working surface shall be crowned, shaped, and rolled with smooth steel or pneumatic tired rollers to ensure proper drainage.

E. Protection of Fill

1. Protection of compacted fill shall be the responsibility of the Contractor. Park does not guarantee that gutters will not overflow during a storm event. Newly graded areas shall be protected from the actions of the elements and traffic. Any settlement or washing that occurs prior to acceptance of the work shall be repaired and grades shall be established to the required elevations and slopes. Damage to any compacted lift (including those lifts previously tested and approved by the CO) occurring at any time during the course of construction, which is caused by equipment, moisture entering the embankment, or from any other cause, shall be fully repaired by the Contractor prior to placement of overlying materials, at no additional cost to the Government and to the complete satisfaction of the CO.

2. In the event of and prior to the commencement of heavy rains, the Contractor shall suspend fill operations immediately and shall take all necessary steps to keep the site as well drained as possible. Fill operations shall not be resumed until the moisture content of the fill is such as to permit compliance with the Specifications.

3. All corrective work or operations necessary to maintain proper moisture control of the fill material shall be at the expense of the Contractor.

F. Finish

1. Upon completion of the work, ground surface shall be left in a firm, unyielding, true, uniform condition, free of ruts.

END OF SECTION 31 00 00

SECTION 32 11 00 – BASE COURSE

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies requirements for the preparation of the subgrade for and placement of granular subbase.

B. The work includes:

1. Fine grading and compaction of pavement subgrade, furnishing, placing and compacting of subbase and base materials.

1.2 RELATED SECTIONS

A. Other specification Sections which directly relate to the work of this Section include:

1. Section 31 00 00 – EARTHWORK

PART 2 - PRODUCTS

2.1 MATERIALS

A. Subgrade course and aggregate base course for pavement sections shall conform to the latest version of Virginia Department of Transportation's Road and Bridge Specification.

1. See Subbase and Aggregate Base Material – Section 208

PART 3 – EXECUTION

3.1 SUBGRADE PREPARATION

1. Subgrade preparation shall conform to the latest version of Virginia Department of Transportation's Road and Bridge Specification, as well as all other sections referenced therein.

1. See Aggregate Base Course – Section 309
2. See Density Requirements – Section 309.05

END OF SECTION 32 11 00

SECTION 32 13 13 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concrete sidewalk

1.2 RELATED WORK

1. SECTION 03 10 00 – FORMWORK
2. SECTION 31 00 00 – EARTHWORK
3. SECTION 32 11 00 – BASE COURSE

1.3 ACTION SUBMITTALS

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

B. Other Action Submittals:

1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

1.4 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. ACI Publications: Comply with ACI 301 unless otherwise indicated.

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS

A. Concrete Standards: All requirements for concrete shall be in accordance with the latest edition of the Virginia Department of Transportation Standard Specifications for Construction and Materials Section 404 – Hydraulic Cement Concrete Operations.

2.2 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, with the following properties:

1. Compressive Strength (28 Days): 3000 psi for paths
2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.50.
3. Slump Limit: 4 inches, plus or minus 1 inch.
4. Air Content: 5-1/2 percent plus or minus 1.5 percent.

B. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

2.3 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M and ASTM C 1116/C 1116M. Furnish batch certificates for each batch discharged and used in the Work.

2.4 WELDED WIRE MESH

A. Virginia Department of Transportation 2020 Standard Specifications for Construction and Material Section 223 – Steel Reinforcement

2.5 DETECTABLE WARNING SURFACE

A. Virginia Department of Transportation 2020 Standard Specifications for Construction and Material Section 504 – Sidewalks

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Proof-roll prepared sub-base surface below concrete slabs to identify soft pockets and areas of excess yielding.

B. Remove loose material from compacted sub-base surface immediately before placing concrete.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.3 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Provide flat sheets of 6 X 6 10/10 in sidewalk slabs resting on plastic chairs.

C. Pins to tie in existing pavement to new pavement and expansion joints shall be 3/8” smooth steel pins, one half of length sleeved or greased.

3.4 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting structures and other fixed objects, and where indicated. Joints shall also be placed in all walks and sidewalks, spaced 40’ apart and perpendicular to the centerline.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, to match jointing of existing adjacent concrete paving:

E. Edging: After initial floating, tool edges of paving and joints in concrete with an edging tool to a 3/8-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

F. Pinning: Pin between the new and existing sidewalks. Set pins 18” o.c. and 9” through expansion joint material and into concrete. Sleeve or grease one end. Install ½” X 6” premolded expansion joint material the entire depth of the joint.

3.5 CONCRETE PLACEMENT

A. Moisten sub-base to provide a uniform dampened condition at time concrete is placed.

B. Comply with ACI 301 requirements for measuring, mixing, transporting, placing, and consolidating concrete.

C. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

D. Screed paving surface with a straightedge and strike off.

E. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

3.6 BROOM FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Broom Finish: Begin the finishing operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Finish surfaces to true planes. Cut down high spots and fill low spots.

3.7 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before broom finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture curing moisture-retaining-cover curing curing compound or a combination of these.

3.8 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:

1. Elevation: 3/4 inch.
2. Thickness: Plus 3/8 inch, minus 1/4 inch.
3. Surface: Gap below 10-foot- long, unleveled straightedge not to exceed 1/2 inch.
4. Joint Spacing: 5 feet.
5. Contraction Joint Depth: Plus 1/4 inch, no minus.
6. Joint Width: Plus 1/8 inch, no minus.

3.9 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by the contracting officer.

B. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

END OF SECTION 32 13 13

SECTION 32 92 00 - SEEDING, FERTILIZING, MULCHING

PART 1 GENERAL

1.1 DESCRIPTION

A. The work of this section consists of preparing topsoil, seeding, fertilizing, and mulching of all disturbed landscapes and placing plant materials.

1.2 SUBMITTALS

A. Seed:

1. Seed shall be fresh new crop seed which meets the purity, weed, and germination standards. The Contractor shall submit a report from an independent seed testing laboratory confirming seed meets state standards for grass seed mixes.

B. Fertilizer:

1. Fertilizer shall be a complete commercial fertilizer containing in available form with a minimum of ten percent Nitrogen, six percent Phosphoric Acid, and four percent Potash. The contractor shall submit information on the fertilizer proposed.

C. Mulch:

1. Mulch shall be wheat straw or other materials as may be processed or manufactured for this purpose. The contractor shall submit information on the mulch material to be used.

D. Certificates:

1. Laboratory certified analyses verifying that peat moss and fertilizer comply with specifications.

1.3 PRODUCT HANDLING

A. Seed:

1. Deliver in acceptable condition in original, unopened containers.

B. Fertilizer:

1. Deliver in original, unopened containers with analysis, type, and trade name attached.

1.4 PROJECT CONDITIONS

A. Plant during normal season determined by climatic conditions and accepted practices in region of construction.

PART 2 PRODUCTS

2.1 TOPSOIL

A. On-Site Topsoil

B. Free from weeds, sod, clods and stones larger than 1-inch, toxic substances, litter, or other deleterious material.

2.2 LIMESTONE

A. Agricultural limestone containing minimum of 85 percent carbonates. Minimum gradation: 100 percent passing a 10 mesh sieve; 98 percent a 20 mesh sieve; 55 percent a 60 mesh sieve; and 40 percent a 100 mesh sieve.

2.3 FERTILIZER

A. Standard 12-12-12 fertilizer

2.4 SEED

A. Standard Turfgrass Mix Section 603

2.5 WATER

A. Clean, fresh, free from harmful substances.

2.6 MULCH

A. Clean straw, free from noxious weed seed and other harmful material. Commercial products may be used with approval.

2.7 BINDER

A. Emulsified asphalt, ASTM D977-91, Grade SS-1.

PART 3 EXECUTION

3.1 SEEDING

A. Sow uniformly. Using a mechanical spreader, make two applications at right angles to each other. Lightly roll immediately after sowing with a 200 to 250-pound hand roller.

3.2 FERTILIZING

A. Apply the fertilizer evenly with a mechanical spreader as specified by the manufacturer

3.3 MULCHING

A. Immediately after rolling, apply mulch uniformly to a depth of 2 inches. Application by mechanical methods is preferred; however, mulch chopped or cut into short pieces will not be acceptable. Secure mulch in place by staking and tying or by spraying with binder. Apply binder at the rate of 6 to 10 gallons per 1,000 square feet.

3.4 WATERING

A. After mulching, water with a mist spray soaking ground to minimum depth of 2 inches. Water as necessary until final inspection.

3.5 CLEAN-UP

A. Upon completion of work, remove debris and leave area in clean, acceptable condition.

END OF SECTION 32 92 00

SECTION 32 92 05 - TOPSOIL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work of this Section consists of placing topsoil on a previously prepared subgrade.

1.2 SUBMITTALS

A. As specified in Section 01 33 00. Submit soil analysis report for imported topsoil from the approved soil testing laboratory. Report shall cover soil textural classification (percentages of sand, silt, and clay) and include additive recommendations. Testing will be at the expense of the Contractor.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Use all on-site stockpiled topsoil before importing topsoil. Do not deliver or place topsoil in frozen, wet, or muddy condition.

PART 2 - PRODUCTS

2.1 IMPORTED TOPSOIL:

A. Fertile, friable, loamy soil, containing 1 to 10 percent organic matter; reasonably free from subsoil, refuse, roots, heavy or stiff clay, stones larger than 1 inch, coarse sand, noxious seeds, sticks, brush, litter, and other deleterious substances; suitable for the germination of seeds and the support of vegetative growth. The pH value shall be between 7 and 8.

B. Soil Texture: Sand, 20 to 70 percent; silt, 10 to 60 percent; clay, 5 to 30 percent.

C. Additives: As determined by soil fertility tests.

PART 3 - EXECUTION

3.1 PLACING TOPSOIL

A. Scarify compacted subgrade to a 2-inch depth to bond topsoil to subsoil. Place topsoil to a minimum depth of 6 inches. Spread evenly and grade to elevations and slopes shown. Hand rake areas inaccessible to machine grading.

END SECTION 32 92 05