



STATE OF UTAH - DEPARTMENT OF ADMINISTRATIVE SERVICES

**Division of Facilities Construction and Management**

**DFCM**

**MULTI-STEP BIDDING PROCESS  
FOR  
CONTRACTORS**

**Request For Solicitation For  
Construction Services**

**Stage II – Mechanical Contractors Bidders List FY09**

**February 3, 2009**

**ENGINEERING AND TECHNOLOGY  
AIR HANDLER REPLACEMENT**

**SOUTHERN UTAH UNIVERSITY**

**CEDAR CITY, UTAH**

**DFCM Project No. 08109730**

Design Firm WHW Engineering Inc.  
8619 South Sandy Parkway #101  
Sandy, Utah. 84070  
Ph. 801-466-4021  
Fax 801-466-8536

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Current copies of the following documents are hereby made part of these contract documents by reference. These documents are available on the DFCM web site at <http://dfcm.utah.gov> or are available upon request from DFCM:

DFCM Supplemental General Conditions dated July 15, 2008  
DFCM General Conditions dated May 25, 2005  
DFCM Application and Certificate for Payment dated May 25, 2005

Technical Specifications:  
Drawings:

**The Agreement and General Conditions dated May 25, 2005 have been updated from versions that were formally adopted and in use prior to this date. The changes made to the General Conditions are identified in a document entitled Revisions to General Conditions that is available on DFCM's web site at <http://dfcm.utah.gov>**

## INVITATION TO BID

**ONLY FIRMS PRE-QUALIFIED DURING STAGE I OF THE RFS ARE ALLOWED TO BID ON THIS PROJECT**

The State of Utah - Division of Facilities Construction and Management (DFCM) is requesting bids for the construction of the following project:

**Project Name: Engineering and Technology Air Handler Replacement – Southern Utah University**  
**DFCM Project No: 08109730**

**Project Description: Replace two roof mounted multi zone units, reconnect to existing control system. Install new access roof hatch and ladder.**

**Construction Cost Estimate: \$ 286,000.00**

<b>Company</b>	<b>Contact</b>	<b>Fax</b>
Ben Lomond Mechanical	Mr. Jeff Dalton	(801) 731-7844
Commercial Mechanical Sys & Srv	Mr. Norman J. Cole	(801) 977-3928
Envision Mechanical, Inc.	Mr. Ray Squier	(801) 731-8070
Harris Air Systems, Inc.	Mr. Omar Nava	(801) 467-6524
Harris Companies	Mr. Frank Dorhofer	(801) 433-2641
KOH Mechanical Contractors	Mr. Larry Hansen	(801) 254-6374
Mechanical Service & Systems, Inc.	Mr. Randy Karren	(801) 561-4673
Ralph Tye and Sons, Inc.	Mr. Doug Tye	(801) 262-1391
Rocky Mountain Mechanical	Mr. Jeff Larsen	(801) 467-1460
S.R. Mechanical, Inc.	Mr. Steven Roberts	(435) 529-7851
Tod R. Packer Heating & Air	Mr. Todd R. Packer	(801) 849-1314

The bid documents will be available on **Tuesday, February 3, 2009** in electronic format only on CDs from DFCM at 4110 State Office Building, Salt Lake City, Utah 84114, telephone (801)538-3018 and on the DFCM web page at <http://dfcm.utah.gov>. For questions regarding this project, please contact **Jeff Reddoor**, Project Manager, DFCM, at (801) 971-9830. No others are to be contacted regarding this project.

A **MANDATORY** pre-bid meeting and site visit will be held at **1:00 PM on Wednesday, February 11, 2009 at Southern Utah University NEW Facility Management Building, 385 South 1275 West, Cedar City Utah 84720**. All pre-qualified prime contractors wishing to bid on this project must attend this meeting.

Bids must be submitted by **3:00 PM on Tuesday, February 24, 2009** to DFCM, 4110 State Office Building, Salt Lake City, Utah 84114. Bids will be opened and read aloud in the DFCM Conference Room, 4110 State Office Building, Salt Lake City, Utah. Note: Bids must be received at 4110 State Office Building by the specified time. The contractor shall comply with and require all of its subcontractors to comply with the license laws as required by the State of Utah.

A bid bond in the amount of five percent (5%) of the bid amount, made payable to the Division of Facilities Construction and Management on DFCM's bid bond form, shall accompany the bid.

The Division of Facilities Construction & Management reserves the right to reject any or all bids or to waive any formality or technicality in any bid in the interest of the State.

DIVISION OF FACILITIES CONSTRUCTION AND MANAGEMENT  
JOANNA REESE, CONTRACT COORDINATOR  
4110 State Office Bldg., Salt Lake City, Utah 84114

## **STAGE II - MULTI-STEP BIDDING PROCESS**

**ONLY FIRMS PRE-QUALIFIED DURING STAGE I OF THE RFS ARE ALLOWED TO BID ON THIS PROJECT**

### **1. Invitational Bid Procedures**

The following is an overview of the invitational bid process. More detailed information is contained throughout the document. Contractors are responsible for reading and complying with all information contained in this document.

Notification: DFCM will notify each registered pre-qualified firm (via fax or e-mail) when a project is ready for Construction Services and invite them to bid on the project.

Description of Work: A description of work or plans/specifications will be given to each contractor. If required, the plans and specifications will be available on the DFCM web page at <http://dfcm.utah.gov> and on CDs from DFCM, at 4110 State Office Building, Salt Lake City, Utah 84114.

Schedule: The Stage II Schedule shows critical dates including the mandatory pre-bid site meeting (if required), the question and answer period, the bid submittal deadline, the subcontractor list submittal deadline, etc. Contractors are responsible for meeting all deadlines shown on the schedule.

Mandatory Pre-Bid Site Meeting: If a firm fails to attend a pre-bid site meeting labeled “Mandatory” they will not be allowed to bid on the project. At the mandatory meeting, contractors may have an opportunity to inspect the site, receive additional instructions and ask questions about project. The schedule contains information on the date, time, and place of the mandatory pre-bid site meeting.

Written Questions: All questions must be in writing and directed to DFCM’s project manager assigned to this project. No others are to be contacted regarding this project. The schedule contains information on the deadline for submitting questions.

Addendum: All clarifications from DFCM will be in writing and issued as an addendum to the RFS. Addenda will be posted on DFCM’s web site at <http://dfcm.utah.gov>. Contractors are responsible for obtaining information contained in each addendum from the web site. Addenda issued prior to the submittal deadline shall become part of the bidding process and must be acknowledged on the bid form. Failure to acknowledge addenda may result in disqualification from bidding.

Submitting Bids: Bids must be submitted to DFCM 4110 State Office Building, Salt Lake City, Utah 84114 by the deadline indicated on the schedule. Bids submitted after the deadline will not be accepted. Bids will be opened at DFCM on the date, time, and place indicated on the schedule.

Subcontractors List: The firm selected for the project must submit a list of all subcontractors by the deadline indicated on the schedule contained in this document.

Pre-qualified List of Contractors: Contractors shall remain on DFCM’s list of pre-qualified contractors provided: (a) they maintain a performance rating of 3.5 or greater on each project, (b) they are not suspended for failure to comply with requirements of their contract, (c) the firm has not undergone a significant reorganization involving the loss of key personnel (site superintendents, project managers, owners, etc.) to a degree such that the firm no longer meets the pre-qualification requirements outlined in Stage I, (d) the financial viability of the firm has not significantly changed, and (e) the firm is not otherwise disqualified by DFCM. Note: If a contractor fails to comply with items (a) through (e) above,

they may be removed from DFCM's list of pre-qualified contractors following an evaluation by a review committee. Contractors will be given the opportunity to address the review committee before a decision is made. Pre-qualified contractors are ONLY authorized to bid on projects within the discipline that they were originally pre-qualified under.

**2. Drawings and Specifications and Interpretations**

Drawings, specifications and other contract documents may be obtained as stated in the Invitation to Bid. If any firm is in doubt as to the meaning or interpretation of any part of the drawings, specifications, scope of work or contract documents, they shall submit, in writing, a request for interpretation to the authorized DFCM representative by the deadline identified in the schedule. Answers to questions and interpretations will be made via addenda issued by DFCM. Neither DFCM or the designer shall be responsible for incorrect information obtained by contractors from sources other than the official drawings/specifications and addenda issued by DFCM.

**3. Product Approvals**

Where reference is made to one or more proprietary products in the contract documents, but restrictive descriptive materials of one or more manufacturer(s) is referred to in the contract documents, the products of other manufacturers will be accepted, provided they equal or exceed the standards set forth in the drawings and specifications and are compatible with the intent and purpose of the design, subject to the written approval of the Designer. Such written approval must occur prior to the deadline established for the last scheduled addendum to be issued. The Designer's written approval will be included as part of the addendum issued by DFCM. If the descriptive material is not restrictive, the products of other manufacturers specified will be accepted without prior approval provided they are compatible with the intent and purpose of the design as determined by the Designer.

**4. Addenda**

All clarifications from DFCM will be in writing and issued as an addendum to the RFS. Addenda will be posted on DFCM's web site at <http://dfcm.utah.gov>. Contractors are responsible for obtaining information contained in each addendum from the web site. Addenda issued prior to the submittal deadline shall become part of the bidding process and must be acknowledged on the bid form. Failure to acknowledge addenda shall result in disqualification from bidding. DFCM shall not be responsible for incorrect information obtained by contractors from sources other than official addenda issued by DFCM.

**5. Financial Responsibility of Contractors, Subcontractors and Sub-subcontractors**

Contractors shall respond promptly to any inquiry in writing by DFCM to any concern of financial responsibility of the Contractor, Subcontractor or Sub-subcontractor. Failure to respond may result in suspension from DFCM's list of pre-qualified contractors.

**6. Licensure**

The Contractor shall comply with and require all of its Subcontractors to comply with the license laws as required by the State of Utah.

**7. Permits**

In concurrence with the requirements for permitting in the general conditions, it is the responsibility of the contractor to obtain the fugitive dust plan requirements from the Utah Division of Air Quality and the SWPPP requirements from the Utah Department of Environmental Quality and submit the completed forms and pay any permit fee that may be required for this specific project. Failure to obtain the required permit may result in work stoppage and/or fines from the regulating authority that will be the sole responsibility of the contractor. Any delay to the project as a result of any such failure to obtain the permit or noncompliance with the permit shall not be eligible for any extension in the Contract Time.

**8. Time is of the Essence**

Time is of the essence in regard to all the requirements of the contract documents.

**9. Bids**

Before submitting a bid, each bidder shall carefully examine the contract documents; shall visit the site of the work; shall fully inform themselves as to all existing conditions and limitations; and shall include in the bid the cost of all items required by the contract documents including those added via addenda. If the bidder observes that portions of the contract documents are at variance with applicable laws, building codes, rules, regulations or contain obvious erroneous or uncoordinated information, the bidder shall promptly notify the DFCM Project Manager prior to the bidding deadline. Changes necessary to correct these issues will be made via addenda issued by DFCM.

The bid, bearing original signatures, must be typed or handwritten in ink on the Bid Form provided in the procurement documents and submitted in a sealed envelope at the location specified by the Invitation to Bid prior to the published deadline for the submission of bids.

Bid bond security, in the amount of five percent (5%) of the bid, made payable to the Division of Facilities Construction and Management, shall accompany bid. **THE BID BOND MUST BE ON THE BID BOND FORM PROVIDED IN THE PROCUREMENT DOCUMENTS IN ORDER TO BE CONSIDERED AN ACCEPTABLE BID.**

If the bid bond security is submitted on a form other than DFCM's required bid bond form, and the bid security meets all other legal requirements, the bidder will be allowed to provide an acceptable bid bond by the close of business on the next business day following notification by DFCM of submission of a defective bid bond security. **A cashier's check cannot be used as a substitute for a bid bond.**

**10. Listing of Subcontractors**

Listing of Subcontractors shall be as summarized in the "Instructions and Subcontractor's List Form", included as part of the contract documents. The subcontractors list shall be delivered to DFCM or faxed to DFCM at (801) 538-3677 within 24 hours of the bid opening. Requirements for listing additional subcontractors will be listed in the contract documents.

DFCM retains the right to audit or take other steps necessary to confirm compliance with requirements for the listing and changing of subcontractors. Any contractor who is found to not be in compliance with these requirements may be suspended from DFCM's list of pre-qualified contractors.

**11. Contract and Bond**

The Contractor's Agreement will be in the form provided in this document. The duration of the contract shall be for the time indicated by the project completion deadline shown on the schedule. The successful bidder, simultaneously with the execution of the Contractor's Agreement, will be required to furnish a performance bond and a payment bond, both bearing original signatures, upon the forms provided in the procurement documents.

The performance and payment bonds shall be for an amount equal to one hundred percent (100%) of the Contract Sum and secured from a company that meets the requirements specified in the requisite forms. Any bonding requirements for Subcontractors will be specified in the Supplementary General Conditions.

**12. Award of Contract**

The Contract will be awarded as soon as possible to the lowest, responsive and responsible bidder, based on the lowest combination of base bid and acceptable prioritized alternates, provided the bid is reasonable, is in the interests of DFCM to accept and after applying the Utah Preference Laws in U.C.A. Title 63, Chapter 56. DFCM reserves the right to waive any technicalities or formalities in any bid or in the bidding. Alternates will be accepted on a prioritized basis with Alternate 1 being highest priority, Alternate 2 having second priority, etc. Alternates will be selected in prioritized order up to the construction cost estimate.

**13. Right to Reject Bids**

DFCM reserves the right to reject any or all Bids.

**14. Withdrawal of Bids**

Bids may be withdrawn on written request received from bidders within 24 hours after the bid opening if the contractor has made an error in preparing the bid.

**15. DFCM Contractor Performance Rating**

As a contractor completes each project, DFCM will evaluate project performance based on the enclosed "DFCM Contractor Performance Rating" form. The ratings issued on this project may affect the firm's "pre-qualified" status and their ability to obtain future work with DFCM.



## Stage II PROJECT SCHEDULE

<b>PROJECT NAME: ENGINEERING AND TECHNOLOGY AIR HANDLER REPLACEMENT SOUTHERN UTAH UNIVERSITY – CEDAR CITY, UTAH DFCM PROJECT #: 08109730</b>				
<b>Event</b>	<b>Day</b>	<b>Date</b>	<b>Time</b>	<b>Place</b>
Stage II Bidding Documents Available	Tuesday	February 3, 2009	10:00 AM	DFCM 4110 State Office Building SLC, UT and the DFCM web site*
Mandatory Pre-bid Site Meeting	Wednesday	February 11, 2009	1:00 PM	SUU NEW Facility Mngt. Bldg. 385 S. 1275 W. Cedar City, Utah 84720
Deadline for Submitting Questions	Wednesday	February 18, 2009	1:00 PM	Jeff Reddoor – DFCM E-mail jreddoor@utah.gov Fax (435) 743-6624
Addendum Deadline (exception for bid delays)	Thursday	February 19, 2009	4:00 PM	DFCM web site*
Prime Contractors Turn in Bid and Bid Bond	Tuesday	February 24, 2009	3:00 PM	DFCM 4110 State Office Building SLC, UT
Subcontractors List Due	Wednesday	February 25, 2009	3:00 PM	DFCM 4110 State Office Building SLC, UT Fax 801-538-3677
Substantial Completion Date	Tuesday	June 30, 2009	5:00 PM	

\* NOTE: DFCM's web site address is <http://dfcm.utah.gov>



## BID FORM

NAME OF BIDDER \_\_\_\_\_ DATE \_\_\_\_\_

To the Division of Facilities Construction and Management  
4110 State Office Building  
Salt Lake City, Utah 84114

The undersigned, responsive to the "Invitation to Bid" and in accordance with the Request for Bids for the **Engineering and Technology Air Handler Replacement – Southern Utah University – Cedar City, Utah** **DFCM PROJECT NO. 08109730** and having examined the Contract Documents and the site of the proposed Work and being familiar with all of the conditions surrounding the construction of the proposed Project, including the availability of labor, hereby proposes to furnish all labor, materials and supplies as required for the Work in accordance with the Contract Documents as specified and within the time set forth and at the price stated below. This price is to cover all expenses incurred in performing the Work required under the Contract Documents of which this bid is a part:

I/We acknowledge receipt of the following Addenda: \_\_\_\_\_

For all work shown on the Drawings and described in the Specifications and Contract Documents, I/we agree to perform for the sum of:

\_\_\_\_\_ DOLLARS (\$ \_\_\_\_\_)

(In case of discrepancy, written amount shall govern)

I/We guarantee that the Work will be Substantially Complete by June 30, 2009, should I/we be the successful bidder, and agree to pay liquidated damages in the amount of **\$250.00** per day for each day after expiration of the Contract Time as stated in Article 3 of the Contractor's Agreement.

This bid shall be good for 45 days after bid opening.

Enclosed is a 5% bid bond, as required, in the sum of \_\_\_\_\_

The undersigned Contractor's License Number for Utah is \_\_\_\_\_.

BID FORM  
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Upon receipt of notice of award of this bid, the undersigned agrees to execute the contract within ten (10) days, unless a shorter time is specified in Contract Documents, and deliver acceptable Performance and Payment bonds in the prescribed form in the amount of 100% of the Contract Sum for faithful performance of the contract. The Bid Bond attached, in the amount not less than five percent (5%) of the above bid sum, shall become the property of the Division of Facilities Construction and Management as liquidated damages for delay and additional expense caused thereby in the event that the contract is not executed and/or acceptable 100% Performance and Payment bonds are not delivered within time set forth.

Type of Organization: \_\_\_\_\_  
(Corporation, Partnership, Individual, etc.)

Any request and information related to Utah Preference Laws:

\_\_\_\_\_

Respectfully submitted,

\_\_\_\_\_  
Name of Bidder

ADDRESS:  
\_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
Authorized Signature

**BID BOND**

(Title 63, Chapter 56, U. C. A. 1953, as Amended)

**KNOW ALL PERSONS BY THESE PRESENTS:**

That \_\_\_\_\_ hereinafter referred to as the "Principal," and \_\_\_\_\_, a corporation organized and existing under the laws of the State of \_\_\_\_\_, with its principal office in the City of \_\_\_\_\_ and authorized to transact business in this State and U. S. Department of the Treasury Listed, (Circular 570, Companies Holding Certificates of Authority as Acceptable Securities on Federal Bonds and as Acceptable Reinsuring Companies); hereinafter referred to as the "Surety," are held and firmly bound unto the STATE OF UTAH, hereinafter referred to as the "Obligee," in the amount of \$ \_\_\_\_\_ (5% of the accompanying bid), being the sum of this Bond to which payment the Principal and Surety bind themselves, their heirs, executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

**THE CONDITION OF THIS OBLIGATION IS SUCH** that whereas the Principal has submitted to Obligee the accompanying bid incorporated by reference herein, dated as shown, to enter into a contract in writing for the \_\_\_\_\_ Project.

**NOW, THEREFORE, THE CONDITION OF THE ABOVE OBLIGATION IS SUCH**, that if the said principal does not execute a contract and give bond to be approved by the Obligee for the faithful performance thereof within ten (10) days after being notified in writing of such contract to the principal, then the sum of the amount stated above will be forfeited to the State of Utah as liquidated damages and not as a penalty; if the said principal shall execute a contract and give bond to be approved by the Obligee for the faithful performance thereof within ten (10) days after being notified in writing of such contract to the Principal, then this obligation shall be null and void. It is expressly understood and agreed that the liability of the Surety for any and all defaults of the Principal hereunder shall be the full penal sum of this Bond. The Surety, for value received, hereby stipulates and agrees that obligations of the Surety under this Bond shall be for a term of sixty (60) days from actual date of the bid opening.

**PROVIDED, HOWEVER**, that this Bond is executed pursuant to provisions of Title 63, Chapter 56, Utah Code Annotated, 1953, as amended, and all liabilities on this Bond shall be determined in accordance with said provisions to same extent as if it were copied at length herein.

**IN WITNESS WHEREOF**, the above bounden parties have executed this instrument under their several seals on the date indicated below, the name and corporate seal of each corporate party being hereto affixed and these presents duly signed by its undersigned representative, pursuant to authority of its governing body.

**DATED** this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_\_ .

**Principal's name and address (if other than a corporation):**

\_\_\_\_\_  
\_\_\_\_\_

By: \_\_\_\_\_

Title: \_\_\_\_\_

**Principal's name and address (if a corporation):**

\_\_\_\_\_  
\_\_\_\_\_

By: \_\_\_\_\_

Title: \_\_\_\_\_

(Affix Corporate Seal)

**Surety's name and address:**

\_\_\_\_\_  
\_\_\_\_\_

By: \_\_\_\_\_

Attorney-in-Fact (Affix Corporate Seal)

STATE OF \_\_\_\_\_ )  
 ) ss.  
COUNTY OF \_\_\_\_\_ )

On this \_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_, personally appeared before me \_\_\_\_\_, whose identity is personally known to me or proved to me on the basis of satisfactory evidence, and who, being by me duly sworn, did say that he/she is the Attorney-in-fact of the above-named Surety Company, and that he/she is duly authorized to execute the same and has complied in all respects with the laws of Utah in reference to becoming sole surety upon bonds, undertakings and obligations, and that he/she acknowledged to me that as Attorney-in-fact executed the same.

Subscribed and sworn to before me this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_.  
My Commission Expires: \_\_\_\_\_  
Resides at: \_\_\_\_\_

NOTARY PUBLIC

**Agency:** \_\_\_\_\_  
**Agent:** \_\_\_\_\_  
**Address:** \_\_\_\_\_  
**Phone:** \_\_\_\_\_

Approved As To Form: May 25, 2005  
By Alan S. Bachman, Asst Attorney General

**Division of Facilities Construction and Management****INSTRUCTION AND SUBCONTRACTORS LIST FORM**

The three low bidders, as well as all other bidders that desire to be considered, are required by law to submit to DFCM within 24 hours of bid opening a list of **ALL** first-tier subcontractors, including the subcontractor's name, bid amount and other information required by Building Board Rule and as stated in these Contract Documents, based on the following:

**DOLLAR AMOUNTS FOR LISTING**

**PROJECTS UNDER \$500,000: ALL FIRST-TIER SUBS \$20,000 OR OVER MUST BE LISTED**  
**PROJECTS \$500,000 OR MORE: ALL FIRST-TIER SUBS \$35,000 OR OVER MUST BE LISTED**

- Any additional subcontractors identified in the bid documents shall also be listed.
- The DFCM Director may not consider any bid submitted by a bidder if the bidder fails to submit a subcontractor list meeting the requirements of State law.
- List subcontractors for base bid as well as the impact on the list that the selection of any alternate may have.
- Bidder may not list more than one subcontractor to perform the same work.
- If there are no subcontractors for the job that are required to be reported by State law (either because there are no subcontractors that will be used on the project or because there are no first-tier subcontractors over the dollar amounts referred to above), then you do not need to submit a sublist. If you do not submit a sublist, it will be deemed to be a representation by you that there are no subcontractors on the job that are required to be reported under State law. At any time, DFCM reserves the right to inquire, for security purposes, as to the identification of the subcontractors at any tier that will be on the worksite.

**LICENSURE:**

The subcontractor's name, the type of work, the subcontractor's bid amount, and the subcontractor's license number as issued by DOPL, if such license is required under Utah Law, shall be listed. Bidder shall certify that all subcontractors, required to be licensed, are licensed as required by State law. A subcontractor includes a trade contractor or specialty contractor and does not include suppliers who provide only materials, equipment, or supplies to a contractor or subcontractor.

**'SPECIAL EXCEPTION':**

A bidder may list 'Special Exception' in place of a subcontractor when the bidder intends to obtain a subcontractor to perform the work at a later date because the bidder was unable to obtain a qualified or reasonable bid under the provisions of U.C.A. Section 63A-5-208(4). The bidder shall insert the term 'Special Exception' for that category of work, and shall provide documentation with the subcontractor list describing the bidder's efforts to obtain a bid of a qualified subcontractor at a reasonable cost and why the bidder was unable to obtain a qualified subcontractor bid. The Director must find that the bidder complied in good faith with State law requirements for any 'Special Exception' designation, in order for the bid to be considered. If awarded the contract, the Director shall supervise the bidder's efforts to obtain a qualified subcontractor bid. The amount of the awarded contract may not be adjusted to reflect the actual amount of the subcontractor's bid. Any listing of 'Special Exception' on the sublist form shall also include amount allocated for that work.

**GROUNDS FOR DISQUALIFICATION:**

The Director may not consider any bid submitted by a bidder if the bidder fails to submit a subcontractor list meeting the requirements of State law. Director may withhold awarding the contract to a particular bidder if one or more of the proposed subcontractors are considered by the Director to be unqualified to do the Work or for such

**INSTRUCTIONS AND SUBCONTRACTORS LIST FORM**  
**Page No. 2**

other reason in the best interest of the State of Utah. Notwithstanding any other provision in these instructions, if there is a good faith error on the sublist form, at the sole discretion of the Director, the Director may provide notice to the contractor and the contractor shall have 24 hours to submit the correction to the Director. If such correction is submitted timely, then the sublist requirements shall be considered met.

**CHANGES OF SUBCONTRACTORS SPECIFICALLY IDENTIFIED ON SUBLIST FORM:**

Subsequent to twenty-four hours after the bid opening, the contractor may change its listed subcontractors only after receiving written permission from the Director based on complying with all of the following criteria.

- (1) The contractor has established in writing that the change is in the best interest of the State and that the contractor establishes an appropriate reason for the change, which may include, but not is not limited to, the following reasons: the original subcontractor has failed to perform, or is not qualified or capable of performing, and/or the subcontractor has requested in writing to be released.
- (2) The circumstances related to the request for the change do not indicate any bad faith in the original listing of the subcontractors.
- (3) Any requirement set forth by the Director to ensure that the process used to select a new subcontractor does not give rise to bid shopping.
- (4) Any increase in the cost of the subject subcontractor work is borne by the contractor.
- (5) Any decrease in the cost of the subject subcontractor work shall result in a deductive change order being issued for the contract for such decreased amount.
- (6) The Director will give substantial weight to whether the subcontractor has consented in writing to being removed unless the Contractor establishes that the subcontractor is not qualified for the work.

**EXAMPLE:**

Example of a list where there are only four subcontractors:

TYPE OF WORK	SUBCONTRACTOR, "SELF" OR "SPECIAL EXCEPTION"	SUBCONTRACTOR BID AMOUNT	CONTRACTOR LICENSE #
ELECTRICAL	ABCD Electric Inc.	\$350,000.00	123456789000
LANDSCAPING	"Self" *	\$300,000.00	123456789000
CONCRETE (ALTERNATE #1)	XYZ Concrete Inc	\$298,000.00	987654321000
MECHANICAL	"Special Exception" (attach documentation)	Fixed at: \$350,000.00	(TO BE PROVIDED AFTER OBTAINING SUBCONTRACTOR)

\* Bidders may list "self", but it is not required.

**PURSUANT TO STATE LAW - SUBCONTRACTOR BID AMOUNTS CONTAINED IN THIS SUBCONTRACTOR LIST SHALL NOT BE DISCLOSED UNTIL THE CONTRACT HAS BEEN AWARDED.**



SUBCONTRACTORS LIST
FAX TO 801-538-3677

PROJECT TITLE: \_\_\_\_\_

Caution: You must read and comply fully with instructions.

Table with 4 columns: TYPE OF WORK, SUBCONTRACTOR, "SELF" OR "SPECIAL EXCEPTION", SUBCONTRACTOR BID AMOUNT, CONT. LICENSE #. The table contains 15 empty rows for data entry.

We certify that:

- 1. This list includes all subcontractors as required by the instructions, including those related to the base bid as well as any alternates.
2. We have listed "Self" or "Special Exception" in accordance with the instructions.
3. All subcontractors are appropriately licensed as required by State law.

FIRM: \_\_\_\_\_

DATE: \_\_\_\_\_

SIGNED BY: \_\_\_\_\_

NOTICE: FAILURE TO SUBMIT THIS FORM, PROPERLY COMPLETED AND SIGNED, AS REQUIRED IN THESE CONTRACT DOCUMENTS, SHALL BE GROUNDS FOR OWNER'S REFUSAL TO ENTER INTO A WRITTEN CONTRACT WITH BIDDER. ACTION MAY BE TAKEN AGAINST BIDDERS BID BOND AS DEEMED APPROPRIATE BY OWNER. ATTACH A SECOND PAGE IF NECESSARY.

## CONTRACTOR'S AGREEMENT

FOR:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

THIS CONTRACTOR'S AGREEMENT, made and entered into this \_\_\_\_ day of \_\_\_\_\_, 20\_\_, by and between the DIVISION OF FACILITIES CONSTRUCTION AND MANAGEMENT, hereinafter referred to as "DFCM", and \_\_\_\_\_, incorporated in the State of \_\_\_\_\_ and authorized to do business in the State of Utah, hereinafter referred to as "Contractor", whose address is \_\_\_\_\_.

WITNESSETH: WHEREAS, DFCM intends to have Work performed at \_\_\_\_\_  
\_\_\_\_\_.

WHEREAS, Contractor agrees to perform the Work for the sum stated herein.

NOW, THEREFORE, DFCM and Contractor for the consideration provided in this Contractor's Agreement, agree as follows:

**ARTICLE 1. SCOPE OF WORK.** The Work to be performed shall be in accordance with the Contract Documents prepared by \_\_\_\_\_ and entitled "\_\_\_\_\_"

The DFCM General Conditions ("General Conditions") dated May 25, 2005 and Supplemental General Conditions dated July 15, 2008 ("also referred to as General Conditions") and on file at the office of DFCM and available on the DFCM website, are hereby incorporated by reference as part of this Agreement and are included in the specifications for this Project. All terms used in this Contractor's Agreement shall be as defined in the Contract Documents, and in particular, the General Conditions.

The Contractor Agrees to furnish labor, materials and equipment to complete the Work as required in the Contract Documents which are hereby incorporated by reference. It is understood and agreed by the parties hereto that all Work shall be performed as required in the Contract Documents and shall be subject to inspection and approval of DFCM or its authorized representative. The relationship of the Contractor to the DFCM hereunder is that of an independent Contractor.

**ARTICLE 2. CONTRACT SUM.** The DFCM agrees to pay and the Contractor agrees to accept in full performance of this Contractor's Agreement, the sum of \_\_\_\_\_ DOLLARS AND NO CENTS (\$\_\_\_\_\_.00), which is the base bid, and which sum also includes the cost of a 100%

CONTRACTOR'S AGREEMENT  
PAGE NO. 2

Performance Bond and a 100% Payment Bond as well as all insurance requirements of the Contractor. Said bonds have already been posted by the Contractor pursuant to State law. The required proof of insurance certificates have been delivered to DFCM in accordance with the General Conditions before the execution of this Contractor's Agreement.

**ARTICLE 3. TIME OF COMPLETION AND DELAY REMEDY.** The Work shall be Substantially Complete by \_\_\_\_\_. Contractor agrees to pay liquidated damages in the amount of \$\_\_\_\_\_ per day for each day after expiration of the Contract Time until the Contractor achieves Substantial Completion in accordance with the Contract Documents, if Contractor's delay makes the damages applicable. The provision for liquidated damages is: (a) to compensate the DFCM for delay only; (b) is provided for herein because actual damages can not be readily ascertained at the time of execution of this Contractor's Agreement; (c) is not a penalty; and (d) shall not prevent the DFCM from maintaining Claims for other non-delay damages, such as costs to complete or remedy defective Work.

No action shall be maintained by the Contractor, including its or Subcontractor or suppliers at any tier, against the DFCM or State of Utah for damages or other claims due to losses attributable to hindrances or delays from any cause whatsoever, including acts and omissions of the DFCM or its officers, employees or agents, except as expressly provided in the General Conditions. The Contractor may receive a written extension of time, signed by the DFCM, in which to complete the Work under this Contractor's Agreement in accordance with the General Conditions.

**ARTICLE 4. CONTRACT DOCUMENTS.** The Contract Documents consist of this Contractor's Agreement, the Conditions of the Contract (DFCM General Conditions, Supplementary and other Conditions), the Drawings, Specifications, Addenda and Modifications. The Contract Documents shall also include the bidding documents, including the Notice to Contractors, Instructions to Bidders/Proposers and the Bid/Proposal, to the extent not in conflict therewith and other documents and oral presentations that are documented as an attachment to the contract.

All such documents are hereby incorporated by reference herein. Any reference in this Contractor's Agreement to certain provisions of the Contract Documents shall in no way be construed as to lessen the importance or applicability of any other provisions of the Contract Documents.

**ARTICLE 5. PAYMENT.** The DFCM agrees to pay the Contractor from time to time as the Work progresses, but not more than once each month after the date of Notice to Proceed, and only upon Certificate of the A/E for Work performed during the preceding calendar month, ninety-five percent (95%) of the value of the labor performed and ninety-five percent (95%) of the value of materials furnished in place or on the site. The Contractor agrees to furnish to the DFCM invoices for materials purchased and on the site but not installed, for which the Contractor requests payment and agrees to safeguard and protect such equipment or materials and is responsible for safekeeping thereof and if such be stolen, lost or destroyed, to replace same.

Such evidence of labor performed and materials furnished as the DFCM may reasonably require shall be supplied by the Contractor at the time of request for Certificate of Payment on account. Materials for which payment has been made cannot be removed from the job site without DFCM's written approval. Five percent (5%) of the earned amount shall be retained from each monthly payment. The retainage, including any additional retainage imposed and the release of any retainage, shall be in accordance with UCA 13-8-5 as amended. Contractor shall also comply with the requirements of UCA 13-8-5, including restrictions of retainage regarding subcontractors and the distribution of interest earned on the retention proceeds. The DFCM shall not be responsible for enforcing the Contractor's obligations under State law in fulfilling the retention law requirements with subcontractors at any tier.

**ARTICLE 6. INDEBTEDNESS.** Before final payment is made, the Contractor must submit evidence satisfactory to the DFCM that all payrolls, materials bills, subcontracts at any tier and outstanding indebtedness in connection with the Work have been properly paid. Final Payment will be made after receipt of said evidence, final acceptance of the Work by the DFCM as well as compliance with the applicable provisions of the General Conditions.

Contractor shall respond immediately to any inquiry in writing by DFCM as to any concern of financial responsibility and DFCM reserves the right to request any waivers, releases or bonds from Contractor in regard to any rights of Subcontractors (including suppliers) at any tier or any third parties prior to any payment by DFCM to Contractor.

**ARTICLE 7. ADDITIONAL WORK.** It is understood and agreed by the parties hereto that no money will be paid to the Contractor for additional labor or materials furnished unless a new contract in writing or a Modification hereof in accordance with the General Conditions and the Contract Documents for such additional labor or materials has been executed. The DFCM specifically reserves the right to modify or amend this Contractor's Agreement and the total sum due hereunder either by enlarging or restricting the scope of the Work.

**ARTICLE 8. INSPECTIONS.** The Work shall be inspected for acceptance in accordance with the General Conditions.

**ARTICLE 9. DISPUTES.** Any dispute, PRE or Claim between the parties shall be subject to the provisions of Article 7 of the General Conditions. DFCM reserves all rights to pursue its rights and remedies as provided in the General Conditions.

**ARTICLE 10. TERMINATION, SUSPENSION OR ABANDONMENT.** This Contractor's Agreement may be terminated, suspended or abandoned in accordance with the General Conditions.

**ARTICLE 11. DFCM'S RIGHT TO WITHHOLD CERTAIN AMOUNT AND MAKE USE THEREOF.** The DFCM may withhold from payment to the Contractor such amount as, in DFCM's judgment, may be necessary to pay just claims against the Contractor or Subcontractor at any tier for labor and services rendered and materials furnished in and about the Work. The DFCM may apply such withheld amounts for the payment of such claims in DFCM's discretion. In so doing, the DFCM shall be deemed the agent of Contractor and payment so made by the DFCM shall be considered as payment made under this Contractor's Agreement by the DFCM to the Contractor. DFCM shall not be liable to the Contractor for any such payment made in good faith. Such withholdings and payments may be made without prior approval of the Contractor and may be also be prior to any determination as a result of any dispute, PRE, Claim or litigation.

**ARTICLE 12. INDEMNIFICATION.** The Contractor shall comply with the indemnification provisions of the General Conditions.

**ARTICLE 13. SUCCESSORS AND ASSIGNMENT OF CONTRACT.** The DFCM and Contractor, respectively bind themselves, their partners, successors, assigns and legal representatives to the other party to this Agreement, and to partners, successors, assigns and legal representatives of such other party with respect to all covenants, provisions, rights and responsibilities of this Contractor's Agreement. The Contractor shall not assign this Contractor's Agreement without the prior written consent of the DFCM, nor shall the Contractor assign any moneys due or to become due as well as any rights under this Contractor's Agreement, without prior written consent of the DFCM.

**ARTICLE 14. RELATIONSHIP OF THE PARTIES.** The Contractor accepts the relationship of trust and confidence established by this Contractor's Agreement and covenants with the DFCM to cooperate with the DFCM and A/E and use the Contractor's best skill, efforts and judgment in furthering the interest of the DFCM; to furnish efficient business administration and supervision; to make best efforts to furnish at all times an adequate supply of workers and materials; and to perform the Work in the best and most expeditious and economic manner consistent with the interests of the DFCM.

**ARTICLE 15. AUTHORITY TO EXECUTE AND PERFORM AGREEMENT.** Contractor and DFCM each represent that the execution of this Contractor's Agreement and the performance thereunder is within their respective duly authorized powers.

**ARTICLE 16. ATTORNEY FEES AND COSTS.** Except as otherwise provided in the dispute resolution provisions of the General Conditions, the prevailing party shall be entitled to reasonable attorney fees and costs incurred in any action in the District Court and/or appellate body to enforce this Contractor's Agreement or recover damages or any other action as a result of a breach thereof.



**PERFORMANCE BOND**  
(Title 63, Chapter 56, U. C. A. 1953, as Amended)

That \_\_\_\_\_ hereinafter referred to as the "Principal" and \_\_\_\_\_, a corporation organized and existing under the laws of the State of \_\_\_\_\_, with its principal office in the City of \_\_\_\_\_ and authorized to transact business in this State and U. S. Department of the Treasury Listed (Circular 570, Companies Holding Certificates of Authority as Acceptable Securities on Federal Bonds and as Acceptable Reinsuring Companies); hereinafter referred to as the "Surety," are held and firmly bound unto the State of Utah, hereinafter referred to as the "Obligee," in the amount of \_\_\_\_\_ DOLLARS (\$) for the payment whereof, the said Principal and Surety bind themselves and their heirs, administrators, executors, successors and assigns, jointly and severally, firmly by these presents.

**WHEREAS**, the Principal has entered into a certain written Contract with the Obligee, dated the \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_, to construct \_\_\_\_\_ in the County of \_\_\_\_\_, State of Utah, Project No. \_\_\_\_\_, for the approximate sum of \_\_\_\_\_ Dollars (\$ \_\_\_\_\_), which Contract is hereby incorporated by reference herein.

**NOW, THEREFORE**, the condition of this obligation is such that if the said Principal shall faithfully perform the Contract in accordance with the Contract Documents including, but not limited to, the Plans, Specifications and conditions thereof, the one year performance warranty, and the terms of the Contract as said Contract may be subject to Modifications or changes, then this obligation shall be void; otherwise it shall remain in full force and effect.

No right of action shall accrue on this bond to or for the use of any person or corporation other than the state named herein or the heirs, executors, administrators or successors of the Owner.

The parties agree that the dispute provisions provided in the Contract Documents apply and shall constitute the sole dispute procedures of the parties.

**PROVIDED, HOWEVER**, that this Bond is executed pursuant to the Provisions of Title 63, Chapter 56, Utah Code Annotated, 1953, as amended, and all liabilities on this Bond shall be determined in accordance with said provisions to the same extent as if it were copied at length herein.

**IN WITNESS WHEREOF**, the said Principal and Surety have signed and sealed this instrument this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_.

**WITNESS OR ATTESTATION:**

\_\_\_\_\_

**PRINCIPAL:**

\_\_\_\_\_

By: \_\_\_\_\_ (Seal)

Title: \_\_\_\_\_

**WITNESS OR ATTESTATION:**

\_\_\_\_\_

**SURETY:**

\_\_\_\_\_

By: \_\_\_\_\_ (Seal)

Attorney-in-Fact

STATE OF \_\_\_\_\_ )  
 ) ss.  
COUNTY OF \_\_\_\_\_ )

On this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_, personally appeared before me \_\_\_\_\_, whose identity is personally known to me or proved to me on the basis of satisfactory evidence, and who, being by me duly sworn, did say that he/she is the Attorney in-fact of the above-named Surety Company and that he/she is duly authorized to execute the same and has complied in all respects with the laws of Utah in reference to becoming sole surety upon bonds, undertakings and obligations, and that he/she acknowledged to me that as Attorney-in-fact executed the same.

Subscribed and sworn to before me this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_.

My commission expires: \_\_\_\_\_

Resides at: \_\_\_\_\_

\_\_\_\_\_  
NOTARY PUBLIC

<b>Agency:</b> _____
<b>Agent:</b> _____
<b>Address:</b> _____
<b>Phone:</b> _____

Approved As To Form: May 25, 2005  
By Alan S. Bachman, Asst Attorney General

**PAYMENT BOND**

(Title 63, Chapter 56, U. C. A. 1953, as Amended)

**KNOW ALL PERSONS BY THESE PRESENTS:**

That \_\_\_\_\_ hereinafter referred to as the "Principal," and \_\_\_\_\_, a corporation organized and existing under the laws of the State of \_\_\_\_\_ authorized to do business in this State and U. S. Department of the Treasury Listed (Circular 570, Companies Holding Certificates of Authority as Acceptable Securities on Federal Bonds and as Acceptable Reinsuring Companies); with its principal office in the City of \_\_\_\_\_, hereinafter referred to as the "Surety," are held and firmly bound unto the State of Utah hereinafter referred to as the "Obligee," in the amount of \_\_\_\_\_ Dollars (\$ \_\_\_\_\_) for the payment whereof, the said Principal and Surety bind themselves and their heirs, administrators, executors, successors and assigns, jointly and severally, firmly by these presents.

**WHEREAS**, the Principal has entered into a certain written Contract with the Obligee, dated the \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_, to construct \_\_\_\_\_ in the County of \_\_\_\_\_, State of Utah, Project No. \_\_\_\_\_ for the approximate sum of \_\_\_\_\_ Dollars (\$ \_\_\_\_\_), which contract is hereby incorporated by reference herein.

**NOW, THEREFORE**, the condition of this obligation is such that if the said Principal shall pay all claimants supplying labor or materials to Principal or Principal's Subcontractors in compliance with the provisions of Title 63, Chapter 56, of Utah Code Annotated, 1953, as amended, and in the prosecution of the Work provided for in said Contract, then, this obligation shall be void; otherwise it shall remain in full force and effect.

That said Surety to this Bond, for value received, hereby stipulates and agrees that no changes, extensions of time, alterations or additions to the terms of the Contract or to the Work to be performed thereunder, or the specifications or drawings accompanying same shall in any way affect its obligation on this Bond, and does hereby waive notice of any such changes, extensions of time, alterations or additions to the terms of the Contract or to the Work or to the specifications or drawings and agrees that they shall become part of the Contract Documents.

**PROVIDED, HOWEVER**, that this Bond is executed pursuant to the provisions of Title 63, Chapter 56, Utah Code Annotated, 1953, as amended, and all liabilities on this Bond shall be determined in accordance with said provisions to the same extent as if it were copied at length herein.

**IN WITNESS WHEREOF**, the said Principal and Surety have signed and sealed this instrument this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_.

**WITNESS OR ATTESTATION:**

\_\_\_\_\_

**PRINCIPAL:**

\_\_\_\_\_

By: \_\_\_\_\_ (Seal)  
Title: \_\_\_\_\_

**WITNESS OR ATTESTATION:**

\_\_\_\_\_

**SURETY:**

\_\_\_\_\_

By: \_\_\_\_\_ (Seal)  
Attorney-in-Fact

STATE OF \_\_\_\_\_ )  
 ) ss.  
COUNTY OF \_\_\_\_\_ )

On this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_, personally appeared before me \_\_\_\_\_, whose identity is personally known to me or proved to me on the basis of satisfactory evidence, and who, being by me duly sworn, did say that he/she is the Attorney-in-fact of the above-named Surety Company, and that he/she is duly authorized to execute the same and has complied in all respects with the laws of Utah in reference to becoming sole surety upon bonds, undertakings and obligations, and that he/she acknowledged to me that as Attorney-in-fact executed the same.

Subscribed and sworn to before me this \_\_\_\_\_ day of \_\_\_\_\_, 20\_\_\_\_.

My commission expires: \_\_\_\_\_

Resides at: \_\_\_\_\_

\_\_\_\_\_  
NOTARY PUBLIC

**Agency:** \_\_\_\_\_  
**Agent:** \_\_\_\_\_  
**Address:** \_\_\_\_\_  
**Phone:** \_\_\_\_\_

Approved As To Form: May 25, 2005  
By Alan S. Bachman, Asst Attorney General



Division of Facilities Construction and Management

DFCM

CERTIFICATE OF SUBSTANTIAL COMPLETION

PROJECT \_\_\_\_\_ PROJECT NO: \_\_\_\_\_

AGENCY/INSTITUTION \_\_\_\_\_

AREA ACCEPTED \_\_\_\_\_

The Work performed under the subject Contract has been reviewed on this date and found to be Substantially Completed as defined in the General Conditions; including that the construction is sufficiently completed in accordance with the Contract Documents, as modified by any change orders agreed to by the parties, so that the State of Utah can occupy the Project or specified area of the Project for the use for which it is intended.

The DFCM - (Owner) accepts the Project or specified area of the Project as Substantially Complete and will assume full possession of the Project or specified area of the Project at \_\_\_\_\_ (time) on \_\_\_\_\_ (date).

The DFCM accepts the Project for occupancy and agrees to assume full responsibility for maintenance and operation, including utilities and insurance, of the Project subject to the itemized responsibilities and/or exceptions noted below:

\_\_\_\_\_  
\_\_\_\_\_

The Owner acknowledges receipt of the following closeout and transition materials:

- Record Drawings
- O & M Manuals
- Warranty Documents
- Completion of Training Requirements

A list of items to be completed or corrected (Punch List) is attached hereto. The failure to include an item on it does not alter the responsibility of the Contractor to complete all the Work in accordance with the Contract Documents, including authorized changes thereof. The amount of \_\_\_\_\_. (Twice the value of the punch list work) shall be retained to assure the completion of the punch list work.

The Contractor shall complete or correct the Work on the list of (Punch List) items appended hereto within \_\_\_\_\_ calendar days from the above date of issuance of this Certificate. If the list of items is not completed within the time allotted the Owner has the right to be compensated for the delays and/or complete the work with the help of independent contractor at the expense of the retained project funds. If the retained project funds are insufficient to cover the delay/completion damages, the Owner shall be promptly reimbursed for the balance of the funds needed to compensate the Owner.

\_\_\_\_\_  
CONTRACTOR (include name of firm) by: \_\_\_\_\_  
(Signature) DATE

\_\_\_\_\_  
A/E (include name of firm) by: \_\_\_\_\_  
(Signature) DATE

\_\_\_\_\_  
USING INSTITUTION OR AGENCY by: \_\_\_\_\_  
(Signature) DATE

\_\_\_\_\_  
DFCM (Owner) by: \_\_\_\_\_  
(Signature) DATE

4110 State Office Building, Salt Lake City, Utah 84114  
telephone 801-538-3018 • facsimile 801-538-3267 • <http://dfcm.utah.gov>

cc: Parties Noted  
DFCM, Director

**General Contractor Performance Rating Form**

Project Name:		DFCM Project#	
Contractor:  (ABC Construction, John Doe, 111-111-1111)	A/E:  (ABC Architects, Jane Doe, 222-222-2222)	Original Contract Amount:	Final Contract Amount:
DFCM Project Manager:		Contract Date:	
Completion Date:		Date of Rating:	

Rating Guideline	QUALITY OF PRODUCT OR SERVICES	COST CONTROL	TIMELINESS OF PERFORMANCE	BUSINESS RELATIONS
<b>5-Exceptional</b>	Contractor has demonstrated an exceptional performance level in any of the above four categories that justifies adding a point to the score. Contractor performance clearly exceeds the performance levels described as "Very Good"			
<b>4-Very Good</b>	Contractor is in compliance with contract requirements and/or delivers quality product/service.	Contractor is effective in managing costs and submits current, accurate, and complete billings	Contractor is effective in meeting milestones and delivery schedule	Response to inquiries, technical/service/administrative issues is effective
<b>3-Satisfactory</b>	Minor inefficiencies/errors have been identified	Contractor is usually effective in managing cost	Contractor is usually effective in meeting milestones and delivery schedules	Response to inquires technical/service/administrative issues is somewhat effective
<b>2-Marginal</b>	Major problems have been encountered	Contractor is having major difficulty managing cost effectively	Contractor is having major difficulty meeting milestones and delivery schedule	Response to inquiries, technical/service/administrative issues is marginally effective
<b>1-Unsatisfactory</b>	Contractor is not in compliance and is jeopardizing achievement of contract objectives	Contractor is unable to manage costs effectively	Contractor delays are jeopardizing performance of contract objectives	Response to inquiries, technical/service/administrative issues is not effective

<b>1. Rate Contractors quality of workmanship, management of sub contractor performance, project cleanliness, organization and safety requirement.</b>	<b>Score</b>
<u>Agency Comments:</u>	
<u>A &amp; E Comments:</u>	
<u>DFCM Project Manager Comments:</u>	

<b>2. Rate Contractor administration of project costs, change orders and financial management of the project budget.</b>	<b>Score</b>
<u>Agency Comments:</u>	
<u>A &amp; E Comments:</u>	
<u>DFCM Project Manager Comments:</u>	

<b>3. Rate Contractor's performance and adherence to Project Schedule, delay procedures and requirements of substantial completion, inspection and punch-list performance.</b>	<b>Score</b>
<u>Agency Comments:</u>	
<u>A &amp; E Comments:</u>	
<u>DFCM Project Manager Comments:</u>	

<b>4. Evaluate performance of contractor management team including project manager, engineer and superintendent also include in the rating team's ability to work well with owner, user agency and consultants.</b>	<b>Score</b>
<u>Agency Comments:</u>	
<u>A &amp; E Comments:</u>	
<u>DFCM Project Manager Comments:</u>	

5. Rate success of Contractor's management plan, completion of the plans mitigation of project risks and performance of value engineering concepts.	Score
<u>Agency Comments:</u>	
<u>A &amp; E Comments:</u>	
<u>DFCM Project Manager Comments:</u>	

<b>Signed by:</b>	<b>Date:</b>	<b>Mean Score</b>
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**Additional Comments:**

# **Southern Utah University Engineering and Technology - Air Handler Replacement**

**DFCM PROJECT #08109730**



State of Utah—Department of Administrative Services

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## **DIVISION OF FACILITIES CONSTRUCTION AND MANAGEMENT**

4110 State Office Building / Salt Lake City, Utah 84114 / 538-3018

# **SPECIFICATIONS**

**PREPARED BY**

**WHW ENGINEERING INC.  
8619 SOUTH SANDY PARKWAY, SUITE 101  
SANDY, UTAH 84070  
PHONE: (801) 466-4021  
FAX: (801) 466-8536**

**July 2008**

**WHW Engineering Project #08016**

## **DIVISION 1 - GENERAL REQUIREMENTS**

01100 SUMMARY  
01330 SUBMITTAL PROCEDURES  
01732 SELECTIVE DEMOLITION  
01770 CLOSEOUT PROCEDURES  
01781 PROJECT RECORD DOCUMENTS

## **DIVISION 15 - MECHANICAL**

15010 GENERAL REQUIREMENTS  
15050 BASIC MATERIALS & METHODS  
15062 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT  
15074 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT  
15077 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT  
15080 HVAC INSULATION  
15112 GENERAL-DUTY VALVES FOR HVAC AND PLUMBING PIPING  
15127 METERS AND GAUGES FOR HVAC PIPING  
15181 HYDRONIC PIPING  
15182 STEAM AND CONDENSATE PIPING  
15725 MULTI ZONE INDOOR AIR HANDLING UNITS  
15815 METAL DUCTS  
15820 DUCT ACCESSORIES  
15900 HVAC AND INSTRUMENTATION CONTROLS  
15940 SEQUENCE OF OPERATION  
15950 TESTING, ADJUSTING AND BALANCING

## **DIVISION 16 - ELECTRICAL**

16050 BASIC ELECTRICAL MATERIALS AND METHODS  
16060 GROUNDING AND BONDING  
16075 ELECTRICAL IDENTIFICATION  
16120 CONDUCTORS AND CABLES  
16130 RACEWAYS AND BOXES  
16140 WIRING DEVICES  
16410 ENCLOSED SWITCHES AND CIRCUIT BREAKERS  
16420 ENCLOSED CONTROLLERS  
16491 FUSES  
16511 INTERIOR LIGHTING  
16860 FIRE ALARM

**DIVISION 1  
GENERAL REQUIREMENTS**

- 01100 SUMMARY
- 01330 SUBMITTAL PROCEDURES
- 01732 SELECTIVE DEMOLITION
- 01770 CLOSEOUT PROCEDURES
- 01781 PROJECT RECORD DOCUMENTS

## **SECTION 01100 - SUMMARY**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Work covered by the Contract Documents.
  - 2. Type of the Contract.
  - 3. Owner's occupancy requirements.
  - 4. Work restrictions.
  - 5. Specification formats and conventions.

#### **1.3 WORK COVERED BY CONTRACT DOCUMENTS**

- A. Project Identification: Southern Utah University - Engineering and Technology - Air Handler Replacement.
  - 1. Project Location: Southern Utah University - Cedar City, UT.
- B. Owner: Southern Utah University
  - 1. Owner's Representative: Jeff Reddoor.
- C. Architect: WHW Engineering 8619 S Sandy Parkway #101 Sandy UT 84070.
- D. The Work consists of the following:
  - 1. The Work includes
    - a. Removing and replacing two existing roof mounted multizone units.
    - b. Providing an exterior access to the roof.
    - c. All pipe changes to accommodate new units.
    - d. Control Changes.
    - e. Test and Balance

#### **1.4 TYPE OF CONTRACT**

- A. Project will be constructed under a single prime contract.

#### **1.5 USE OF PREMISES**

- A. General: Contractor shall have limited use of premises for construction operations as indicated in project documents. Both areas of construction are exterior i.e. roof and access to roof.
- B. Use of Site: Limit use of premises to areas within the Contract limits indicated. Do not disturb portions of Project site beyond areas in which the Work is indicated.
  - 1. Owner Occupancy: Allow for Owner occupancy of Project site and use by the public.
  - 2. Driveways and Entrances: Keep driveways loading areas, and entrances serving premises clear and available to Owner, Owner's employees, students and emergency vehicles at all times. Do not use these areas for parking or storage of materials.
    - a. Schedule deliveries to minimize use of driveways and entrances.
    - b. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.
- C. Use of Existing Building: Maintain existing building in a weathertight condition throughout construction period. Repair damage caused by construction operations. Protect building and its occupants during construction period.

#### **1.6 OWNER'S OCCUPANCY REQUIREMENTS**

- A. Full Owner Occupancy: Owner will occupy site and existing building during entire construction period. Cooperate with Owner during construction operations to minimize conflicts and facilitate Owner usage. Perform the Work so as not to interfere with Owner's day-to-day operations. Maintain existing exits, unless otherwise indicated.
  - 1. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities. Do not close or obstruct walkways, corridors, or other occupied or used facilities without written permission from Owner and authorities having jurisdiction.
  - 2. Provide not less than 72 hours' notice to Owner of activities that will affect Owner's operations.

#### **1.7 WORK RESTRICTIONS**

- A. On-Site Work Hours: Work shall be generally performed during normal business working hours of 8:00 a.m. to 5:00 p.m., Monday through Friday, except as otherwise accepted by owner during the pre-construction meeting.

- B. Existing Utility Interruptions: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
  - 1. Notify Owner not less than 72 hours in advance of proposed utility interruptions.
  - 2. Do not proceed with utility interruptions without Owner's written permission.

## 1.8 SPECIFICATION FORMATS AND CONVENTIONS

- A. Specification Format: The Specifications are organized into Divisions and Sections using the 16-division format and CSI/CSC's "MasterFormat" numbering system.
  - 1. Section Identification: The Specifications use Section numbers and titles to help cross-referencing in the Contract Documents. Sections in the Project Manual are in numeric sequence; however, the sequence is incomplete because all available Section numbers are not used. Consult the table of contents at the beginning of the Project Manual to determine numbers and names of Sections in the Contract Documents.
  - 2. Division 1: Sections in Division 1 govern the execution of the Work of all Sections in the Specifications.
- B. Specification Content: The Specifications use certain conventions for the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations. These conventions are as follows:
  - 1. Abbreviated Language: Language used in the Specifications and other Contract Documents is abbreviated. Words and meanings shall be interpreted as appropriate. Words implied, but not stated, shall be inferred as the sense requires. Singular words shall be interpreted as plural, and plural words shall be interpreted as singular where applicable as the context of the Contract Documents indicates.
  - 2. Imperative mood and streamlined language are generally used in the Specifications. Requirements expressed in the imperative mood are to be performed by Contractor. Occasionally, the indicative or subjunctive mood may be used in the Section Text for clarity to describe responsibilities that must be fulfilled indirectly by Contractor or by others when so noted.
    - a. The words "shall," "shall be," or "shall comply with," depending on the context, are implied where a colon (:) is used within a sentence or phrase.

**1.9 MISCELLANEOUS PROVISIONS**

**PART 2 - PRODUCTS (Not Used)**

**PART 3 - EXECUTION (Not Used)**

END OF SECTION 01100

## **SECTION 01330 - SUBMITTAL PROCEDURES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals.
- B. Related Sections include the following:
  - 1. Divisions 2 through 16 Sections for specific requirements for submittals in those Sections.

#### **1.3 SUBMITTAL PROCEDURES**

- A. 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. Engineer reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.
- B. Processing Time: Allow enough time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Engineer'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 7 days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Engineer will advise Contractor when a submittal being processed must be delayed for coordination.
  - 2. Resubmittal Review: Allow 7 days for review of each resubmittal.

- C. Identification: Place a permanent label or title block on each submittal for identification.
1. Indicate name of firm or entity that prepared each submittal on label or title block.
  2. Provide a space approximately on label or beside title block to record Contractor's review and approval markings and action taken by Architect.
  3. Include the following information on label for processing and recording action taken:
    - a. Project name.
    - b. Date.
    - c. Name and address of Architect.
    - d. Name and address of Contractor.
    - e. Name and address of subcontractor.
    - f. Name and address of supplier.
    - g. Name of manufacturer.
    - h. Submittal number or other unique identifier, including revision identifier.
      - 1) Submittal number shall use Specification Section number followed by a decimal point and then a sequential number (e.g., 06100.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., 06100.01.A).
    - i. Number and title of appropriate Specification Section.
    - j. Drawing number and detail references, as appropriate.
    - k. Location(s) where product is to be installed, as appropriate.
    - l. Other necessary identification.
- D. Deviations: Highlight or encircle, or otherwise specifically identify deviations from the Contract Documents on submittals.
- E. Transmittal: Package each submittal individually and appropriately for transmittal and handling. Transmit each submittal using a transmittal form.
- F. 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 approved.
- G. 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.

## **PART 2 - PRODUCTS**

### **2.1 ACTION SUBMITTALS**

- A. General: Prepare and submit Action Submittals required by individual Specification Sections.
- B. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.
  - 1. Mark each copy of each submittal to show which products and options are applicable.
  - 2. Include the following information, as applicable:
    - a. Manufacturer's written recommendations.
    - b. Manufacturer's product specifications.
    - c. Manufacturer's installation instructions.
    - d. Standard color charts.
    - e. Manufacturer's catalog cuts.
    - f. Wiring diagrams showing factory-installed wiring.
    - g. Printed performance curves.
    - h. Operational range diagrams.
    - i. Mill reports.
    - j. Standard product operation and maintenance manuals.
    - k. Compliance with specified referenced standards.
    - l. Testing by recognized testing agency.
    - m. Application of testing agency labels and seals.
    - n. Notation of coordination requirements.
  - 3. Number of Copies: Submit five copies of Product Data, unless otherwise indicated. Architect will return four copies. Mark up and retain one returned copy as a Project Record Document.

## **PART 3 - EXECUTION**

### **3.1 CONTRACTOR'S REVIEW**

- A. Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Architect.
- B. 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 ENGINEER'S / ACTION**

- A. General: Architect will not review submittals that do not bear Contractor's approval stamp and will return them without action.
- B. Action Submittals: Architect will review each submittal, make marks to indicate corrections or modifications required, and return it. Architect will stamp each submittal with an action stamp and will mark stamp appropriately to indicate action taken.
- C. Partial submittals are not acceptable, will be considered nonresponsive, and will be returned without review.
- D. Submittals not required by the Contract Documents may not be reviewed and may be discarded.

END OF SECTION 01330

## **SECTION 01732 - SELECTIVE DEMOLITION**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Demolition and removal of existing roof mounted multi-zone air handling units including piping, electrical etc.
- B. Related Sections include the following:
  - 1. Division 1 Section "Summary" for use of premises and Owner-occupancy requirements.

#### **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. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed.

#### **1.4 QUALITY ASSURANCE**

- A. Demolition Firm Qualifications: An experienced firm that has specialized in demolition work similar in material and extent to that indicated for this Project.
- B. Refrigerant Recovery Technician Qualifications: Certified by an EPA-approved certification program.
- C. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
- D. Standards: Comply with ANSI A10.6 and NFPA 241.

## **1.5 PROJECT 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.
  - 1. Comply with requirements specified in Division 1 Section "Summary."
- 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. Any items that are in the way or are stored in the areas to be demolished.
- C. Notify Engineer of discrepancies between existing conditions and Drawings before proceeding with selective demolition.
- D. Hazardous Materials: It is unknown whether hazardous materials will be encountered in the Work.
  - 1. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify Engineer and Owner. Owner will remove hazardous materials under a separate contract.
- E. Storage or sale of removed items or materials on-site is not permitted.
- F. 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.

## **1.6 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.

## **PART 2 - PRODUCTS (Not Used)**

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Verify location of existing utilities before starting demolition.

- B. Survey existing conditions and correlate with requirements indicated to determine extent of selective demolition required.
- C. 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 Engineer.
- D. Perform surveys as the Work progresses to detect hazards resulting from selective demolition activities.

### **3.2 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS**

- A. Existing Services/Systems: Maintain services/systems indicated to remain and protect them against damage during demolition operations.
  - 1. Comply with requirements for existing services/systems interruptions specified in Division 1 Section "Summary."
- B. Service/System Requirements: Locate, identify and disconnect indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.
  - 1. Owner will arrange to shut off indicated services/systems when requested by Contractor.
  - 2. Arrange to shut off indicated building services to existing units.
  - 3. If services/systems are required to be removed or relocated before proceeding with selective demolition provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.

### **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.

### **3.4 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. Temporarily cover duct openings to remain.
  - 2. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
  - 3. Do not use cutting torches until work area is cleared of flammable materials. Maintain portable fire-suppression devices during flame-cutting operations.
  - 4. Maintain adequate ventilation when using cutting torches.
  - 5. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
  - 6. Dispose of demolished items and materials promptly.
- B. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition.

### **3.5 DISPOSAL OF DEMOLISHED MATERIALS**

- A. General: Except for items or materials to remain, 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.
- B. Burning: Do not burn demolished materials.
- C. Disposal: Transport demolished materials off Owner's property and legally dispose of them.

### **3.6 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 01732

## **SECTION 01770 - CLOSEOUT PROCEDURES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following:
  - 1. Inspection procedures.
  - 2. Warranties.
  - 3. Final cleaning.
- B. Related Sections include the following:
  - 1. Division 1 Section "Project Record Documents" for submitting Record Drawings, Record Specifications, and Record Product Data.
  - 2. Division 1 Section "Operation and Maintenance Data" for operation and maintenance manual requirements.
  - 3. Divisions 2 through 16 Sections for specific closeout and special cleaning requirements for the Work in those Sections.

#### **1.3 SUBSTANTIAL COMPLETION**

- A. Preliminary Procedures: Before requesting inspection for determining date of Substantial Completion, complete the following. List items below that are incomplete in request.
  - 1. Prepare a list of items to be completed and corrected (punch list), the value of items on the list, and reasons why the Work is not complete.
  - 2. Advise Owner of pending insurance changeover requirements.
  - 3. Submit specific warranties, bonds, maintenance service agreements, final certifications, and similar documents.
  - 4. Prepare and submit Project Record Documents, and operation and maintenance manuals.
  - 5. Deliver tools, spare parts, extra materials, and similar items to location designated by Owner. Label with manufacturer's name and model number where applicable.
  - 6. Complete startup testing of systems.

7. Submit test/adjust/balance records.
8. Submit changeover information related to Owner's occupancy, use, operation, and maintenance.
9. Complete final cleaning requirements, including touchup painting.
10. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.

B. Inspection: Submit a written request for inspection for Substantial Completion. On receipt of request, Engineer will either proceed with inspection or notify Contractor of unfulfilled requirements. Engineer 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 Engineer, 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.

#### **1.4 WARRANTIES**

- A. Submittal Time: Submit written warranties on request of Engineer for designated portions of the Work where commencement of warranties other than date of Substantial Completion is indicated.
- B. Organize warranty documents into an orderly sequence based on the table of contents of the Project Manual.
  1. Bind warranties and bonds in the operation and maintenance manual.

### **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.

### **PART 3 - EXECUTION**

#### **3.1 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. Cleaning: Employ experienced workers or professional cleaners for final cleaning of new construction.
1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project:
    - a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including areas, of rubbish, waste material, litter, and other foreign substances.
    - b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits made by this contractor.
    - c. Remove tools, construction equipment, machinery, and surplus material from Project site.
    - d. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances.
    - e. Remove labels that are not permanent.
    - f. Touch up and otherwise repair and restore marred, exposed finishes and surfaces. Replace finishes and surfaces that cannot be satisfactorily repaired or restored or that already show evidence of repair or restoration.
      - 1) Do not paint over "UL" and similar labels, including mechanical and electrical nameplates.
    - g. Wipe surfaces of mechanical and electrical equipment and similar equipment. Remove excess lubrication, paint and other foreign substances.
    - h. Replace parts subject to unusual operating conditions.
    - i. Replace disposable air filters and clean permanent air filters.
    - j. Clean ducts, blowers, and coils if units were operated without filters during construction.
    - k. Leave Project clean and ready for occupancy.
- C. Comply with safety standards for cleaning. Do not burn waste materials. Do not bury debris or excess materials on Owner's property. Do not discharge volatile, harmful, or dangerous materials into drainage systems. Remove waste materials from Project site and dispose of lawfully.

END OF SECTION 01770

## **SECTION 01781 - PROJECT RECORD DOCUMENTS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes administrative and procedural requirements for Project Record Documents, including the following:
  - 1. Record Drawings.
  - 2. Record Specifications.
- B. Related Sections include the following:
  - 1. Division 1 Section "Closeout Procedures" for general closeout procedures.
  - 2. Division 1 Section "Operation and Maintenance Data" for operation and maintenance manual requirements.
  - 3. Divisions 2 through 16 Sections for specific requirements for Project Record Documents of the Work in those Sections.

### **PART 2 - PRODUCTS**

#### **2.1 RECORD DRAWINGS**

- A. Record Prints: Maintain one set of black-line white prints of the Contract Drawings and Shop Drawings.
  - 1. Preparation: Mark Record Prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to prepare the 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. Accurately record information in an understandable drawing technique.
    - c. Record data as soon as possible after obtaining it. Record and check the markup before enclosing concealed installations.

2. Content: Types of items requiring marking include, but are not limited to, the following:
  - a. Dimensional changes to Drawings.
  - b. Revisions to details shown on Drawings.
  - c. Revisions to routing of piping and conduits.
  - d. Revisions to electrical circuitry.
  - e. Actual equipment locations.
  - f. Duct size and routing.
  - g. Changes made by Change Order or Change Directive.
  - h. Changes made following Engineer's written orders.
  - i. Details not on the original Contract Drawings.
  - j. Field records for variable and concealed conditions.
  - k. Record information on the Work that is shown only schematically.
3. Mark the Contract Drawings completely and accurately.
4. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.
5. Mark important additional information that was either shown schematically or omitted from original Drawings.
6. Note Construction Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.

### **PART 3 - EXECUTION**

#### **3.1 RECORDING AND MAINTENANCE**

- A. Recording: Maintain one copy of each submittal during the construction period for Project Record Document purposes. Post changes and modifications to Project Record Documents as they occur; do not wait until the end of Project.

END OF SECTION 01781

**DIVISION 15  
MECHANICAL**

- 15010 GENERAL REQUIREMENTS
- 15050 BASIC MATERIALS & METHODS
- 15062 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
- 15074 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
- 15077 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
- 15080 HVAC INSULATION
- 15112 GENERAL-DUTY VALVES FOR HVAC AND PLUMBING PIPING
- 15127 METERS AND GAUGES FOR HVAC PIPING
- 15181 HYDRONIC PIPING
- 15182 STEAM AND CONDENSATE PIPING
- 15725 MULTI ZONE INDOOR AIR HANDLING UNITS
- 15815 METAL DUCTS
- 15820 DUCT ACCESSORIES
- 15900 HVAC AND INSTRUMENTATION CONTROLS
- 15940 SEQUENCE OF OPERATION
- 15950 TESTING, ADJUSTING AND BALANCING

## **SECTION 15010 - GENERAL REQUIREMENTS**

### **PART 1 - GENERAL**

#### **1.1 GENERAL**

- A. General Conditions and Division 01 apply to this Division.

#### **1.2 SCOPE**

- A. Includes -

1. Furnish all labor, materials, and equipment necessary for the completion of the scope of work noted on the drawings.
2. Furnish and install all motors specified in this Division and be responsible for the proper operation of electrical powered equipment furnished by this Division.
3. Furnish exact location of electrical connections and information on motor controls to Division 16.
4. Mechanical Contractor shall obtain the services of independent Test and Balance Agency.
5. Placing the air conditioning, heating and ventilating, systems into full operation and continuing their operation during each working day of testing and balancing.
6. Making changes in pulleys, belts, and dampers, or adding dampers, as required for the correct balance as recommended by Balancing Contractor at no additional cost to Owner.
7. Air and chilled water balance, final adjustment and test run.
8. The satisfactory performance of the completed systems is a requirement of this specification.

- B. Related Work Specified Elsewhere

1. Conduit, line voltage wiring, outlets, and disconnect switches specified in Division 16.
2. Magnetic starters and thermal protective devices (heaters) not a factory mounted integral part of packaged equipment are specified in Division 16.

#### **1.3 SITE OBSERVATION**

- A. The Contractor shall examine the site and understand the conditions which may affect the performance of work of this Division before submitting proposals for this work.

- B. No subsequent allowance for time or money will be considered for any consequence related to failure to examine existing site conditions.

#### **1.4 DRAWINGS**

- A. Mechanical drawings show general arrangement of piping, ductwork, equipment, etc; however, locations are to be regarded as shown diagrammatically only. Follow as closely as actual building construction and work of other trades will permit.
- B. Because of the small scale of mechanical drawings, it is not possible to indicate all offsets, fittings, and accessories which may be required. Investigate existing structural and finished conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions.
- C. If changes in location of piping, equipment, ducts, etc. are required due to lack of coordination of work under this division, such changes shall be made without charge.

#### **1.5 CODE REQUIREMENTS, FEES, AND PERMITS**

- A. The work shall be installed in accordance with the following applicable codes, ordinances and standards unless otherwise specified. The codes and standards shall include but not be limited to and be of the latest and current editions.
  - 1. Air Movement and Control Association (AMCA)
  - 2. American National Standards Institute (ANSI)
  - 3. Air Conditioning & Refrigeration Institute (ARI)
  - 4. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) - ASHRAE 90.1-2004
  - 5. American Society of Mechanical Engineers (ASME)
  - 6. American Society of Testing Materials (ASTM)
  - 7. American Standards Association (ASA)
  - 8. American Welding Society (AWS)
  - 9. Associated Air Balance Council (AABC)
  - 10. Heat Exchange Institute (HEI)
  - 11. Hydraulic Institute (HI)
  - 12. BR
  - 13. National Electrical Code (NEC)
  - 14. National Fire Protection Association (NFPA)
  - 15. Sheet Metal and Air Conditioning contractors National Association (SMACNA)
  - 16. Underwriters Laboratories (UL)
  - 17. International Building Code (IBC) 2006 Ed
  - 18. International Mechanical Code (IMC) 2006 Ed
  - 19. International Plumbing Code (IPC) with Utah Amendments 2006 Ed
  - 20. International Energy Conservation Code (IECC) 2006 Ed
  - 21. Utah State Safety Orders (OSHA/UOSH)

22. Utah Fire Rating Bureau
23. Utah Air Conservation Regulations/Waste Disposal regulations.
24. ASHRAE Ventilation STD.62-2004

- B. Should drawings conflict with any code, the code shall govern. If drawings and specifications establish a quality exceeding the code, the drawings and specifications shall govern. If conflicts do exist among the drawings, specifications and codes, the same shall be brought to the attention of the Engineer in writing prior to bidding, otherwise Contractor shall comply with applicable codes.
- C. The latest edition of all codes shall be used.

## 1.6 OPERATION AND MAINTENANCE MANUAL FOR MECHANICAL SYSTEMS

- A. Upon completion of work and before final payment, Contractor shall furnish and deliver to the Owner, through the Engineer, installation, operation and maintenance manuals with instructions for all new materials and equipment used in the building. The contractor shall provide three (3) hard copies of the manuals, and three (3) CD's with electronic copies of the manuals. Electronic information shall be .PDF format. The CD's shall include the same information as the hard copies, and shall be organized in the same manner with electronic bookmarks for each section. CD case and the CD itself shall be labeled the same as the hard copies of the manuals.
- B. Bind Operation and Maintenance Manual for Mechanical Systems in a hard-backed piano hinge loose-leaf binder with strong sturdy cover. The project name shall be on the spine and the front of the binder. The front of the binder shall include the following information:

OPERATION  
AND  
MAINTENANCE  
MANUAL  
for MECHANICAL SYSTEMS of  
(Name of Project)  
(Location of Project)  
(Date of Project Award)  
(Name of Engineer)

- C. Introduction
1. Title page including name of project, project number, date awarded and date of substantial completion.
  2. Second page shall contain the names, phone numbers and addresses of Engineers and Mechanical and Electrical Contractor.
  3. Third page shall include a Table of Contents for the entire manual.

D. First Section - Summary information including:

1. First page shall contain the contractor's warranties.
2. Second page shall contain a list of names, addresses and phone numbers of contractors and all sub-contractors and work to which each was assigned.
3. Final page or pages shall contain an equipment list. The list shall contain each item of equipment or material for which a submittal was required giving ID or tag no as contained on the drawings make and model No. Serial No. Identification No. Location in building, function along with the name, address, and phone number of the supplier.

E. Second Section - Mechanical Equipment O&M data including:

1. Mechanical maintenance schedule, including a lubrication list when necessary.
2. Mechanical Equipment Operation and Maintenance Data including:
  - a. Equipment descriptions
  - b. Detailed installation instruction, operating and maintenance instructions. Instructions include in a step by step manner identifying start-up, operating, shutdown and emergency action sequence sufficiently clear so a person unfamiliar with the equipment could perform its operations.
  - c. Equipment drawings, performance curves, operating characteristics, etc.
  - d. Name addresses and phone number of manufacturer, fabricator and local vender clearly printed or stamped on cover.
  - e. Complete parts listing which include catalog number, serial number, contract number or other accurate provision for ordering replacement and spare parts.
  - f. Certified drawings, where applicable, showing assembly of parts and general dimensions.
3. Approved Mechanical submittals

F. Third Section - Controls O&M data including:

1. Sequence of Operation
2. Description of each operating system included location of switches, breakers, thermostats, and control devices. Provide a single line diagram, showing set points, normal operating parameters for all loads, pressures, temperatures and flow check points; Describe all alarms and cautions for operation.
3. Provide schematic control diagrams, panel diagrams, wiring diagrams, etc. for each new multi-zone unit, chilled water system, etc. Each control diagram shall show a schematic representation of mechanical equipment and location of start-stop switches, thermometers, pressure gauges, automatic valves, etc. The correct reading for each control instrument shall be marked on the diagram.

- G. The Fourth Section shall contain a complete air and chilled water test and balance report. The report shall contain the name, address and phone number of the agency. It shall also include:
1. Floor plans showing all air openings and thermostats locations clearly marked and cross referenced with data sheets. Format may be 8 1/2 x 11 or 11x14 if legible.
  2. Data sheets showing amount of air and chilled water at each setting. See sections 15950.
  3. List of equipment with date of last calibration.
- H. Drawings and reproducible masters of drawings as required in individual specification sections, are not to be bound in volumes but are to be delivered separate with the maintenance manuals.
- I. See the following checklist for assistance in assembling manual:

Item #	Description	Y, N, or NA
1.	3 ring heavy duty binder with Project name, number and date on cover and project name on spine.	
2.	O&M manual on CD (with label on CD matching label on manual). Electronic copy shall be a PDF file with bookmarks that match the tabs in the hard copy.	
3.	Title Page [including project name, number, address, date awarded, date of substantial completion]	
4.	Second Page Contact List [including architect (if applicable), mechanical engineer, mechanical contractor, and general contractor (if applicable)]	
5.	Table of Contents	
<b>6.</b>	<b>Section 1 - Summary</b>	
A.	Warranty	
B.	Mechanical's Sub-contractor List	
C.	Vendor List	
D.	Equipment List	
<b>7.</b>	<b>Section 2 – Mechanical Equipment</b>	
A.	Maintenance Schedule (including lubrication list)	
B.	Mechanical Equipment O&M Data (for each piece of equipment submitted) per specifications	
C.	Approved mechanical submittals	
<b>8.</b>	<b>Section 3 - Controls</b>	
A.	Sequence of Operation	
B.	Controls diagrams	
C.	Controls Equipment	
<b>9.</b>	<b>Section4 – Test and Balance Report</b>	

A.	Complete Test and Balance Report per specifications	
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## 1.7 OPERATION AND MAINTENANCE INSTRUCTIONS

- A. Contractor shall instruct building maintenance personnel in the operation and maintenance of the installed mechanical systems utilizing the Operation and Maintenance Manual when so doing.
- B. Minimum instruction periods shall be as follows -
  - 1. Mechanical - Eight hours.
  - 2. Temperature Control - Eight hours.
- C. Instruction periods shall occur before final site observation when systems are properly working and before final payment is made.
- D. None of these instructional periods shall overlap each other.

## 1.8 RECORD DRAWINGS

- A. Contractor shall keep an up-to-date set of mechanical and plumbing drawings in his custody showing all changes in red, clearly defined and neatly drafted by him. At the end of construction, he shall turn these drawings over to the Engineer. Record drawings must be completed and submitted prior to final site observation

## PART 2 - PRODUCTS

(Not Used)

## PART 3 - EXECUTION

(Not Used)

END OF SECTION 15010

## **SECTION 15050 - BASIC MECHANICAL MATERIALS AND METHODS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Piping materials and installation instructions common to most piping systems.
  - 2. Transition fittings.
  - 3. Dielectric fittings.
  - 4. Mechanical demolition.
  - 5. Equipment installation requirements common to equipment sections.
  - 6. Painting and finishing.
  - 7. Supports and anchorages.

#### **1.3 QUALITY ASSURANCE**

- A. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
  - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
  - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- B. All materials, piping, etc. shall be new, and domestically made of the best commercial quality obtainable, consistent with specified materials and for the purpose or function intended unless specifically approved in writing prior to bid.

#### **1.4 DELIVERY, STORAGE, AND HANDLING**

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

#### **1.5 COORDINATION**

- A. Coordinate installation of required supporting devices.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

### **2.2 PIPE, TUBE, AND FITTINGS**

- A. Refer to individual Division 15 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

### **2.3 JOINING MATERIALS**

- A. Refer to individual Division 15 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
  - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
    - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
    - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

### **2.4 DIELECTRIC FITTINGS**

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

- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
  - 1. Available Manufacturers:
    - a. Capitol Manufacturing Co.
    - b. Central Plastics Company.
    - c. Eclipse, Inc.
    - d. Epco Sales, Inc.
    - e. Hart Industries, International, Inc.
    - f. Watts Industries, Inc.; Water Products Div.
    - g. Zurn Industries, Inc.; Wilkins Div.
    - h. Prior Approved Equal.
  
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
  - 1. Available Manufacturers:
    - a. Capitol Manufacturing Co.
    - b. Central Plastics Company.
    - c. Epco Sales, Inc.
    - d. Watts Industries, Inc.; Water Products Div.
    - e. Prior Approved Equal.

## **PART 3 - EXECUTION**

### **3.1 MECHANICAL DEMOLITION**

- A. Disconnect, demolish, and remove mechanical systems, equipment, and components indicated to be removed.
  - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
  - 2. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
  - 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
  
- B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

### **3.2 PIPING SYSTEMS - COMMON REQUIREMENTS**

- A. Install piping according to the following requirements and Division 15 Sections specifying piping systems.

- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Drawings do not show every offset, or bend that may be required. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in equipment room at right angles and parallel to building walls. Diagonal runs are prohibited.
- D. Install piping to permit valve servicing.
- E. Install piping free of sags and bends.
- F. Install fittings for changes in direction and branch connections.
- G. Install piping to allow application of insulation.
- H. Select system components with pressure rating equal to or greater than system operating pressure.

### **3.3 PIPING JOINT CONSTRUCTION**

- A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- 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.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

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

### **3.4 PIPING CONNECTIONS**

- A. Make connections according to the following, unless otherwise indicated:
  - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
  - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

### **3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS**

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

### **3.6 PAINTING**

- A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

END OF SECTION 15050

## **SECTION 15062 - 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 1 Specification Sections, apply to this Section.

#### **1.2 SUMMARY**

- A. This Section includes the following hangers and supports for HVAC system piping and equipment:
  - 1. Steel pipe hangers and supports.
  - 2. Thermal-hanger shield inserts.
  - 3. Pipe stands.
  - 4. Equipment supports.
- B. Related Sections include the following:
  - 1. Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
  - 2. Division 15 Section(s) "Metal Ducts" for duct hangers and supports.

#### **1.3 DEFINITIONS**

- A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

#### **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.
- C. Design seismic-restraint hangers and supports for piping and equipment.

## **1.5 SUBMITTALS**

- A. Product Data: For the following:
  - 1. Steel pipe hangers and supports.
  - 2. Thermal-hanger shield inserts.

## **1.6 QUALITY ASSURANCE**

- A. Welding: Qualify procedures and personnel according to the following:
  - 1. AWS D1.1, "Structural Welding Code--Steel."

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

### **2.2 STEEL PIPE HANGERS AND SUPPORTS**

- A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.
- B. Manufacturers:
  - 1. AAA Technology & Specialties Co., Inc.
  - 2. Bergen-Power Pipe Supports.
  - 3. B-Line Systems, Inc.; a division of Cooper Industries.
  - 4. Grinnell Corp.
  - 5. Prior approved equal.
- C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

### **2.3 TRAPEZE PIPE HANGERS**

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

## **2.4 EQUIPMENT AND PIPE STAND SUPPORTS**

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

## **2.5 MISCELLANEOUS MATERIALS**

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

## **PART 3 - EXECUTION**

### **3.1 HANGER AND SUPPORT APPLICATIONS**

- A. Specific hanger and support requirements are specified 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. 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 insulated stationary pipes, NPS 1/2 to NPS 30.
  - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
  - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
  - 4. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
  - 5. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
- E. 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 20.
  - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- F. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

### **3.2 HANGER AND SUPPORT INSTALLATION**

- A. Steel 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 building structure.
- B. 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 above for individual pipe hangers.
  - 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- D. Install hangers and supports complete with necessary bolts, rods, nuts, washers, and other accessories.
- E. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement.
- F. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- G. Insulated Piping: Comply with the following:
  - 1. Attach clamps and spacers to piping.
    - a. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
  - 2. Shield Dimensions for Pipe: Not less than the following:
    - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
    - b. NPS 4: 12 inches long and 0.06 inch thick.
    - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
  - 3. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

### **3.3 METAL FABRICATIONS**

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

- C. Field Welding: Comply with AWS D1.1 procedures for 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 contours of welded surfaces match adjacent contours.

### **3.4 ADJUSTING**

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

END OF SECTION 15062

**SECTION 15074 - VIBRATION AND SEISMIC CONTROLS 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 1 Specification Sections, apply to this Section.

**1.2 SUMMARY**

- A. This Section includes the following: Provide seismic controls for new steam and condensate piping chilled water piping and two air handling units. Provide vibration control for two air handling units and piping connections to AH units.
  - 1. Isolation pads.
  - 2. Isolation mounts.
  - 3. Freestanding and restrained spring isolators.
  - 4. Spring hangers.
  - 5. Pipe riser resilient supports.
  - 6. Restrained vibration isolation roof-curb rails.
  - 7. Restraining braces and cables.

**1.3 DEFINITIONS**

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.

**1.4 PERFORMANCE REQUIREMENTS**

- A. Wind-Restraint Loading:
  - 1. Basic Wind Speed: Design standards.
  - 2. Building Classification Category: As defined in the IBC.
  - 3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.
- B. Seismic-Restraint Loading:
  - 1. Site Class: As defined in the IBC.
  - 2. Assigned Seismic Use Group or Building Category: As defined in the IBC.

- a. Component Importance Factor: 1.5.

## **1.5 SUBMITTALS**

- A. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

## **1.6 QUALITY ASSURANCE**

- A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings.

## **PART 2 - PRODUCTS**

### **2.1 VIBRATION ISOLATORS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Amber/Booth Company, Inc.
  - 2. Kinetics Noise Control.
  - 3. Mason Industries.
  - 4. Vibration Eliminator Co., Inc.
  - 5. Prior approved equal.
- B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
  - 1. Resilient Material: Oil- and water-resistant neoprene or rubber.
- C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
  2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
- D. Restrained Mounts: All-directional mountings with seismic restraint.
1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
  2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
- E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
  6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- F. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
1. 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.
  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. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
  7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
- G. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- thick neoprene. Include steel and

neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.

## 2.2 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
  2. Kinetics Noise Control.
  3. Mason Industries.
  4. Vibration Eliminator Co., Inc.
  5. Prior approved equal.
- B. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.
- C. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches of rigid, glass-fiber insulation on inside of assembly.
- D. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch-thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof. If spring isolators come with the equipment additional spring isolators are not required.
1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic and wind restraint.
    - a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
    - b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
    - c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
    - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
    - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  2. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel

baseplates, and factory cut to sizes that match requirements of supported equipment.

- a. Resilient Material: Oil- and water-resistant standard neoprene or natural rubber.

## 2.3 SEISMIC-RESTRAINT DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  1. Amber/Booth Company, Inc.
  2. Hilti, Inc.
  3. Kinetics Noise Control.
  4. Mason Industries.
  5. Unistrut; Tyco International, Ltd.
  6. Prior approved equal.
- B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.
  1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. Restraint Cables: -steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
- D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.
- E. 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.
- F. 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.
- G. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- H. 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. Minimum length of eight times diameter.

- I. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl 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.

## **2.4 FACTORY FINISHES**

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
  1. Powder coating on springs and housings.
  2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
  3. Baked enamel or powder coat for metal components on isolators for interior use.
  4. Color-code or otherwise mark vibration isolation and seismic- and wind-control devices to indicate capacity range.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas and equipment to receive vibration isolation and seismic- and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- 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 evaluation service member of ICC-ES or 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 will be adequate to carry present and future static and seismic loads within specified loading limits.

### **3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION**

- A. Equipment Restraints:
  - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
  - 2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction providing required submittals for component.
- B. Piping Restraints:
  - 1. Comply with requirements in MSS SP-127.
  - 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
  - 3. Brace a change of direction longer than 12 feet.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction providing required submittals for component.
- E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- F. 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.
- G. 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.
- H. 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 Division 15 Section "Hydronic Piping" for piping flexible connections.

### **3.5 FIELD QUALITY CONTROL**

- A. Testing Agency: Leave a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

### **3.6 ADJUSTING**

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust active height of spring isolators.
- C. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 15074

## **SECTION 15077 - 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 1 Specification Sections, apply to this Section.

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Equipment labels.
  - 2. Pipe labels.

#### **1.3 COORDINATION**

- 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.

### **PART 2 - PRODUCTS**

#### **2.1 EQUIPMENT LABELS**

- A. Plastic Labels for Equipment:
  - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
  - 2. Letter Color: White.
  - 3. Background Color: Black.
  - 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
  - 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
  - 6. Minimum Letter Size: 1/2 inch for viewing distances up to 72 inches. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
  - 7. Fasteners: Stainless-steel self-tapping screws.
- B. Label Content: Include equipment's Drawing designation AHU-1, CFM, SP and HP.

## **2.2 PIPE LABELS**

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
  - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
  - 2. Lettering Size: At least 1-1/2 inches high.

## **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 EQUIPMENT LABEL INSTALLATION**

- A. Install labels on the two new multizone units with self tapping screws.
- B. Locate equipment labels where accessible and visible.

### **3.3 PIPE LABEL INSTALLATION**

- A. Locate pipe labels in three locations in penthouse as follows:
  - 1. Near each valve and control device.
  - 2. Where flow pattern is not obvious, mark each pipe at branch.
  - 3. Near penetrations through floor.
  - 4. Near major equipment.
- B. Pipe Label Color Schedule:
  - 1. Chilled-Water Piping:
    - a. Background Color: Blue.
    - b. Letter Color: Black.

2. Low-Pressure Steam Piping:
  - a. Background Color: Red.
  - b. Letter Color: Black.

END OF SECTION 15077

## **SECTION 15080 - HVAC INSULATION**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. Section Includes: Insulation for steam and chilled water piping.

- 1. Insulation Materials:
  - a. Calcium silicate.
  - b. Mineral fiber.
- 2. Fire-rated insulation systems.
- 3. Insulating cements.
- 4. Adhesives.
- 5. Lagging adhesives.
- 6. Factory-applied jackets.
- 7. Field-applied jackets.
- 8. Tapes.
- 9. Securements.
- 10. Corner angles.

- B. Related Sections:

- 1. Division 15 Section "Metal Ducts" for duct liners.

#### **1.3 SUBMITTALS**

- A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).
- B. Qualification Data: For qualified Installer.
- C. Field quality-control reports.

#### **1.4 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. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting 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 and inspecting agency.
  - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

#### **1.5 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.
- B. Store in a clean, dry room. Exterior storage is not allowed.

#### **1.6 COORDINATION**

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 15 Section "Hangers and Supports."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

#### **1.7 SCHEDULING**

- A. Schedule insulation application after pressure testing systems.

### **PART 2 - PRODUCTS**

#### **2.1 INSULATION MATERIALS**

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Calcium Silicate:
  - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
    - a. Industrial Insulation Group (The); Thermo-12 Gold.
    - b. Prior approved equal.
  - 2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
  - 3. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
- D. Mineral-Fiber, Preformed Pipe Insulation:
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Johns Manville; Micro-Lok.
    - b. Owens Corning; Fiberglas Pipe Insulation.
    - c. Knauf Insulation; 1000 Pipe Insulation.
    - d. Manson Insulation Inc.; Alley-K.
    - e. Prior approved equal.
  - 2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A.

## 2.2 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
  - 1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Insulco, Division of MFS, Inc.; Triple I.
    - b. P. K. Insulation Mfg. Co., Inc.; Super-Stik.
    - c. Prior approved equal.

## 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.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Childers Products, Division of ITW; CP-97.
  - b. Foster Products Corporation, H. B. Fuller Company; 81-27/81-93.
  - c. Marathon Industries, Inc.; 290.
  - d. Mon-Eco Industries, Inc.; 22-30.
  - e. Vimasco Corporation; 760.
  - f. Prior approved equal.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Childers Products, Division of ITW; CP-82.
  - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
  - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
  - d. Marathon Industries, Inc.; 225.
  - e. Mon-Eco Industries, Inc.; 22-25.
  - f. Prior approved equal.

D. PVC Jacket Adhesive: Compatible with PVC jacket - chilled water

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Dow Chemical Company (The); 739, Dow Silicone.
  - b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
  - c. P.I.C. Plastics, Inc.; Welding Adhesive.
  - d. Red Devil, Inc.; Celulon Ultra Clear.
  - e. Speedline Corporation; Speedline Vinyl Adhesive.
  - f. Prior approved equal.

## 2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Products: Subject to compliance with requirements, provide one of the following:
  - a. Childers Products, Division of ITW; CP-52.
  - b. Foster Products Corporation, H. B. Fuller Company; 81-42.
  - c. Marathon Industries, Inc.; 130.
  - d. Mon-Eco Industries, Inc.; 11-30.
  - e. Vimasco Corporation; 136.
  - f. Prior approved equal.
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
3. Service Temperature Range: Minus 50 to plus 180 deg F.

4. Color: White.

## 2.5 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.
  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.
  3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

## 2.6 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules. Chilled water piping only.
  1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Johns Manville; Zeston.
    - b. P.I.C. Plastics, Inc.; FG Series.
    - c. Proto PVC Corporation; LoSmoke.
    - d. Speedline Corporation; SmokeSafe.
    - e. Prior approved equal.
  2. Adhesive: As recommended by jacket material manufacturer.
  3. Color: White.
  4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
    - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers.
- C. Metal Jacket: (Steam Only)
  1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Products, Division of ITW; Metal Jacketing Systems.
    - b. PABCO Metals Corporation; Surefit.
    - c. RPR Products, Inc.; Insul-Mate.
    - d. Prior approved equal.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
  - a. Sheet and roll stock ready for shop or field sizing.
  - b. Finish and thickness are indicated in field-applied jacket schedules.
  - c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
  - d. Factory-Fabricated Fitting Covers:
    - 1) Same material, finish, and thickness as jacket.
    - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
    - 3) Tee covers.
    - 4) Flange and union covers.
    - 5) Beveled collars.
    - 6) Valve covers.
    - 7) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

## 2.7 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
  1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
    - b. Compac Corp.; 104 and 105.
    - c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
    - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
    - e. Prior approved equal.
  2. Width: 3 inches.
  3. Thickness: 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. Products: Subject to compliance with requirements, provide one of the following:
    - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
    - b. Compac Corp.; 110 and 111.
    - c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
    - d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.
    - e. Prior approved equal.

2. Width: 3 inches.
  3. Thickness: 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. Products: Subject to compliance with requirements, provide one of the following:
    - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
    - b. Compac Corp.; 130.
    - c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
    - d. Venture Tape; 1506 CW NS.
    - e. Prior approved equal.
  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.

## 2.8 SECUREMENTS

- A. Bands:
1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Products; Bands.
    - b. PABCO Metals Corporation; Bands.
    - c. RPR Products, Inc.; Bands.
    - d. Prior approved equal.
  2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide.

## 2.9 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.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

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

### **3.2 PREPARATION**

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. 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. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
- C. 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 when looking up and bottom when looking down of horizontal runs.
- E. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- 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, and other projections with vapor-barrier mastic.
  - 1. Install insulation continuously through hangers
  - 2. 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.
  - 3. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied 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 o.c.
  - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
  - 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
  - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- O. For above ambient services, do not install insulation to the following:
  - 1. Vibration-control devices.
  - 2. Testing agency labels and stamps.
  - 3. Nameplates and data plates.

### **3.4 PENETRATIONS**

- A. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.

### **3.5 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 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 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. 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, vessels, and equipment. 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 at locations indicated. 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.

### **3.6 CALCIUM SILICATE INSULATION INSTALLATION**

- A. 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 2-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.
- 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 block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

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 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.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve 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.

### 3.7 MINERAL-FIBER INSULATION INSTALLATION

A. 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 laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but 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 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.

C. 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.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install 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.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

### **3.8 FIELD-APPLIED JACKET INSTALLATION**

- A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's 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.

### **3.9 FIELD QUALITY CONTROL**

A. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Engineer, 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.

- B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

### 3.10 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.
- C. Piping System insulation:
  - 1. Hydronic Piping - Mineral Fiber, per chart.

### 3.11 INDOOR PIPING INSULATION SCHEDULE

- A. Minimum Pipe Insulation Thickness from ANSI/ASHRAE/IESNA Standard 90.1-2004, with modifications per 2006 IECC

Fluid Design Operating Temp. Range (°F)	Insulation Conductivity		Nominal				
	Conductivity Btu•in./(h•ft <sup>2</sup> •°F)	Mean Rating Temp. °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
<b>Heating Systems (Steam, Steam Condensate, and Hot Water)</b>							
>350	0.32-0.34	250	2.5	3.0	3.0	4.0	4.0
251-350	0.29-0.32	200	1.5	3.0	3.0	3.0	3.0
201-250	0.27-0.30	150	1.5	1.5	2.0	2.0	2.0
141-200	0.25-0.29	125	1.0	1.0	2.0	2.0	2.0
105-140	0.22-0.28	100	0.5	0.5	1.0	1.0	1.0
<b>Domestic and Service Hot Water Systems</b>							
105+	0.22-0.28	100	0.5	0.5	1.0	1.0	1.0
<b>Cooling Systems (Chilled Water, Brine, and Refrigerant)</b>							
40-60	0.22-0.28	100	0.5	1.0	1.5	1.5	1.5
<40	0.22-0.28	100	0.5	1.0	1.5	1.5	1.5

### 3.12 INDOOR, 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. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Exposed:

1. PVC: 20 mils thick: Chilled water piping.
2. Aluminum Jacket: Steam Piping.

END OF SECTION 15083

## **SECTION 15112 - GENERAL-DUTY VALVES FOR HVAC AND PLUMBING PIPING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes the following general-duty valves:
  - 1. Copper-alloy ball valves.
  - 2. Ferrous-alloy ball valves.
  - 3. Ferrous-alloy butterfly valves.
  - 4. Bronze check valves.
- B. Related Sections include the following:
  - 1. Division 15 piping Sections for specialty valves applicable to those Sections only.
  - 2. Division 15 Section "Identification for HVAC Piping and Equipment" for valve tags and charts.
  - 3. Division 15 Section "HVAC Instrumentation and Controls" for control valves and actuators.

#### **1.3 DEFINITIONS**

- A. The following are standard abbreviations for valves:
  - 1. CWP: Cold working pressure.
  - 2. EPDM: Ethylene-propylene-diene terpolymer rubber.
  - 3. PTFE: Polytetrafluoroethylene plastic.
  - 4. SWP: Steam working pressure.
  - 5. TFE: Tetrafluoroethylene plastic.

#### **1.4 SUBMITTALS**

- A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

## **1.5 QUALITY ASSURANCE**

- A. ASME Compliance: ASME B31.9 for building services piping valves.
- B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

## **1.6 DELIVERY, STORAGE, AND HANDLING**

- A. Prepare valves for shipping as follows:
  - 1. Protect internal parts against rust and corrosion.
  - 2. Protect threads, flange faces and weld ends.
  - 3. Set ball valves open to minimize exposure of functional surfaces.
  - 4. Set butterfly valves closed or slightly open.
  - 5. Block check valves in either closed or open position.
- B. Use the following precautions during storage:
  - 1. Maintain valve end protection.
  - 2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

## **PART 2 - PRODUCTS**

### **2.1 VALVES, GENERAL**

- A. Refer to Part 3 "Valve Applications" Article for applications of valves.
- B. Bronze Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated.
- C. Ferrous Valves: NPS 2-1/2 and larger with flanged ends, unless otherwise indicated.
- D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.
- F. Valve Actuators:
  - 1. Handwheel: For valves other than quarter-turn types.
  - 2. Lever Handle: For quarter-turn valves NPS 6 and smaller.
- G. Extended Valve Stems: On insulated valves.
- H. Valve Flanges: ASME B16.1 for cast-iron valves, and ASME B16.24 for bronze valves.

- I. Valve Ends:
  - 1. Threaded: With threads according to ASME B1.20.1.
- J. Valve Bypass and Drain Connections: MSS SP-45.

## 2.2 COPPER-ALLOY BALL VALVES

- A. Manufacturers:
  - 1. One-Piece, Copper-Alloy Ball Valves:
    - a. Kitz Corporation of America.
    - b. NIBCO INC.
    - c. Watts Industries, Inc.; Water Products Div.
    - d. Grinnell Corporation.
    - e. Conbraco Industries, Inc.; Apollo Div.
    - f. Crane Co.; Crane Valve Group; Jenkins Valves.
    - g. Crane Co.; Crane Valve Group; Stockham Div.
    - h. Prior approved equal.
  - 2. Two-Piece, Copper-Alloy Ball Valves:
    - a. Kitz Corporation of America.
    - b. NIBCO INC.
    - c. Watts Industries, Inc.; Water Products Div.
    - d. Grinnell Corporation.
    - e. Conbraco Industries, Inc.; Apollo Div.
    - f. Crane Co.; Crane Valve Group; Crane Valves.
    - g. Crane Co.; Crane Valve Group; Jenkins Valves.
    - h. Crane Co.; Crane Valve Group; Stockham Div.
    - i. Hammond Valve.
    - j. Milwaukee Valve Company.
    - k. Prior approved equal.
- B. Copper-Alloy Ball Valves, General: MSS SP-110.
- C. One-Piece, Copper-Alloy Ball Valves: Brass or bronze body with chrome-plated and vented bronze ball with blow-out proof stem and PTFE or TFE seats, and 400-psig minimum CWP rating.
- D. Two-Piece, Copper-Alloy Ball Valves: Brass or bronze body with full-port, chrome-plated and vented bronze ball with blow-out proof stem; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.

## 2.3 FERROUS-ALLOY BALL VALVES

- A. Manufacturers:

1. Crane Co.; Crane Valve Group; Stockham Div.
2. Milwaukee Valve Company.
3. NIBCO INC.
4. Kitz Corporation of America.
5. Hammond Valve.
6. Prior approved equal.

B. Ferrous-Alloy Ball Valves, General: MSS SP-72, with flanged ends.

C. Ferrous-Alloy Ball Valves: Class 150, full port.

## **2.4 FERROUS-ALLOY BUTTERFLY VALVES**

A. Manufacturers:

1. Flangeless, Ferrous-Alloy Butterfly Valves:

- a. Milwaukee Valve Company.
- b. NIBCO INC.
- c. Hammond Valve.
- d. Grinnell Corporation.
- e. Crane Co.; Crane Valve Group; Center Line.
- f. Crane Co.; Crane Valve Group; Stockham Div.
- g. Kitz Corporation of America.
- h. Metraflex Co.
- i. Mueller Steam Specialty.
- j. Prior approved equal.

2. Flanged, Ferrous-Alloy Butterfly Valves:

- a. Grinnell Corporation.
- b. Cooper Cameron Corp.; Cooper Cameron Valves Div.
- c. Bray International, Inc.
- d. Mueller Steam Specialty.
- e. Prior approved equal.

B. Flangeless, 150-psig CWP Rating, Ferrous-Alloy Butterfly Valves: Wafer type with one- or two-piece stem.

C. Flanged, 150-psig CWP Rating, Ferrous-Alloy Butterfly Valves: Flanged-end type with one- or two-piece stem.

## **2.5 BRONZE CHECK VALVES**

A. Manufacturers:

1. Type 2, Bronze, Horizontal Lift Check Valves with Nonmetallic Disc:

- a. Walworth Co.
  - b. Cincinnati Valve Co.
  - c. Crane Co.; Crane Valve Group; Crane Valves.
  - d. Crane Co.; Crane Valve Group; Jenkins Valves.
  - e. Crane Co.; Crane Valve Group; Stockham Div.
  - f. Prior approved equal.
2. Type 2, Bronze, Vertical Lift Check Valves with Nonmetallic Disc:
- a. Grinnell Corporation.
  - b. Kitz Corporation of America.
  - c. Milwaukee Valve Company.
  - d. Prior approved equal.
3. Type 4, Bronze, Swing Check Valves with Nonmetallic Disc:
- a. Walworth Co.
  - b. Cincinnati Valve Co.
  - c. Crane Co.; Crane Valve Group; Crane Valves.
  - d. Crane Co.; Crane Valve Group; Jenkins Valves.
  - e. Crane Co.; Crane Valve Group; Stockham Div.
  - f. Grinnell Corporation.
  - g. Hammond Valve.
  - h. Milwaukee Valve Company.
  - i. NIBCO INC.
  - j. Watts Industries, Inc.; Water Products Div.
  - k. Prior approved equal.
- B. Bronze Check Valves, General: MSS SP-80.
- C. Type 2, Class 150, Bronze, Horizontal Lift Check Valves: Bronze body with nonmetallic disc and bronze seat.
- D. Type 2, Class 150, Bronze, Vertical Lift Check Valves: Bronze body with nonmetallic disc and bronze seat.
- E. Type 4, Class 150, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- F. Do not attempt to repair defective valves; replace with new valves.

### **3.2 VALVE APPLICATIONS**

- A. Refer to piping Sections and drawings for specific valve applications. If valve applications are not indicated, use the following:
  1. Shutoff Service: Ball or butterfly valves.
  2. Throttling Service: Ball or butterfly.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.
- C. Chilled-Water Piping: Use the following types of valves:
  1. Ball Valves, NPS 2 and Smaller: Two-piece, 400-psig CWP rating, copper alloy.
  2. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous alloy.
  3. Butterfly Valves, NPS 2-1/2 and Larger: Flangeless or Flanged, 150-psig CWP rating, ferrous alloy, with EPDM liner.
  4. Lift Check Valves, NPS 2 and Smaller: Type 2, Class 150, vertical, bronze.
  5. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 150, bronze.
  6. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
- D. Low-Pressure Steam Piping: Use the following types of valves:
  1. Ball Valves, NPS 2 and Smaller: Two-piece, 600-psig CWP rating, copper alloy.
  2. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous alloy.
  3. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 150, bronze.
  4. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
- E. Steam Condensate Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: Two-piece, 600-psig CWP rating, copper alloy.
2. Ball Valves, NPS 2-1/2 and Larger: Class 150, ferrous alloy.
3. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 150, bronze.
4. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.

F. Select valves, except wafer and flangeless types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded ends, except provide valves with threaded ends for steam, and steam condensate services.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged or threaded ends.
3. For Steel Piping, NPS 2 and Smaller: Threaded ends.
4. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends.
5. For Grooved-End, chilled water only: Valve ends may be grooved. Do not use for steam or steam condensate piping.

### **3.3 VALVE INSTALLATION**

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- C. Locate valves for easy access and provide separate support where necessary.
- D. Install valves in horizontal piping with stem at or above center of pipe.
- E. Install valves in position to allow full stem movement.
- F. Install check valves for proper direction of flow and as follows:
  1. Swing Check Valves: In horizontal position with hinge pin level.
  2. Lift Check Valves: With stem upright and plumb.

### **3.4 JOINT CONSTRUCTION**

- A. Refer to Division 15 Section "Common Work Results for HVAC" for basic piping joint construction.
- B. Grooved Joints Chilled water only: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

### **3.5 ADJUSTING**

- 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.

END OF SECTION 15112

## **SECTION 15127 - METERS AND GAGES FOR HVAC PIPING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Liquid-in-glass thermometers.
  - 2. Thermowells.
  - 3. Dial-type pressure gages.
  - 4. Gage attachments.
- B. Related Sections:
  - 1. Division 15 Section "Steam and Condensate Piping" for steam and condensate meters.
  - 2. Division 15 Section "Facility Natural-Gas Piping" for gas meters.

#### **1.3 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Wiring Diagrams: For power, signal, and control wiring.
- C. Product Certificates: For each type of meter and gage, from manufacturer.
- D. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

### **PART 2 - PRODUCTS**

#### **2.1 LIQUID-IN-GLASS THERMOMETERS**

- A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Miljoco Corporation.
  - b. Trerice, H. O. Co.
  - c. Weiss Instruments, Inc.
  - d. Palmer Wahl Instrumentation Group.
  - e. Prior approved equal.
2. Standard: ASME B40.200.
  3. Case: Cast aluminum; 9 inch nominal size unless otherwise indicated.
  4. Case Form: Adjustable angle unless otherwise indicated.
  5. Tube: Glass with magnifying lens and blue organic liquid.
  6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
  7. Window: Glass.
  8. Stem: Aluminum and of length to suit installation.
    - a. Design for Thermowell Installation: Bare stem.
  9. Connector: 1-1/4 inches, 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.

## 2.2 THERMOWELLS

### A. 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.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, 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.

### B. Heat-Transfer Medium: Mixture of graphite and glycerin.

## 2.3 PRESSURE GAGES

### A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Miljoco Corporation.
  - b. Ashcroft Inc.
  - c. AMETEK, Inc.; U.S. Gauge.
  - d. Marsh Bellofram.
  - e. Palmer Wahl Instrumentation Group.
  - f. Terice, H. O. Co.
  - g. Weiss Instruments, Inc.
  - h. Prior approved equal.
2. Standard: ASME B40.100.
  3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
  4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
  5. Pressure Connection: Brass, with NPS 1/4, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
  6. Movement: Mechanical, with link to pressure element and connection to pointer.
  7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
  8. Pointer: Dark-colored metal.
  9. Window: Glass.
  10. Ring: Stainless steel.
  11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

## **2.4 GAGE ATTACHMENTS**

- A. Snubbers: ASME B40.100, brass; with NPS 1/4, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.
- B. Siphons: Steam only: Loop-shaped section of steel pipe with NPS 1/4 pipe threads.
- C. Valves: Brass ball, with NPS 1/4, ASME B1.20.1 pipe threads.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.

- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- G. Install valve and snubber in piping for each pressure gage for fluids (except steam).
- H. Install valve and syphon fitting in piping for each pressure gage for steam.
- I. Install thermometers in the following locations:
  - 1. Inlet and outlet of each chilled water coil connection in the two multizone units.
  - 2. Inlet and outlet of each steam coil in multizone air-handling units.
- J. Install pressure gages in the following locations:
  - 1. Inlet and outlet of each chilled-water coil.

### **3.2 CONNECTIONS**

- A. Install gages adjacent to machines and equipment to allow service and maintenance of gages, and equipment.

### **3.3 ADJUSTING**

- A. Adjust faces of gages and thermometers to proper angle for best visibility.

### **3.4 THERMOMETER SCHEDULE**

- A. Thermometers at inlet and outlet of each chilled water coil in new multizone air-handling units shall be one of the following:
  - 1. Industrial-style, liquid-in-glass type.
- B. Thermometer stems shall be of length to match thermowell insertion length.

### **3.5 THERMOMETER SCALE-RANGE SCHEDULE**

- A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.
- B. Scale Range for Steam and Steam-Condensate Piping: 0 to 250 deg F.

**3.6 PRESSURE-GAGE SCHEDULE**

- A. Pressure gages at inlet and outlet of each chilled-water coil connection shall be one of the following:
  - 1. Liquid-filled, direct-mounted, metal case.

**3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE**

- A. Scale Range for Chilled-Water Piping: 0 to 100 psi.
- B. Scale Range for Steam Piping: 0 to 100 psi.

END OF SECTION 15127

## **SECTION 15181 - HYDRONIC PIPING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
  - 1. Chilled-water piping.
  - 2. Drain piping.
  - 3. Air-vent piping.

#### **1.3 PERFORMANCE REQUIREMENTS**

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
  - 1. Chilled-Water Piping: 125 psig at 100° F.
  - 2. Drain Piping: 100° F.
  - 3. Air-Vent Piping: Equal to the pressure of the piping system to which it is attached.

#### **1.4 SUBMITTALS**

- A. Product Data: For each type of the following:
  - 1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
  - 2. Air control devices.

#### **1.5 QUALITY ASSURANCE**

- A. Installer Qualifications:
  - 1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

- B. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
  - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
  - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

## 1.6 EXTRA MATERIALS

- A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 COPPER TUBE AND FITTINGS

- A. Hard Drawn-Temper Copper Tubing: Type L.
- B. Wrought-Copper Fittings: ASME B16.22.
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Victaulic Company of America.
    - b. Anvil International, Inc.
    - c. S. P. Fittings; a division of Star Pipe Products.
    - d. Prior approved equal.
  - 2. Grooved-End Copper Fittings: Copper tube or ASTM B 584, bronze casting.
  - 3. Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, EPDM gasket rated for minimum for use with housing, and steel bolts and nuts.
- C. Copper or Bronze Pressure-Seal Fittings:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Stadler-Viega.
  - b. Prior approved equal.
2. Housing: Copper.
  3. O-Rings and Pipe Stops: EPDM.
  4. Tools: Manufacturer's special tools.
  5. Minimum working-pressure rating at.
- D. Wrought-Copper Unions: ASME B16.22.

## 2.2 STEEL PIPE AND FITTINGS

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

2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

I. Steel Pressure-Seal Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Victaulic Company of America.
  - b. Prior approved equal.
2. Housing: Steel.
3. O-Rings and Pipe Stop: EPDM.
4. Tools: Manufacturer's special tool.
5. Minimum working-pressure rating at.

J. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

## 2.3 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
1. ASME B16.21, nonmetallic, flat, asbestos free, maximum thickness unless thickness or specific material is indicated.
    - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- E. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

## 2.4 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Capitol Manufacturing Company.
    - b. Central Plastics Company.
    - c. Hart Industries International, Inc.
    - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    - e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.
    - f. Prior approved equal.
  - 2. Factory-fabricated union assembly, for minimum working pressure at.
- D. Dielectric Flanges:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Capitol Manufacturing Company.
    - b. Central Plastics Company.
    - c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    - d. Prior approved equal.
  - 2. Factory-fabricated companion-flange assembly, for minimum working pressure as required to suit system pressures.
- E. Dielectric Couplings:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Calpico, Inc.
    - b. Lochinvar Corporation.
    - c. Prior approved equal.

## 2.5 VALVES

- A. Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 15 Section "Valves."

- B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 15 Section "HVAC Instrumentation and Controls."
- C. Bronze, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Bell & Gossett Domestic Pump; a division of ITT Industries.
    - b. Armstrong Pumps, Inc.
    - c. Flow Design Inc.
    - d. Gerand Engineering Co.
    - e. Prior Approved Equal
  2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
  3. Ball: Brass or stainless steel.
  4. Plug: Resin.
  5. Seat: PTFE.
  6. End Connections: Threaded or socket.
  7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
  8. Handle Style: Lever, with memory stop to retain set position.
  9. CWP Rating: Minimum.
  10. Maximum Operating Temperature: 250° F .
- D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Bell & Gossett Domestic Pump; a division of ITT Industries.
    - b. Armstrong Pumps, Inc.
    - c. Flow Design Inc.
    - d. Gerand Engineering Co.
    - e. Griswold Controls.
    - f. Taco.
    - g. Tour & Andersson; available through Victaulic Company of America.
    - h. Prior approved equal.
  2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
  3. Ball: Brass or stainless steel.
  4. Stem Seals: EPDM O-rings.
  5. Disc: Glass and carbon-filled PTFE.
  6. Seat: PTFE.
  7. End Connections: Flanged or grooved.
  8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
  9. Handle Style: Lever, with memory stop to retain set position.

10. CWP Rating: Minimum.
11. Maximum Operating Temperature: 250° F .

## **2.6 AIR CONTROL DEVICES**

### **A. Manual Air Vents:**

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

## **2.7 CHEMICAL TREATMENT**

- ### **A.**
- This contractor shall be responsible for replacing chemicals lost during draining of chilled water system.

## **2.8 HYDRONIC PIPING SPECIALTIES**

### **A. Y-Pattern Strainers:**

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

## **PART 3 - EXECUTION**

### **3.1 PIPING APPLICATIONS**

- #### **A.**
- Chilled-water piping, aboveground, 2" and smaller, shall be the following:

1. Type L, hard drawn copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Schedule 40 steel pipe; Class 150, malleable-iron, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

- #### **B.**
- Chilled-water piping, aboveground, 2 1/2" and larger, shall be the following:

1. Type L, hard drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
  2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
  3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
- C. Drain Piping: Type L, Hard drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- D. Air-Vent Piping:
1. Inlet: Same as service
  2. Outlet Type: annealed-temper copper tubing with soldered or flared joints.

### **3.2 VALVE APPLICATIONS**

- A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.
- B. Install balancing valves at each branch connection to return main.
- C. Install check valves as required to control flow direction.

### **3.3 PIPING INSTALLATIONS**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping at right angles and parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- C. Install piping to permit valve servicing.
- D. Install piping free of sags and bends.
- E. Install fittings for changes in direction and branch connections.
- F. Install piping to allow application of insulation.
- G. Select system components with pressure rating equal to or greater than system operating pressure.
- H. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

- I. Install drains, consisting of a tee fitting, ball valve, and short threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- J. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- K. 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.
- L. Install valves according to Division 15 Section "Valves."
- M. Install unions in piping, 2" and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- N. Install flanges in piping, 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- O. Install strainers on inlet side of each control valve, and elsewhere as indicated. Install nipple and ball valve in blowdown connection of strainers 2-1/2 inch and larger. Match size of strainer blowoff connection for strainers smaller than 2 inch.
- P. Identify piping as specified in Division 15 Section "Mechanical Identification."

### **3.4 HANGERS AND SUPPORTS**

- A. Hanger, support, and anchor devices are specified in Division 15 Section "Hangers and Supports." Comply with the following requirements for maximum spacing of supports.
- B. Seismic restraints are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."
- C. Install the following pipe attachments:
  - 1. Adjustable steel clevis hangers for individual horizontal piping.
  - 2. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
  - 1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
  - 2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
  - 3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
  - 4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
  - 5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
  - 6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
  - 7. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.

- E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
  - 1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
  - 2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
  - 3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
  - 4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
  - 5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
  - 6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
  - 7. NPS 4: Maximum span, 12 feet; minimum rod size, 3/8 inch.

### **3.5 PIPE JOINT CONSTRUCTION**

- A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- 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.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- I. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written

instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

### **3.6 HYDRONIC SPECIALTIES INSTALLATION**

- A. Install manual air vents at high points in piping, at chilled-transfer coils, and elsewhere as required for system air venting.

### **3.7 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 ball valve around control valve. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 15 Section "Meters and Gages."

### **3.8 CHEMICAL TREATMENT**

- A. Fill existing and new system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
- B. Add initial chemical treatment and maintain water quality in ranges required by existing WTC.

### **3.9 FIELD QUALITY CONTROL**

- A. Prepare chilled piping according to ASME B31.9 and as follows:
  - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
  - 2. Flush piping system with clean water; then remove and clean or replace strainer screens.
  - 3. 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.
  - 4. 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 new hydronic piping:

1. Use ambient temperature water as a testing medium
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. 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 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 "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
4. After hydrostatic test pressure has been applied for at least 4 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
5. Prepare written report of testing.

END OF SECTION 15181

## **SECTION 15182 - STEAM AND CONDENSATE PIPING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes the following for LP steam and condensate piping:
  - 1. Pipe and fittings.
  - 2. Strainers.
  - 3. Steam traps.
  - 4. Thermostatic air vents and vacuum breakers.

#### **1.3 DEFINITIONS**

- A. HP Systems: High-pressure piping operating at more than 15 psig as required by ASME B31.1.
- B. LP Systems: Low-pressure piping operating at 15 psig or less as required by ASME B31.9.

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures:
  - 1. LP Steam Piping: 30 psig
  - 2. Condensate Piping: 30 psig at 250 deg F.
  - 3. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.

#### **1.5 SUBMITTALS**

- A. Product Data: For each type of the following:
  - 1. Steam trap.
  - 2. Air vent and vacuum breaker.
- B. Qualification Data: For Installer.

- C. Welding certificates.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For valves, steam traps, air vents and vacuum breakers to include in operation, and maintenance manuals.

## **1.6 QUALITY ASSURANCE**

- A. Pipe Welding: Qualify processes and operators according to the following:
  - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
  - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

## **PART 2 - PRODUCTS**

### **2.1 STEEL PIPE AND FITTINGS**

- A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, Type, Grade, and Schedule as indicated in Part 3 piping applications articles.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in Part 3 piping applications articles.
- C. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in Part 3 piping applications articles.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 piping applications articles.
- E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in Part 3 piping applications articles; raised ground face, and bolt holes spot faced.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
  - 1. Material Group: 1.1.
  - 2. End Connections: Butt welding.
  - 3. Facings: Raised face.
- H. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

## 2.2 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
  - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
    - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
    - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

## 2.3 VALVES

- A. Ball and Butterfly Valves: Comply with requirements specified in Division 15 Section "Valves."
- B. Stop-Check Valves:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. Crane Co.
    - b. Jenkins Valves; a Crane Company.
    - c. Lunkenheimer Valves.
    - d. A.Y. McDonald Mfg. Co.
    - e. Prior approved equal.
  - 2. Body and Bonnet: Malleable iron.
  - 3. End Connections: Flanged.
  - 4. Disc: Cylindrical with removable liner and machined seat.
  - 5. Stem: Brass alloy.
  - 6. Operator: Outside screw and yoke with cast-iron handwheel.
  - 7. Packing: Polytetrafluoroethylene-impregnated packing with two-piece packing gland assembly.
  - 8. Pressure Class: 250.

## 2.4 STRAINERS

### A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20 mesh strainer, and perforated stainless-steel basket with 50 percent free area.
4. Tapped blowoff plug.
5. CWP Rating: 250-psig working steam pressure.

## 2.5 STEAM TRAPS

### A. Float and Thermostatic Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Armstrong International, Inc.
  - b. Barnes & Jones, Inc.
  - c. Dunham-Bush, Inc.
  - d. Hoffman Specialty; Division of ITT Industries.
  - e. Spirax Sarco, Inc.
  - f. Sterling.
  - g. Prior approved equal.
2. Body and Bolted Cap: ASTM A 126, cast iron.
3. End Connections: Threaded.
4. Float Mechanism: Replaceable, stainless steel.
5. Head and Seat: Hardened stainless steel.
6. Trap Type: Balanced pressure.
7. Thermostatic Bellows: Stainless steel or monel.
8. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.
9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless steel cage, valve, and seat.
10. Maximum Operating Pressure: 125 psig.

### B. Inverted Bucket Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Armstrong International, Inc.
  - b. Barnes & Jones, Inc.
  - c. Dunham-Bush, Inc.
  - d. Hoffman Specialty; Division of ITT Industries.

- e. Spirax Sarco, Inc.
  - f. Sterling.
  - g. Prior approved equal.
2. Body and Cap: Cast iron.
  3. End Connections: Threaded.
  4. Head and Seat: Stainless steel.
  5. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
  6. Bucket: Brass or stainless steel.
  7. Strainer: Integral stainless-steel inlet strainer within the trap body.
  8. Air Vent: Stainless-steel thermostatic vent.
  9. Pressure Rating: 250 psig.

## **2.6 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS**

### **A. Thermostatic Air Vents:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a. Armstrong International, Inc.
  - b. Barnes & Jones, Inc.
  - c. Dunham-Bush, Inc.
  - d. Hoffman Specialty; Division of ITT Industries.
  - e. Spirax Sarco, Inc.
  - f. Sterling.
  - g. Prior approved equal.
2. Body: Cast iron, bronze or stainless steel.
3. End Connections: Threaded.
4. Float, Valve, and Seat: Stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
6. Pressure Rating: 125 psig.
7. Maximum Temperature Rating: 350 deg F.

## **PART 3 - EXECUTION**

### **3.1 LP STEAM PIPING APPLICATIONS**

- A. LP Steam Piping, NPS 2 and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
- B. LP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
- C. Condensate piping above grade, NPS 2 and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

D. Condensate piping above grade, NPS 2-1/2 and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

### **3.2 ANCILLARY PIPING APPLICATIONS**

A. Air-Vent Piping:

1. Inlet: Same as service where installed.
2. Outlet: Type K annealed-temper copper tubing with soldered or flared joints.

### **3.3 VALVE APPLICATIONS**

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

### **3.4 PIPING INSTALLATION**

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping at right angles and parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- C. Install piping to permit valve servicing.
- D. Install piping free of sags and bends.
- E. Install fittings for changes in direction and branch connections.
- F. Install piping to allow application of insulation.
- G. Select system components with pressure rating equal to or greater than system operating pressure.
- H. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- I. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

- J. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.
- K. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.
- L. Reduce pipe sizes using eccentric reducer fitting installed with level side down.
- M. Install branch connections to mains with the branch connected to top of main pipe.
- N. Install valves according to Division 15 Section "Valves."
- O. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- P. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- Q. Install strainers on supply side of control valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- R. Identify piping as specified in Division 15 Section "Mechanical Identification."
- S. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of control valves.

### **3.5 STEAM-TRAP INSTALLATION**

- A. Install steam traps in accessible locations as close as possible to connected equipment.
- B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

### **3.6 HANGERS AND SUPPORTS**

- A. Install hangers and supports according to Division 15 Section "Hangers and Supports." Comply with requirements below for maximum spacing.
- B. Seismic restraints are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."
- C. Install the following pipe attachments:
  - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.

2. Spring hangers to support vertical runs.
- D. Install hangers with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 9 feet; minimum rod size, 1/4 inch.
  2. NPS 1: Maximum span, 9 feet; minimum rod size, 1/4 inch.
  3. NPS 1-1/2: Maximum span, 12 feet; minimum rod size, 3/8 inch.
  4. NPS 2: Maximum span, 13 feet; minimum rod size, 3/8 inch.
  5. NPS 2-1/2: Maximum span, 14 feet; minimum rod size, 3/8 inch.
  6. NPS 3: Maximum span, 15 feet; minimum rod size, 3/8 inch.
  7. NPS 4: Maximum span, 17 feet; minimum rod size, 1/2 inch.

### **3.7 PIPE JOINT CONSTRUCTION**

- A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.
- B. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. 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.
- E. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

### **3.8 TERMINAL EQUIPMENT CONNECTIONS**

- A. Size for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install traps and control valves in accessible locations close to connected equipment.
- C. Install bypass piping with ball valve around control valve.

- D. Install vacuum breakers downstream from control valve, close to coil inlet connection.
- E. Install a drip leg at coil outlet.

### **3.9 FIELD QUALITY CONTROL**

- A. Prepare steam and condensate piping according to ASME B31.9, "Building Services Piping," and as follows:
  - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
  - 2. Flush new system with clean water. Clean strainers.
  - 3. 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.
- B. Perform the following tests on steam and condensate piping:
  - 1. Use ambient temperature water as a testing medium.
  - 2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any 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.
  - 3. After hydrostatic test pressure has been applied for at least 4 hours, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
- C. Prepare written report of testing.

END OF SECTION 15182

## **SECTION 15725 - MULTIZONE AIR-HANDLING UNITS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Provide the constant-air-volume packaged, multizone air-handling units scheduled and shown on the drawings. AH-1 will serve nine (9) zones and AH-2 will serve four (4) zones.

#### **1.3 PERFORMANCE REQUIREMENTS**

- A. Delegated Design: Design vibration isolation and seismic-restraint details.
- B. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of  $L/200$  where "L" is the unsupported span length within completed casings.

#### **1.4 SUBMITTALS**

- A. Product Data: For each multizone air-handling unit indicated.
  - 1. Unit dimensions and weight.
  - 2. Cabinet material, metal thickness, finishes, insulation, and accessories.
  - 3. Fans:
    - a. Certified fan-performance curves with system operating conditions indicated.
    - b. Certified fan-sound power ratings.
    - c. Fan construction and accessories.
    - d. Motor ratings, electrical characteristics, and motor accessories.
  - 4. Certified steam and chilled water coil-performance ratings with system operating conditions indicated.
  - 5. Dampers, including housings, linkages, and operators.
  - 6. Filters with performance characteristics.

7. Electrical requirements and diagrams.
8. Filter information.
9. Capacities, etc. shown on schedule.

## **1.5 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. Units with factory wiring shall be factory UL/ETL/CSA approved and labeled. Failure to comply with this requirement will necessitate the manufacturer, at his expense, to have a certified UL/ETL/CSA representative inspect the equipment prior to affixing a label.
- C. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of multi zone air-handling units and components.
- D. ARI Certification: Multi zone Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
- E. Fans shall conform to AMCA bulletins regarding testing and construction. Airfoil fans shall bear the AMCA certified rating seal for airflow and sound.
- F. Coils shall be ARI certified.
- G. Filter media shall be ULC listed.
- H. Comply with NFPA 70.

## **1.6 COORDINATION**

- A. Coordinate sizes and locations of existing removed units. Coordinate existing roof curbs with footprint of new units.

## **1.7 EXTRA MATERIALS**

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. Filters: One set for each air-handling unit.
  2. Fan Belts: One set for each air-handling unit fan.

**PART 2 - PRODUCTS**

**2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Trane.
  - 2. HAAKON
  - 3. Govern Aire
  - 4. Prior approved equal

**2.2 UNIT CASINGS**

- A. Walls and roofs shall be constructed of 16 gauge galvanized steel 2" thick acoustic thermal panels. The inner liner shall be 22 gauge washdown galvanized steel. Insulation shall be 2" thick 3 lb. density fiberglass with a neoprene liner to seal the insulation. All permanently joined flanged panel surfaces shall be sealed with an individual strip of 1/8" x 3/8" tape sealer. Wall and roof seams shall be turned inward to provide a clean flush exterior finish. All panel seams shall be sealed during assembly to produce an airtight unit.
- B. All panels shall be joined on 8" centers using cadmium plated TEK screws.
- C. All insulation edges shall be protected with metal lagging. Insulation systems using stickpins or adhesives are not acceptable.
- D. Stiffeners of angle steel shall be supplied as required to maintain casing deflection criteria of 1/200 at 1.5 times the working pressure. If panels cannot meet this deflection, an additional internal reinforcing shall be added.
- E. Acoustical Performance:
  - 1. The housing shall have been tested for acoustical performance by an accredited independent laboratory.
  - 2. Test methods and facilities used to establish sound transmission loss values shall conform explicitly with the ASTM designation E90-85 and E413-73.
  - 3. Sound Transmission Loss DB ASTM E-90 & E413-73

	1	2	3	4	5	6	7	8	
2" Walls	18	19	27	33	43	52	52	52	STC=37

- 4. Test methods and facilities used to establish sound absorption values shall conform explicitly with the requirements of the ASTM Standard Test Method for Sound Absorption Coefficients by the Reverberation Method: ASTM C423-84A and E795-83
- 5. Sound Absorption ASTM C423-84A & E795-83

1	2	3	4	5	6	7	8
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2" Walls .10 .23 . 75 1.08 1.05 .99 .97 .95 STC=37

6. The manufacturer shall submit the lab report for approval.

### 2.3 BASE CONSTRUCTION

- A. Units shall be constructed from structural steel C-channel around the perimeter of the unit with intermediate channel and angle iron supports. Units shall have a minimum 4" channel.
- B. A 12 gauge checker plate floor shall be installed on the base. The floor shall be flat, reinforced from below, with all seams continuously welded. Drive screw attachment and caulking are not acceptable. The base shall be provided with lifting lugs, a minimum of four (4) per unit section. The base shall be insulated with 2" fiberglass insulation and sheeted with a 22 gauge galvanized steel liner. Floors that "oil can" are not acceptable.
- C. The manufacturer shall provide a 1.5" perimeter collar around the entire unit and around each floor opening to ensure the unit is internally watertight. The entire base shall act as an auxiliary drain pan and hold up to 1.5" of water.
- D. The manufacturer shall provide auxiliary drains in fan sections downstream of cooling coils and in mixing sections.
- E. All drain connections shall terminate at the side of the unit.
- F. Maximum base deflection shall be ¼" on 240" unsupported span.

### 2.4 ACCESS DOORS

- A. Access doors shall be manufactured from 16 gauge galvanized steel. The doors shall be double wall construction with 22 gauge solid metal liner on the inside. Corners of the doors shall be continuously welded for rigidity. 2" 3 lb/cu ft. density insulation shall be sandwiched between the 16 gauge outer layer and the 22 gauge inner layer. Doors MUST be the same thickness as the unit casing to maximize thermal and acoustical resistance. A 12" round HERMETICALLY SEALED double glazed laminated glass window shall be provided in each door. Hinges shall be continuous piano type stainless steel.
- B. Two (2) "Ventlok" Model #310 high pressure latches operable from either side of the door shall be provided. The door opening shall be fully gasketed with continuous ½" closed cell hollow round black gasketing and a metal encapsulated reinforcing backing that mechanically fastens to the door frame. Door frames shall be made from 16 gauge galvanized steel with the outside of the door flush with the unit. Fan compartments must have a door of minimum width to remove the motor.
- C. All access doors must swing against the air pressure i.e. positive pressure plenum doors must swing in.

## **2.5 BELT DRIVEN FANS**

- A. Fans shall be airfoil as indicated in the schedules.
- B. All fans shall be tested in accordance with AMCA Standard 210-70 Test Code for Air Moving Devices. Fans shall bear the AMCA sticker.
- C. Fan housing shall be constructed of ¼" plate steel, adequately braced with structural steel for rigidity.
- D. Fan shafts shall be solid, ground and polished, carbon steel, SAE 1045 material, machined to close tolerances, keyed to the fan wheel. The fan shaft shall be coated with a rust inhibitor after machining. Hollow shafts will not be acceptable.
- E. Fan bearings shall be in a self aligning pillow block, grease lubricated, extra heavy duty anti-friction ball or spherical roller type, selected for an average life of L50 200,000 hours at design operating conditions. Bearings shall be mounted on the fan structural bracing. The manufacturer shall provide extended lubrication lines to permit lubrication for both bearings from the access door side of the air handling unit.
- F. The fan and motor shall be mounted on an all welded, structural steel, prime coated, internal isolation base with springs selected to provide 99% isolation efficiency from the building structure. The outlet of the fan shall be separated from the unit casing by means of a factory installed flexible fabric connection. The internally mounted motor shall be provided on a slide rail base to allow proper adjustment of belt tensions.
- G. The manufacturer shall provide OSHA approved fully enclosed metal belt guard sides of galvanized steel and an expanded metal face. The belt guard shall be sized to allow either sheave to be increased by two sizes.
- H. Fans shall have inlet OSHA approved inlet screens.

## **2.6 VIBRATION ISOLATION**

- A. An integral all welded steel vibration isolation base shall be provided for the fan and motor.
- B. Isolators shall be free standing with sound deadening pads and leveling bolts.
- C. The spring diameter to compressed operating height ratio shall be 1 to 1.
- D. The spring deflection shall be 4".
- E. Isolators shall have earthquake restraints.

## **2.7 MOTORS AND DRIVES**

- A. Fan motors shall be mounted and isolated on the same integral base as the fan.

- B. Fan motors shall be heavy duty. MOTORS SHALL MEET USA EPACT OF 1992.
- C. The v-belt drive shall have a variable pitch sheave for motors less than 7.5 hp and a constant pitch sheave for motors of 7.5 or greater hp rated at 1.2 times the motor nameplate.

## **2.8 COILS STEAM AND CHILLED WATER.**

- A. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Coils shall be mounted in the unit casing to be accessible for service. Capacities, pressure drops and selection procedure shall be certified in accordance with ARI Standard 410.
- B. Coils shall be fully enclosed within the casing and cooling coils shall be on mounted 304 stainless steel angle racks manufactured to allow coils to slide out individually. Heating coils shall be mounted on galvanized angle racks manufactured to allow coils to slide out individually.
- C. Removable coil access panels shall be provided for removal of coils through the casing wall. Coils shall be individually removable as shown on drawings. Coils must be individually racked, removable through the side access panels.
- D. The manufacturer shall provide drain pans for all cooling coils. Drain pans shall be continuously welded 304 stainless steel. The coil section must have intermediate drain pans and shall be interconnected with 1" stainless steel drain lines. Drain pans shall be IAQ sloped and fully drainable.
- E. Coils shall be designed for chilled water, and steam service.
- F. All pipe connections shall be on the same unit end, extended through the casing for ease of connection. See drawings for locations.
- G. Water coils handling mixed air, or direct outside air, shall be fully drainable by removing a single threaded plug for each coil row.
- H. The primary surface shall be round seamless 5/8" .020 O.D. 1/2" .046 O.D. copper tube on 1½" centers, staggered in the direction of airflow. All joints shall be brazed.
- I. The secondary surface shall consist of rippled copper plate fins for higher capacity and structural strength. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Bare copper tube shall not be visible between fins and the fins shall have no openings or holes which might accumulate lint and dirt. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates.
- J. The casings shall be constructed of continuous galvanized steel. Coil side plates shall be of reinforced flange type.

- K. The coil connection locations shall permit universal mounting of the coil for right or left hand airflow and have equal pressure drop through all circuits. Coils shall be circuited for counterflow heat transfer to provide the maximum mean effective temperature difference for maximum heat transfer rates.
- L. Headers on water coils shall be seamless copper tubing. The headers shall have intruded tube holes to provide a large brazing surface for maximum strength and inherent flexibility.
- M. The complete 5W coil core shall be factory tested with 315 pounds air pressure under warm water and be suitable for operation at 250 psig working pressures. Individual tube and core tests before installation of headers is not considered satisfactory. Hydrostatic tests alone will not be acceptable. Water cooling coils shall be circuited for drainability.

## **2.9 FILTERS**

- A. Filters shall be 2", pleated and disposable. Each filter shall consist of non-woven cotton and synthetic fabric media, media support grid and enclosing frame. The filters shall be listed by Underwriters' Laboratories as Class 2.
- B. Filters shall be installed in a prefabricated channel rack.
- C. Filters shall be lift-out where access is available upstream of the filter, or slide out when access is not available.

## **2.10 LIGHTS**

- A. Marine lights with a protective metal cage and glass seals, complete with duplex receptacles, shall be installed on the wall across from the access doors. A switch with an indicator light shall be installed on the unit. Electrical power shall be 120V/1/60.

## **2.11 FILTER GAUGES**

- A. The manufacturer shall provide Dwyer 2000 photohelic magnehelic gauges.
- B. Magnehelic gauges shall be accurate to  $\pm 2\%$  of full range.
- C. One gauge shall be provided for each filter bank.
- D. Gauges shall be recessed into the cabinet casing.

## **2.12 FINISH**

- A. The unit shall be finish painted with two components, etch bond primer and alkyd enamel. The color shall be selected by the Owner. All uncoated steel shall be painted with grey enamel. All metal surfaces shall be prepainted with vinyl wash primer to ensure paint bonds to metal. Units shall be finish coated with polyurethane paint.

## **2.13 LOUVERS**

- A. Louver blades of extruded aluminum construction shall be fixed on a 45° angle and on 4" centers.
- B. Frames shall be of extruded aluminum, minimum 4" wide.
- C. Birdscreen shall be galvanized mesh with 0.5" x 0.5" openings and shall be fixed to the rear with cadmium plated screws.
- D. The finish shall be natural mill finish.

## **2.14 ALUMINUM AIRFOIL DAMPERS**

- A. Aluminum airfoil frames and blades shall be a minimum of 12 gauge extruded aluminum. Blades shall be of a single unit airfoil design 6" wide.
- B. Frames shall be extruded aluminum channel with grooved inserts for vinyl seals. Standard frames shall be 2" x 4" x 5/8" on the linkage side, 1" x 4" x 1" on the other 3 sides.
- C. Pivot rods shall be 7/8" hexagon extruded aluminum interlocking into the blade section. Bearings shall be of a double sealed type with a Celcon inner bearing on a rod within a Polycarbonate outer bearing inserted into the frame to prevent the outer bearing from rotating.
- D. The bearing shall be designed so there are no metal-to-metal or metal-to-bearing riding surfaces. The interconnecting linkage shall have a separate Celcon bearing to eliminate friction inside the linkage.
- E. Blade linkage hardware shall be installed in a frame outside the airstream. All hardware shall be of non-corrosive, reinforced cadmium plated steel.
- F. Damper seals shall be designed for minimum air leakage by means of overlapping seals.
- G. Jack shaft assemblies shall be provided for multiple damper installations.

### **2.15 DAMPER OPERATORS**

- A. The ATC shall be electric damper operators. All linkage and hardware internally mounted, for each zone as shown on drawings. Coordinate with drawings and section 15900.
- B. The manufacturer shall ensure operators are mounted in easily accessible sections of the air handling units.

### **2.16 AIR FLOW TESTING**

- A. The unit manufacturer shall factory test each unit to ensure it meets the specified air flow requirements.
- B. The test shall be carried out in accordance with the guidelines set forth in the SMACNA HVAC AIR TEST MANUAL.
- C. An officer of the manufacturing company shall certify test results and forward copies of certified test results to the consultant.

### **2.17 AIR LEAKAGE TESTING**

- A. The unit manufacturer shall factory pressure test each air handling unit to ensure the leakage rate of the casing does not exceed 1.0% of the unit air flow at 1.5 times the rated static pressure. A leakage test shall be performed with VSD and humidifier panels installed.
- B. The test shall be conducted in accordance with SMACNA duct construction manual. A calibrated orifice shall be used to measure leakage airflow.
- C. An officer of the manufacturing company shall certify test results and forward copies of the certified test results to the consultant.
- D. Positive pressure plenums shall be tested positively and negative pressure plenums shall be tested negatively.

### **2.18 SOUND TESTING**

- A. Air handling unit sound power levels shall not exceed the levels shown on the schedule.
- B. The manufacturer shall furnish sound power levels at the supply air connection, return air connection, outside air opening, relief air openings and casing radiation for each air handling unit. Test data shall show sound power levels re  $10^{-12}$  watts for each of eight octave band center frequencies.

## **2.19 FLOOD TESTING**

- A. All unit bases shall be flooded to a level of 1.5" after manufacturing to assure there is no leakage through the floor and the perimeter water barrier. The results of the flood test shall be certified by the manufacturer.

## **2.20 FIELD ASSEMBLED AIR-HANDLING UNIT (IF REQUIRED DUE TO SIZE)**

- A. Coordinate shipping breaks with Mechanical Contractor and existing conditions.
- B. The air handling unit shall be field assembled on site by the contractor. All parts shall be pre-formed by the manufacturer and partially assembled where on site access is possible. The parts shall be labeled according to an assembly drawing. All assembly material required such as insulation, sealants, fasteners and hardware shall be supplied by the manufacturer as part of the kit.
- C. Where on site access permits, sections of the exterior casing shall be pre-assembled in the factory. Otherwise, casing panels shall be shipped individually.
- D. The unit base shall be made in factory-assembled sections with joining flanges for field assembly. The base sections shall be factory pre-painted and pre-insulated.
- E. The doors and frames shall be pre-assembled complete with windows where specified.
- F. Where on site access permits, the coil and filter racks shall be factory pre-assembled and pre-painted.
- G. The fan shall be assembled in the factory complete with motor, protective screening, belt guards and isolation base. The fan and guarding shall be factory pre-painted. The fan assembly shall undergo a test run in the factory. Where on site access permits, the fan assembly shall be shipped in one piece. If on site access does not permit shipping in one piece, the fan shall be disassembled and shipped in pieces.
- H. The manufacturer shall supply a representative to supervise assembly of the air handling unit on the job site.
- I. The coils shall be installed on site by the contractor.
- J. The electrical panels shall be factory pre-assembled and pre-tested. The manufacturer shall provide all necessary conduits and fittings to extend the motor wiring to the electrical panel.
- K. The air handling unit manufacturer shall provide marine light fixtures, duplex receptacles, the light switch and the necessary conduit and fittings for field installation of the fixtures.
- L. All factory and field wiring and assembly shall be done in accordance with the N.E.C.

- M. The contractor shall be responsible for obtaining electrical approval of the final assembly.

## **2.21 ELECTRICAL**

- A. The manufacturer shall factory wire, test, and have the air handling units approved by UL.
- B. The manufacturer shall supply one (1) single point power connection for each unit. The manufacturer shall wire all 120 V/208V/60 Hz/1 Ph components such as lights, convenience outlet, controls, heaters, etc. from a panel with circuit breakers for each type of electric device. The panel for 120 V/208 V/60 Hz/3 Ph is fed from a separate service.
- C. The manufacturer shall label and number code all wiring and electrical devices in accordance with the unit electrical diagram. The manufacturer shall mount the devices in a control panel inside the unit's service enclosure or on the outside and ensure the control panel meets the UL.
- D. The manufacturer shall provide a system of motor control including all necessary terminal blocks, motor contactors, motor overload protection, grounding lugs, auxiliary contactors and terminals for the connection of external control devices or relays. The manufacturer shall individually fuse all fan and branch circuits.
- E. The manufacturer shall provide wiring from the motors to the motor control in accordance with UL and contained by EMT conduit with liquid tight connections. The manufacturer shall seal the casing penetrations in a manner that eliminates air leaks.

## **2.22 FACTORY MOUNTED CONTROLS**

- A. The manufacturer shall furnish all material required for direct digital control of components specified. All components shall be installed in EMT conduit with liquid tight fittings. Electrical interlock wiring of field devices e.g. flow switches, thermostats is the responsibility of the contractor.
- B. The manufacturer shall supply and install safety controls. Safety control transmitters shall be located at the sensor and output 0-10 vdc shall terminate on a numbered terminal strip in the main electrical panel. The manufacturer shall provide the following safety controls:
  - 1. Freeze protection thermostat -- one freeze stat for each 20 square feet of coil surface to be protected.
  - 2. Differential pressure switch -- one differential pressure switch for each bank of filters and one differential pressure switch for each fan.
  - 3. Differential pressure control -- a manual reset differential pressure control in the fan discharge plenum and one in the mixing plenum for over pressure protection.

## **2.23 TEST PORTS**

- A. The manufacturer shall provide Duro Dyne IP-4 test ports for unit air stream testing in each plenum section between each component within the AHU.

## **2.24 DRAINS**

- A. The manufacturer shall provide 1" capped floor drain connections on the side of the unit for complete drainability of the base pan for the following sections:
  - 1. Fresh air plenums
  - 2. Humidifier sections
  - 3. Service corridors
  - 4. Fan sections
  - 5. Sections upstream and downstream of coils
  - 6. All sections if unit has washdown liner

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for chilled water, steam and condensate and drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Equipment Mounting: Install air-handling units on existing curbs using spring isolators or pads if units are internally spring isolated. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
  - 1. Minimum Deflection: 1/4 inch.
- B. Arrange installation of units as shown on the drawings.

- C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
- D. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- E. Install housing complete with doors, roof, lights and side as shown on the drawings. Housing shall be manufactured by unit manufacturer.

### **3.3 CONNECTIONS**

- A. Comply with requirements for piping specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to air-handling unit to allow service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using unit drain size, ASTM B 88, Type M copper tubing. Extend to nearest floor drain.
- E. Steam and Chilled-Water Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping" and "Steam Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection. See details on drawings.
- F. Connect duct to air-handling units with flexible connections. Comply with requirements in Division 15 Section "Duct Accessories" and locations on drawings.

### **3.4 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. Tests and Inspections:
  - 1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks.
  - 2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

- C. Air-handling units or components will be considered defective if unit or components do not pass tests and inspections.
- D. Prepare test and inspection reports.

### **3.5 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. Verify that shipping, blocking, and bracing are removed.
  - 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
  - 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
  - 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
  - 6. Verify that zone dampers fully open and close for each zone.
  - 7. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
  - 8. Comb coil fins for parallel orientation.
  - 9. Install new, clean filters.
  - 10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures for air-handling units include the following:
  - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
  - 2. Measure and record motor electrical values for voltage and amperage.
  - 3. Manually operate dampers from fully closed to fully open position and record fan performance.

### **3.6 ADJUSTING**

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Division 15 Section "Testing, Adjusting, and Balancing" for air-handling system testing, adjusting, and balancing.

### **3.7 CLEANING**

- A. After startup service, clean air-handling units externally and internally on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.
- B. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, clean filter housings and install new, clean filters.
- C. Replace filters immediately prior to occupancy.

### **3.8 DEMONSTRATION**

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.
- B. Schedule the time so the factory-authorized representative only has to come to the site once to provide start-up services, checks, adjustments, and training.

END OF SECTION 15725

## **SECTION 15815 - METAL DUCTS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. The only ductwork required is between the existing zone ducts and multi zone units and the return air duct and multi zone unit.
- B. Section Includes:
  - 1. Single-wall rectangular ducts and fittings from existing zone ducts to new multi zone units.
  - 2. Sheet metal materials.
  - 3. Duct liner.
  - 4. Sealants and gaskets.
  - 5. Seismic-restraint devices.
  - 6. Verify the location and routing of ductwork (if required) between existing ductwork and new multi zone units.
- C. Related Sections:
  - 1. Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing requirements for metal 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.
  - 1. Static-Pressure Classes:
    - a. Supply Ducts: 2-inch wg.
    - b. Return Ducts (Negative Pressure): 1-inch wg.
  - 2. Leakage Class:
    - a. Rectangular Supply-Air Duct: 6 cfm/100 sq. ft. at 1-inch wg.

- B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

#### **1.4 SUBMITTALS**

- A. Product Data: For each type of the following products:
  - 1. Liners and adhesives.
  - 2. Sealants and gaskets.
  - 3. Seismic-restraint devices.
- B. Welding certificates.
- C. Field quality-control reports.

### **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 1-4, "Transverse (Girth) 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 1-5, "Longitudinal Seams - Rectangular Ducts," 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 2, "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 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  - 1. Galvanized Coating Designation: G60.
- C. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

## 2.3 DUCT LINER

- A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a. CertainTeed Corporation; Insulation Group.
    - b. Johns Manville.
    - c. Knauf Insulation.
    - d. Owens Corning.
    - e. Prior approved equal.
    - f. Maximum Thermal Conductivity:
      - 1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
      - 2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
  - 2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
  - 3. Solvent-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
- B. Insulation Pins and Washers:
  - 1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."
1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
  2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
  3. Butt transverse joints without gaps, and coat joint with adhesive.
  4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
  5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
  6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
  7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
  8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
    - a. Fan discharges.
    - b. Intervals of lined duct preceding unlined duct.
    - c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

## 2.4 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
  2. Solids Content: Minimum 65 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, positive and negative.
  8. Service: Indoor or outdoor.

9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

## 2.5 HANGERS AND SUPPORTS: IF REQUIRED

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 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "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.

## 2.6 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Ductmate Industries, Inc.
3. Hilti Corp.
4. Kinetics Noise Control.
5. Loos & Co.; Cableware Division.
6. Mason Industries.

7. TOLCO; a brand of NIBCO INC.
  8. Unistrut Corporation; Tyco International, Ltd.
  9. Prior approved equal.
- B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
- D. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
- E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

### **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 " unless otherwise indicated.
- C. Install ducts with fewest possible joints.
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for zone connections.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

- G. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

### **3.2 SEAM AND JOINT SEALING**

- A. Seal duct seams and joints for duct static-pressure and leakage classes specified in "Performance Requirements" Article, according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements," unless otherwise indicated.
  - 1. For static-pressure classes 1- and 1/2-inch wg, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class C, except as follows:
    - a. Ducts that are located directly in zones they serve.

### **3.3 CONNECTIONS**

- A. Make connections to new multizone units equipment with flexible connectors complying with Division 15 Section "Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for connections.

### **3.4 FIELD QUALITY CONTROL**

- A. Perform tests and inspections.
- B. Leakage Tests:
  - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual."
  - 2. Test the following systems:
    - a. Supply air.
  - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
  - 4. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
- C. Duct system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

**3.5 DUCT CLEANING**

- A. Clean new duct system(s) before testing, adjusting, and balancing.

END OF SECTION 15815

## **SECTION 15820 - DUCT ACCESSORIES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Motorized control dampers.
  - 2. Flexible connectors.
- B. Related Sections include the following:
  - 1. Division 15 Section "HVAC Instrumentation and Controls" for electric and damper actuators.

#### **1.3 SUBMITTALS**

- A. Product Data: For the following:
  - 1. Motorized control dampers.
  - 2. Flexible connectors.

#### **1.4 QUALITY ASSURANCE**

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

### **PART 2 - PRODUCTS**

#### **2.1 MANUFACTURERS**

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

## **2.2 SHEET METAL MATERIALS**

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G60 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

## **2.3 MOTORIZED CONTROL DAMPERS**

- A. Manufacturers:
  - 1. Air Balance, Inc.
  - 2. American Warming and Ventilating.
  - 3. CESCO Products.
  - 4. Duro Dyne Corp.
  - 5. Greenheck.
  - 6. McGill AirFlow Corporation.
  - 7. METALAIR, Inc.
  - 8. Nailor Industries Inc.
  - 9. Penn Ventilation Company, Inc.
  - 10. Ruskin Company.
  - 11. Air Rite.
  - 12. Prior approved equal.
- B. General Description: Zone automatic dampers if not part of multi zone unit package. AMCA-rated, opposed-blade design; minimum of 0.1084-inch- thick, galvanized-steel frames with holes for duct mounting; minimum of 0.0635-inch- thick, galvanized-steel damper blades with maximum blade width of 8 inches.
  - 1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
  - 2. Operating Temperature Range: From minus 40 to plus 200 deg F.
  - 3. Provide closed-cell neoprene edging.

## **2.4 FLEXIBLE CONNECTORS**

- A. Manufacturers:
  - 1. Ductmate Industries, Inc.
  - 2. Duro Dyne Corp.
  - 3. Ventfabrics, Inc.
  - 4. Ward Industries, Inc.
  - 5. Prior approved equal.

- B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Select metal compatible with ducts.
- D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
  - 1. Minimum Weight: 26 oz./sq. yd..
  - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
  - 3. Service Temperature: Minus 40 to plus 200 deg F.
- E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
  - 1. Minimum Weight: 24 oz./sq. yd..
  - 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
  - 3. Service Temperature: Minus 50 to plus 250 deg F.

### **PART 3 - EXECUTION**

#### **3.1 APPLICATION AND INSTALLATION**

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.
- B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel.
- C. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
- D. Install duct test holes required for testing and balancing purposes.

#### **3.2 ADJUSTING**

- A. Adjust duct accessories for proper settings.
- B. Final positioning of manual-volume dampers is specified in Division 15 Section "Testing, Adjusting, and Balancing."

END OF SECTION 15820

## **SECTION 15900 - HVAC INSTRUMENTATION AND CONTROLS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes the phasing of the existing control system to electronics in the mechanical penthouse. This section includes control equipment for new AH-1 and AH-2 systems and components, including control components for heating and cooling.
- B. Control contractor shall provide the following scope of work:
  - 1. Change over the two new multizone units from the existing building pneumatics to an electronic DDC system.
  - 2. Control parts, equipment etc. were sold to SUU for their installation. This control's contractor shall receive the items for this portion from SUU and install as required.
  - 3. Any additional parts, equipment etc. required shall be purchased and installed by controls contractor. Controls contractor shall take inventory of all control items stored at SUU and insure that control items are in good working order, and are not outdated.
  - 4. Controls contractor shall provide all new electronic steam and chilled water control valves as shown on the drawings.
  - 5. Controls contractor shall provide all 13 zone controls operators on zone dampers provided by air handler manufacturer.
  - 6. Controls contractor shall replace all pneumatic thermostats with electronic sensors.
  - 7. Controls contractor shall update graphics at the head-end.
  - 8. This building is a Yamas system and all the parts are Yamas.

#### **1.3 SYSTEM PERFORMANCE**

- A. Comply with the following performance requirements:
  - 1. Graphic Refresh: Update and complete graphics with current data within 8 seconds.

## 1.4 SUBMITTALS

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number.
  2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
  3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions method of field assembly, components, and location and size of each field connection.
1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
  2. Schematic flow diagrams showing fans, coils, dampers, valves, and control devices.
  3. Wiring Diagrams: Power, signal, and control wiring.
  4. Written description of sequence of operation.
  5. Schedule of valves including flow characteristics.
  6. DDC System Hardware:
    - a. Wiring diagrams for control units with termination numbers.
    - b. Schematic diagrams and floor plans for field sensors and control hardware.
    - c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
  7. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
  8. Controlled Systems:
    - a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    - b. Written description of sequence of operation including schematic diagram.
    - c. Points list.
- C. Qualification Data: For Installer.
- D. Operation and Maintenance Data: For HVAC instrumentation and control system to include in operation, and maintenance manuals. In addition to items specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

## **1.5 QUALITY ASSURANCE**

- A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with ASHRAE 135 for DDC system components.

## **1.6 DELIVERY, STORAGE, AND HANDLING**

- A. System Software: Update to latest version of software at Project completion.

## **1.7 COORDINATION**

- A. Coordinate location of sensors and other exposed control sensors with plans before installation.
- B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.
- C. Coordinate equipment with Division 16 Section "Electrical Power Monitoring and Control" to achieve compatibility of communication interfaces.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

## **2.2 CONTROL SYSTEM**

- A. Manufacturers:
  - 1. Yamas or prior approved equal.
- B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control the new mechanical systems.

## **2.3 DDC EQUIPMENT**

- A. See Part 1 General 1.2 for scope.

## **2.4 ELECTRONIC SENSORS**

- A. Description: Vibration and corrosion resistant; for wall, immersion, Sensors were purchased. See General - Part 1 - Summary 1.2.

## **2.5 ACTUATORS**

- A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
  - 1. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
  - 2. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
  - 3. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
- B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
  - 1. Manufacturers:
    - a. Belimo Aircontrols (USA), Inc.
    - b. Prior approved equal.
  - 2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
  - 3. Dampers: Size for running torque calculated as follows:
    - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
    - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.

4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Actuator Housing: Molded or die-cast zinc or aluminum.

## 2.6 CONTROL VALVES

### A. Manufacturers:

1. Danfoss Inc.; Air Conditioning & Refrigeration Div.
2. Erie Controls.
3. Hayward Industrial Products, Inc.
4. Magnatrol Valve Corporation.
5. Neles-Jamesbury.
6. Parker Hannifin Corporation; Skinner Valve Division.
7. Pneuline Controls.
8. Sauter Controls Corporation.
9. Prior approved equal.

### B. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

### C. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
  - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
  - b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
4. Sizing: 3-psig maximum pressure drop at design flow rate or the following:
  - a. Two Position: Line size.
  - b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
  - c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

D. Steam system globe valves shall have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel seats.
  - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
  - b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
4. Sizing: For pressure drop based on the following services:
  - a. Two Position: 20 percent of inlet pressure.
  - b. Modulating 15-psig Steam: 80 percent of inlet steam pressure.
5. Flow Characteristics: Modified linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of operating (inlet) pressure.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Verify that power supply is available to control units and operator workstation.

### **3.2 INSTALLATION**

- A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- B. Connect and configure equipment and software to achieve sequence of operation specified.
- C. Verify location of sensors and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.

- D. Install zone damper motors in the air handling units. On outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- E. Install labels and nameplates to identify control components according to Division 15 Section "Mechanical Identification."
- F. Install hydronic instrument wells, valves, and other accessories according to Division 15 Section "Hydronic Piping."
- G. Install steam and condensate instrument wells, valves, and other accessories according to Division 15 Section "Steam and Condensate Piping."

### **3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION**

- A. Install raceways, boxes, and cabinets according to Division 16 Section "Raceways and Boxes."
- B. Install building wire and cable according to Division 16 Section "Conductors and Cables."

### **3.4 FIELD QUALITY CONTROL**

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
  - 2. Test and adjust controls and safeties.
  - 3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
  - 4. Test each point through its full operating range to verify that safety and operating control set points are as required.
  - 5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
  - 6. Test each system for compliance with sequence of operation.
  - 7. Test software and hardware interlocks.
- C. DDC Verification:
  - 1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
  - 2. Check instruments for proper location and accessibility.
  - 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

4. Check temperature instruments and material and length of sensing elements.
  5. Check control valves. Verify that they are in correct direction.
  6. Check DDC system as follows:
    - a. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    - b. Verify that spare I/O capacity has been provided.
    - c. Verify that DDC controllers are protected from power supply surges.
- D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

### 3.5 ADJUSTING

- A. Calibrating and Adjusting:
1. Calibrate instruments.
  2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
  3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
  4. Control System Inputs and Outputs:
    - a. Check analog inputs at 0, 50, and 100 percent of span.
    - b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    - c. Check digital inputs using jumper wire.
    - d. Check digital outputs using ohmmeter to test for contact making or breaking.
    - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
  5. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
  6. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
  7. Provide diagnostic and test instruments for calibration and adjustment of system.
  8. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
- B. Adjust initial temperature set points.

- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

### **3.6 DEMONSTRATION**

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

END OF SECTION 15900

## **SECTION 15940 - SEQUENCE OF OPERATION**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes control sequences for the new multizone air handling units, chilled water coil and steam heating coils.
- B. Related Sections include the following:
  - 1. Division 15 Section "HVAC Instrumentation and Controls" for control equipment and devices and for submittal requirements.

#### **1.3 DEFINITIONS**

- A. DDC: Direct digital control.

#### **1.4 AIR-HANDLING-UNIT CONTROL SEQUENCES**

- A. Start and Stop Supply Fan:
  - 1. Enable: Freeze Protection:
    - a. Input Device: Duct-mounted averaging element thermostat, located before supply fan.
    - b. Output Device: Hard wired through motor starter; DDC system alarm.
    - c. Action: Allow start if duct temperature is above 37 deg F; signal alarm if fan fails to start as commanded.
  - 2. Enable: High-Temperature Protection:
    - a. Input Device: Duct-mounted thermostat, located in return air.
    - b. Output Device: Hard wired through motor starter; DDC system alarm.
    - c. Action: Allow start if duct temperature is below 300 deg F.
  - 3. Enable: Smoke Control:
    - a. Input Device: Duct-mounted smoke detector, located in return air.
    - b. Output Device: Hard wired through motor starter; DDC system alarm.

- c. Action: Allow start if duct is free of products of combustion.
  - 4. Initiate: Occupied Time Schedule:
    - a. Input Device: DDC system time schedule.
    - b. Output Device: Binary output to motor starter.
    - c. Action: Energize fan.
  - 5. Initiate: Unoccupied Time Schedule:
    - a. Input Device: DDC system demand.
    - b. Output Device: Binary output to motor starter.
    - c. Action: Energize fan.
  - 6. Unoccupied Ventilation:
    - a. Input Device: DDC system time schedule and output.
    - b. Output Device: DDC system binary output to motor starter.
    - c. Action: Cycle fan during unoccupied periods.
  - 7. Display: Supply-fan on-off indication.
- B. Supply Fan:
  - 1. Occupied Time Schedule:
    - a. Input Device: DDC system time schedule.
    - b. Output Device: Binary output.
    - c. Action: Enable control.
  - 2. High Pressure:
    - a. Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
    - b. Output Device: DDC system binary output to alarm panel motor starter.
    - c. Action: Stop fan and signal alarm when static pressure rises above excessive-static-pressure set point.
  - 3. Display:
    - a. Supply-fan-discharge static-pressure indication.
    - b. Supply-fan-discharge static-pressure set point.
    - c. Supply-fan airflow rate.
- C. Mixed-Air Control:
  - 1. Occupied Time Schedule:
    - a. Input Device: DDC system time schedule.
    - b. Output Device: DDC system output.

- c. Action: Enable control.
2. Minimum Position:
  - a. Input Device: DDC system time schedule.
  - b. Output Device: DDC system analog output to modulating damper actuator.
  - c. Action: Open outdoor-air dampers to minimum position.
3. Heating Reset:
  - a. Input Device: DDC system software.
  - b. Output Device: DDC system analog output to modulating damper actuator.
  - c. Action: Set outdoor-air dampers to minimum position.
4. Mixed-Air Temperature:
  - a. Input Device: Electronic temperature sensor.
  - b. Output Device: DDC system analog output to modulating damper actuator.
  - c. Action: Modulate outdoor-, return-, and relief-air dampers to maintain mixed air temperature set point of 55 deg F.
5. Cooling Reset:
  - a. Input Device: Outdoor- and return-air, duct-mounted electronic temperature sensors.
  - b. Output Device: DDC system analog output to damper actuator.
  - c. Action: Set outdoor-air dampers to minimum position when outdoor-air temperature exceeds return-air temperature.
6. Unoccupied Time Schedule:
  - a. Input Device: DDC system time schedule.
  - b. Output Device: DDC system analog output to modulating damper actuator.
  - c. Action: Position outdoor- and relief-air dampers closed and return-air dampers open.
7. Display:
  - a. Mixed-air-temperature indication.
  - b. Mixed-air-temperature set point.
  - c. Mixed-air damper position.
- D. Filters: During occupied periods, when fan is running, differential air-pressure transmitters exist.
  1. Occupied Time Schedule:
    - a. Input Device: DDC system time schedule.
    - b. Output Device: DDC system output.
    - c. Action: Enable control.

2. Differential Pressure:
    - a. Input Device: Differential-pressure switches.
    - b. Output Device: DDC system alarm.
    - c. Action: Signal alarm on low- and high-pressure conditions.
  3. Display:
    - a. Filter air-pressure-drop indication.
    - b. Filter low-air-pressure set point.
    - c. Filter high-air-pressure set point.
- E. Steam Heating Coil:
1. Occupied Time Schedule:
    - a. Input Device: DDC system time schedule.
    - b. Output Device: Binary output.
    - c. Action: Enable control.
  2. Supply-Air Temperature:
    - a. Input Device: Electronic temperature sensor.
    - b. Output Device: Normally open modulating control valve.
    - c. Action: Maintain supply-air temperature set point of 55 deg F (adjustable).
  3. Temperature Reset:
    - a. Input Device: DDC system with input from room temperature sensors.
    - b. Output Device: DDC system.
    - c. Action: Reset supply-air temperature in response to greatest heating demand.
  4. Unoccupied Time Schedule:
    - a. Input Device: DDC system time schedule and output.
    - b. Output Device: DDC system binary output.
    - c. Action: Enable normal control when fan is cycled on.
  5. Display:
    - a. Fan-discharge air-temperature indication.
    - b. Fan-discharge air-temperature set point.
    - c. Heating-coil air-temperature indication.
    - d. Heating-coil air-temperature set point.
    - e. Heating-coil pump operation indication.
    - f. Heating-coil control-valve position.
    - g. Hot-deck air-temperature indication.
    - h. Hot-deck air-temperature set point.

F. Hydronic Cooling Coil:

1. Occupied Time Schedule:
  - a. Input Device: DDC system time schedule.
  - b. Output Device: Binary output.
  - c. Action: Enable control.
2. Supply-Air Temperature:
  - a. Input Device: Electronic temperature sensor.
  - b. Output Device: Normally open modulating control valve.
  - c. Action: Maintain supply-air temperature set point of 55 deg F (adjustable).
3. Temperature Reset:
  - a. Input Device: DDC system with input from room temperature sensors.
  - b. Output Device: DDC system.
  - c. Action: Reset supply-air temperature in response to greatest heating demand.
4. Unoccupied Time Schedule:
  - a. Input Device: DDC system time schedule.
  - b. Output Device: Binary output.
  - c. Action: Disable control.
5. Display:
  - a. Fan-discharge air-temperature indication.
  - b. Fan-discharge air-temperature set point.
  - c. Cooling-coil air-temperature indication.
  - d. Cooling-coil air-temperature set point.
  - e. Cooling-coil control-valve position.
  - f. Cold-deck air-temperature indication.
  - g. Cold-deck air-temperature set point.

G. Multizone Damper Control:

1. Occupied Time Schedule:
  - a. Input Device: DDC system time schedule.
  - b. Output Device: Binary output.
  - c. Action: Enable control.
2. Room Temperature:
  - a. Input Device: Electronic temperature sensor.
  - b. Output Device: Damper actuator.
  - c. Action: Maintain room temperature.

3. Display:
  - a. Room temperature indication.
  - b. Room temperature set point.
  - c. Multizone damper position.
  
- H. Coordination of Air-Handling Unit Sequences: Ensure that mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.
  
- I. Operator Station Display: Indicate the following on operator workstation display terminal:
  1. DDC system graphic.
  2. DDC system on-off indication.
  3. DDC system occupied/unoccupied mode.
  4. Outdoor-air-temperature indication.
  5. Supply-fan on-off indication.
  6. Supply-fan-discharge static-pressure indication.
  7. Supply-fan-discharge static-pressure set point.
  8. Supply-fan airflow rate.
  9. Building static-pressure indication.
  10. Building static-pressure set point.
  11. Mixed-air-temperature indication.
  12. Mixed-air-temperature set point.
  13. Mixed-air damper position.
  14. Filter air-pressure-drop indication.
  15. Filter low-air-pressure set point.
  16. Filter high-air-pressure set point.
  17. Fan-discharge air-temperature indication.
  18. Fan-discharge air-temperature set point.
  19. Heating-coil air-temperature indication.
  20. Heating-coil air-temperature set point.
  21. Heating-coil pump operation indication.
  22. Heating-coil control-valve position.
  23. Hot-deck air-temperature indication.
  24. Hot-deck air-temperature set point.
  25. Cooling-coil air-temperature indication.
  26. Cooling-coil air-temperature set point.
  27. Cooling-coil control-valve position.
  28. Cold-deck air-temperature indication.
  29. Cold-deck air-temperature set point.
  30. Room temperature indication.
  31. Room temperature set point.
  32. Multizone damper position.

**PART 2 - PRODUCTS (Not Applicable)**

**PART 3 - EXECUTION (Not Applicable)**

END OF SECTION 15940

## **SECTION 15950 - TESTING, ADJUSTING, AND BALANCING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes TAB to produce design objectives for the following:
  - 1. Air Systems:
    - a. Multizone systems.
  - 2. Hydronic Piping Systems:
    - a. Constant-flow chilled water system to multizone units.
  - 3. Steam system.
  - 4. Existing systems TAB.
  - 5. Verifying that automatic control devices, both existing and new, are functioning properly.
  - 6. Reporting results of activities and procedures specified in this Section.

#### **1.3 DEFINITIONS**

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.
- C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.
- D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
- E. NC: Noise criteria.

- F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- G. RC: Room criteria.
- H. Report Forms: Test data sheets for recording test data in logical order.
- I. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- J. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
- K. TAB: Testing, adjusting, and balancing.
- L. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- M. Test: A procedure to determine quantitative performance of systems or equipment.
- N. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

#### **1.4 SUBMITTALS**

- A. Qualification Data: Within 15 days from Contractor's Notice to Proceed, submit 4 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Sample Report Forms: Submit two sets of sample TAB report forms.

#### **1.5 QUALITY ASSURANCE**

- A. TAB Firm Qualifications: Engage a TAB firm certified by AABC or NEBB.
- B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
  - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
  - 2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.
- C. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

- D. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."
- E. Instrumentation Calibration: Calibrate TAB instruments at least every six months or more frequently if required by instrument manufacturer.
  - 1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.
- F. Approved TAB agencies:
  - 1. Bonneville Test and Balance.
  - 2. BTC Services.
  - 3. Certified Test and Balance.
  - 4. Danis Test and Balance.
  - 5. Intermountain Test and Balance.
  - 6. RS Analysis.
  - 7. Technical Specialties.
  - 8. Testing and Balancing, Inc.

## **1.6 PROJECT CONDITIONS**

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

## **1.7 COORDINATION**

- A. Coordinate the efforts of factory-authorized service representatives for equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- C. 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.
  - 1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
  - 2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, manual and auto volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine Project Record Documents described in Division 1 Section "Project Record Documents."
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data including fan curves. 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. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.
- F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- G. Examine system and equipment test reports.
- H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, manual and auto volume dampers, are properly installed,

and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

- I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine strainers for clean screens and proper 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 equipment for installation and for properly operating safety interlocks and controls.
- O. Examine automatic temperature system components to verify the following:
  - 1. Dampers, valves, and other controlled devices are operated by the intended controller.
  - 2. Dampers and valves are in the position indicated by the controller.
  - 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units.
  - 4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
  - 5. Thermostats are located to avoid adverse effects of sunlight, drafts, and cold walls.
  - 6. Sensors are located to sense only the intended conditions.
  - 7. Sequence of operation for control modes is according to the Contract Documents.
  - 8. Controller set points are set at indicated values.
  - 9. Interlocked systems are operating.
  - 10. Changeover from heating to cooling mode occurs according to indicated values.
- P. 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 strategies and step-by-step procedures.
- B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Chilled water system is filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Isolating and balancing valves are open and control valves are operational.
6. Windows and doors can be closed so indicated conditions for system operations can be met.

### **3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING**

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
- B. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.
- C. 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. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- C. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- D. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- E. Verify that motor starters are equipped with properly sized thermal protection.
- F. Check dampers for proper position to achieve desired airflow path.
- G. Check for airflow blockages.
- H. Check condensate drains for proper connections and functioning.
- I. Check for proper sealing of air-handling unit components.
- J. Check for proper sealing of air duct system.

### **3.5 PROCEDURES FOR MULTIZONE SYSTEMS**

- A. Set units at full flow through the cooling coil if coil has that capacity.
- B. Adjust each zone damper to indicated airflow.

### **3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS**

- A. Prepare test reports with pertinent design data and number in sequence.
- B. Prepare chilled water system 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 flow-control valves for specified sequence of operation and set at indicated flow.
  - 3. Set system controls so automatic valves are wide open.
  - 4. Check air vents for a forceful liquid flow exiting from vents when manually operated.

### **3.7 PROCEDURES FOR HYDRONIC SYSTEMS**

- A. Measure water flow at existing chilled water pumps. Use the following procedures:
  - 1. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights.
  - 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.
  - 3. Report flow rates that are not within plus or minus 5 percent of design.
- B. Set calibrated balancing valves at cooling coils at calculated presettings.
- C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
- D. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- E. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

### **3.8 PROCEDURES FOR STEAM SYSTEMS**

- A. Measure and record upstream and downstream pressure of each steam coil.

- B. Check the setting and operation of automatic temperature-control valves. Record the final setting.
- C. 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, model, and serial numbers.
  - 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.

### **3.10 PROCEDURES FOR HEAT-TRANSFER COILS**

- A. Water Coils: Measure the following data for each chilled water coil:
  - 1. Entering- and leaving-water temperature.
  - 2. Water flow rate.
  - 3. Water pressure drop.
  - 4. Dry-bulb temperature of entering and leaving air.
  - 5. Wet-bulb temperature of entering and leaving air for cooling coils.
  - 6. Airflow.
  - 7. Air pressure drop.
- B. Steam Coils: Measure the following data for each coil:
  - 1. Dry-bulb temperature of entering and leaving air.
  - 2. Airflow.
  - 3. Air pressure drop.
  - 4. Inlet steam pressure.

### **3.11 PROCEDURES FOR TEMPERATURE MEASUREMENTS**

- A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
- B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
- C. Measure outside-air, wet- and dry-bulb temperatures.

### **3.12 TEMPERATURE-CONTROL VERIFICATION**

- A. Verify that controllers are calibrated and commissioned.
- B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

### **3.13 TOLERANCES**

- A. Set HVAC system airflow and water flow rates within the following tolerances:
  - 1. Supply, Return, and Equipment with Fans: Plus 5 to plus 10 percent.
  - 2. Air Outlets and Inlets: 0 to minus 10 percent.
  - 3. Cooling-Water Flow Rate: 0 to minus 5 percent.

### **3.14 FINAL REPORT**

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
  - 1. Include a list of instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to certified field report data, include the following:
  - 1. Fan curves.
  - 2. Manufacturers' test data.
  - 3. Field test reports prepared by system and equipment installers.
  - 4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.
- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
  - 1. Title page.
  - 2. Name and address of TAB firm.
  - 3. Project name.
  - 4. Project location.
  - 5. Engineer's name and address.
  - 6. Contractor's name and address.
  - 7. Report date.
  - 8. Signature of TAB firm who certifies the report.
  - 9. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
  - 10. 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.
11. Nomenclature sheets for each item of equipment.
  12. Notes to explain why certain final data in the body of reports varies from indicated values.
  13. Test conditions for fans performance forms including the following:
    - a. Settings for outside-, return-, and exhaust-air dampers.
    - b. Conditions of filters.
    - c. Cooling coil, wet- and dry-bulb conditions.
    - d. Fan drive settings including settings and percentage of maximum pitch diameter.
    - e. Settings for supply-air, static-pressure controller.
    - f. Other system operating conditions that affect performance.
- E. Multi Zone Air-Handling Units Test Reports: For air-handling units with coils, include the following:
1. Unit Data: Include the following:
    - 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, and bore.
    - i. Sheave dimensions, center-to-center, and amount of adjustments in inches.
    - j. Number of belts, make, and size.
    - k. Number of filters, type, and size.
  2. Motor Data:
    - a. 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, and bore.
    - f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
  3. Test Data (Indicated and Actual Values):
    - a. Total airflow rate in cfm.

- b. Total system static pressure in inches wg.
- c. Fan rpm.
- d. Discharge static pressure in inches wg.
- e. Filter static-pressure differential in inches wg.
- f. Preheat coil static-pressure differential in inches wg.
- g. Cooling coil static-pressure differential in inches wg.
- h. Heating coil static-pressure differential in inches wg.
- i. Outside airflow in cfm.
- j. Return airflow in cfm.
- k. Outside-air damper position.
- l. Return-air damper position.
- m. Each zone CFM.

F. 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 o.c.
- f. Make and model number.
- g. Face area in sq. ft..
- h. Tube size in NPS.
- i. Tube and fin materials.
- j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

- a. Airflow rate in cfm.
- b. Average face velocity in fpm.
- c. Air pressure drop in inches wg.
- d. Outside-air, wet- and dry-bulb temperatures in deg F.
- e. Return-air, wet- and dry-bulb temperatures in deg F.
- f. Entering-air, wet- and dry-bulb temperatures in deg F.
- g. Leaving-air, wet- and dry-bulb temperatures in deg F.
- h. Chilled Water flow rate in gpm.
- i. Chilled Water pressure differential in feet of head or psig.
- j. Entering-chilled water temperature in deg F.
- k. Leaving- chilled water temperature in deg F.
- l. Inlet steam pressure in psig.

G. Fan Test Reports: For supply and return, 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, and bore.
  - h. Sheave dimensions, center-to-center, and amount of adjustments in inches.
- 2. Motor Data:
  - a. 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, and bore.
  - f. Sheave dimensions, center-to-center, and amount of adjustments in inches.
  - g. Number of belts, make, and size.
- 3. Test Data (Indicated and Actual Values):
  - a. Total airflow rate in cfm.
  - b. Total system static pressure in inches wg.
  - c. Fan rpm.
  - d. Discharge static pressure in inches wg.
  - e. Suction static pressure in inches wg.
- H. 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.
    - d. Duct static pressure in inches wg.
    - e. Duct size in inches.
    - f. Duct area in sq. ft..
    - g. Indicated airflow rate in cfm.
    - h. Indicated velocity in fpm.
    - i. Actual airflow rate in cfm.
    - j. Actual average velocity in fpm.
    - k. Barometric pressure in psig.

### 3.15 INSPECTIONS

- A. Final 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. Randomly check the following for each system:
  - a. Measure airflow of at least 10 percent of air outlets.
  - b. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
  - c. Verify that balancing devices are marked with final balance position.
  - d. Note deviations to the Contract Documents in the Final Report.

### **3.16 ADDITIONAL TESTS**

- A. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 15950

**DIVISION 16  
ELECTRICAL**

16050	BASIC ELECTRICAL MATERIALS AND METHODS
16060	GROUNDING AND BONDING
16075	ELECTRICAL IDENTIFICATION
16120	CONDUCTORS AND CABLES
16130	RACEWAYS AND BOXES
16140	WIRING DEVICES
16410	ENCLOSED SWITCHES AND CIRCUIT BREAKERS
16420	ENCLOSED CONTROLLERS
16491	FUSES
16511	INTERIOR LIGHTING
16860	FIRE ALARM

## **SECTION 16491 - FUSES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes cartridge fuses, rated 600 V and less, for use in switches, panelboards, switchboards, controllers, and motor-control centers; and spare fuse cabinets.

#### **1.3 DEFINITIONS**

- A. RK1-TD: Class RK1, Time Delay
- B. J-TD: Class J, Time Delay
- C. RK5-TD: Class RK5, Time Delay

#### **1.4 QUALITY ASSURANCE**

- A. Source Limitations: Provide fuses from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NEMA FU 1.
- D. Comply with NFPA 70.

#### **1.5 PROJECT CONDITIONS**

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (4.4 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

#### **1.6 COORDINATION**

- A. Coordinate fuse ratings with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

## **1.7 EXTRA MATERIALS**

- A. Furnish extra materials described below that match products installed and that are packaged in original cartons or containers and identified with labels describing contents.
  - 1. Fuses: Quantity equal to 10 percent of each fuse type and size, but not fewer than 3 of each type and size.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Cooper Industries, Inc.; Bussmann Div.
  - 2. Gould Shawmut.
  - 3. Tracor, Inc.; Littelfuse, Inc. Subsidiary.

### **2.2 CARTRIDGE FUSES**

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 FUSE APPLICATIONS**

- A. Refer to drawings for fuse types and sizes.

1. Motor fuse sizes: Field select motor fuse sizes using the class of fuse shown on the drawings and sizing the fuse based upon the motor nameplate information and by multiplying by 1.25 (except for special service motors).

### **3.3 INSTALLATION**

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- B. Install spare fuse cabinet.

### **3.4 IDENTIFICATION**

- A. Install labels indicating fuse replacement information on inside door of each fused switch.

END OF SECTION 16491

## **SECTION 16511 - INTERIOR LIGHTING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Interior lighting fixtures with lamps and ballasts.

#### **1.3 SUBMITTALS**

- A. Product Data: For each type of lighting fixture scheduled, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
  - 1. Physical description of fixture, including dimensions and verification of indicated parameters.
  - 2. Emergency lighting unit battery and charger.
  - 3. Fluorescent and high-intensity-discharge ballasts.
  - 4. Lamps.
- B. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section "Closeout Procedures," include the following:
  - 1. Catalog data for each fixture. Include the diffuser, ballast, and lamps installed in that fixture.
- C. Warranties: Special warranties specified in this Section.
- D. Spare Parts: include spare parts materials and quantity.

#### **1.4 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - 1. Test products to UL standards by nationally recognized testing laboratory, where an appropriate standard exists.

- B. Comply with NFPA 70.
- C. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.

## **1.5 COORDINATION**

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

## **1.6 WARRANTY**

- A. Special Warranty for Fluorescent Ballasts: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period for Electronic Ballasts: Five years from date of Substantial Completion.

## **1.7 EXTRA MATERIALS**

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
  - 2. Ballasts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
  - 3. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Products: Subject to compliance with requirements, provide one of the products specified.

### **2.2 FIXTURES AND COMPONENTS, GENERAL**

- A. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.
- B. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- C. Metal Parts: Free of burrs and sharp corners and edges.
- D. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- F. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
  - 1. White Surfaces: 92 percent.
  - 2. Specular Surfaces: 83 percent.
  - 3. Diffusing Specular Surfaces: 75 percent.
  - 4. Laminated Silver Metallized Film: 90 percent.
- G. Plastic Diffusers, Covers, and Globes:
  - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
    - a. Lens Thickness: At least **0.125 inch (3.175 mm)** minimum unless different thickness is scheduled.
    - b. UV stabilized.
  - 2. Glass: Annealed crystal glass, unless otherwise indicated.

## **2.3 LIGHTING FIXTURES**

- A. Fixtures: Refer to drawings.

## **2.4 FLUORESCENT LAMP BALLASTS**

- A. Description: Include the following features, unless otherwise indicated:
  - 1. Designed for type and quantity of lamps indicated at full light output, unless 1.2 BF is specified.
    - a. Linear Electronic Ballasts: full light output is defined as .88 BF.
    - b. Linear Magnetic Ballasts: full light output is defined as .95 BF.
    - c. Compact Fluorescent Ballasts: full light output is defined as 1.0 BF.
  - 2. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

- B. Electronic ballasts (nondimming) for linear lamps shall include the following features, unless otherwise indicated:
1. Comply with NEMA C82.11.
  2. Ballast Type: Programmed start with two-step lamp starting to extend life of frequently started lamps; if not available from any manufacturer, provide rapid start.
  3. Sound Rating: A.
  4. Total harmonic distortion rating of less than 20 percent according to NEMA C82.11.
  5. Transient Voltage Protection: IEEE C62.41, Category A.
  6. Operating Frequency: 20 kHz or higher.
  7. Lamp Current Crest Factor: Less than 1.7.
  8. Parallel Lamp Circuits: Multiple lamp ballasts connected to maintain full light output on surviving lamps if one or more lamps fail.
  9. Manufacturers: Provide products in conformance with the requirements of the contract documents manufactured by one of the following.
    - a. Universal Lighting Technologies
    - b. Advance Transformer CO.
    - c. Osram/Sylvania
    - d. General Electric Co.
- C. Ballasts for compact fluorescent lamps shall have the following features, unless otherwise indicated:
1. Type: Electronic. Ballasts for all lamps larger than 26 watts shall be program start.
  2. Power Factor: 90 percent, minimum.
  3. Flicker: Less than 5 percent.
  4. Lamp Current Crest Factor: Less than 1.7.
  5. Electronic Ballast Operating Frequency: 20 kHz or higher.
  6. Lamp end-of-life detection and shutdown circuit.
  7. Transient Protection: Comply with IEEE C62.41 for Category A1 locations.
  8. Manufacturers: Provide products in conformance with the requirements of the contract documents manufactured by one of the following.
    - a. Universal Lighting Technologies
    - b. Advance Transformer CO.
    - c. Osram/Sylvania
- D. Ballasts for Low-Temperature Environments:
1. Temperatures 0 deg F (Minus 17 deg C) and Higher: Electronic or electromagnetic type rated for 0 deg F (Minus 17 deg C) starting temperature.
  2. Temperatures Minus 20 deg F (Minus 29 deg C) and Higher: Electromagnetic type designed for use with high-output lamps.
  3. Manufacturers: Provide products in conformance with the requirements of the contract documents manufactured by one of the following.
    - a. Universal Lighting Technologies
    - b. Advance Transformer CO.
    - c. Osram/Sylvania.

## 2.5 FLUORESCENT LAMPS

- A. Low-Mercury Lamps: Comply with Federal toxic characteristic leaching procedure (TCLP) test, and yield less than 0.2 mg of mercury per liter, when tested according to NEMA LL 1.
- B. T8 rapid-start low-mercury lamps, CRI of 82 (minimum), color temperature as indicated, and average rated life of 30,000 hours, unless otherwise indicated.
- C. Compact Fluorescent Lamps: CRI 80 (minimum), color temperature as indicated, average rated life of 10,000 hours at 3 hours operation per start, unless otherwise indicated.
- D. Manufacturers: Provide products in conformance with the requirements of the contract documents manufactured by one of the following.
  - a. General Electric Company
  - b. Philips Lighting
  - c. Osram/Sylvania
  - d. Ushio

## 2.6 FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 16 Section "Basic Electrical Materials and Methods" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: **1/2-inch (13-mm)** steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated, 12 gage (2.68 mm).
- D. Rod Hangers: **3/16-inch- (5-mm-)** minimum diameter, cadmium-plated, threaded steel rod.

## 2.7 FINISHES

- A. Fixtures: Manufacturers' standard, unless otherwise indicated.
  - 1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.
  - 2. Metallic Finish: Corrosion resistant.

## 2.8 SOURCE QUALITY CONTROL

- A. Provide services of a qualified, independent testing and inspecting agency to factory test fixtures with ballasts and lamps; certify results for electrical ratings and photometric data.

- B. Factory test fixtures with ballasts and lamps; certify results for electrical ratings and photometric data.

## **PART 3 - EXECUTION**

### **3.1 INSTALLATION**

- A. Fixtures: Set level, plumb, and square with ceilings and walls. Adjust trims for recessed fixtures to eliminate light leaks. Install lamps in each fixture.
  - 1. Install fixtures with the separation from combustible material as required by lighting fixture rating, per manufacturer's written instructions; in no case, install recessed fixture within ½" of combustible material.
- B. Suspended Fixture Support: As follows:
  - 1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
  - 2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
  - 3. Industrial Fixtures, Continuous Rows: Use chain.
  - 4. Extruded fixtures, Continuous Rows: Suspend from cable.

### **3.2 CONNECTIONS**

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### **3.3 FIELD QUALITY CONTROL**

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
  - 1. Clean transparent materials. Replace chipped or broken lenses and other damaged transparent materials.
  - 2. Restore reflective surfaces to their reflective conditions.
  - 3. Clean light fixtures and lamps.
- B. Verify normal operation of each fixture after installation.
- C. Corroded Fixtures: During warranty period, replace fixtures that show any signs of corrosion.

END OF SECTION 16511

## **SECTION 16860 - FIRE ALARM**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes fire alarm systems.

#### **1.3 DEFINITIONS**

- A. FACP: Fire alarm control panel.
- B. LED: Light-emitting diode.
- C. NICET: National Institute for Certification in Engineering Technologies.
- D. Definitions in NFPA 72 apply to fire alarm terms used in this Section.

#### **1.4 SYSTEM DESCRIPTION**

- A. Noncoded, analog-addressable system; automatic sensitivity control of certain smoke detectors; and multiplexed signal transmission dedicated to fire alarm service only.
  - 1. Connect to existing fire alarm system with matching and compatible devices.

#### **1.5 PERFORMANCE REQUIREMENTS**

- A. Comply with NFPA 72.
- B. In addition to existing system operation, fire alarm signal initiation shall be by one or more of the following devices:
  - 1. Heat detectors.
  - 2. Smoke and duct detectors.
- C. Fire alarm signal shall initiate the following actions:
  - 1. Alarm notification appliances shall operate continuously.
  - 2. Identify alarm at the FACP and remote annunciators.

3. De-energize electromagnetic door holders.
  4. Transmit an alarm signal to the remote alarm receiving station.
  5. Unlock electric door locks in designated egress paths.
  6. Release fire and smoke doors held open by magnetic door holders.
  7. Switch heating, ventilating, and air-conditioning equipment controls to fire alarm mode.
  8. Close smoke dampers in air ducts of system serving zone where alarm was initiated.
  9. Initiate elevator recall.
  10. Record events in the system memory.
- D. System trouble signal initiation shall be by one or more of the following devices or actions:
1. Open circuits, shorts and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.
  2. Opening, tampering, or removal of alarm-initiating and supervisory signal-initiating devices.
  3. Loss of primary power at the FACP.
  4. Ground or a single break in FACP internal circuits.
  5. Abnormal ac voltage at the FACP.
  6. A break in standby battery circuitry.
  7. Failure of battery charging.
  8. Abnormal position of any switch at the FACP or annunciator.
  9. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.
- E. System Trouble and Supervisory Signal Actions: Ring trouble bell and annunciate at the FACP and remote annunciators.

## 1.6 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
1. Shop Drawings shall be prepared by persons with the following qualifications:
    - a. Trained and certified by manufacturer in fire alarm system design.
    - b. Fire alarm certified by NICET, minimum Level III.
  2. System Operation Description: Detailed description for this Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.
  3. Device Address List: Coordinate with final system programming.
  4. System riser diagram with device addresses, conduit sizes, and cable and wire types and sizes.

5. Wiring Diagrams: Power, signal, and control wiring. Include diagrams for equipment and for system with all terminals and interconnections identified. Show wiring color code.
  6. Batteries: Size calculations.
  7. Duct Smoke Detectors: Performance parameters and installation details for each detector, verifying that each detector is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
  8. Ductwork Coordination Drawings: Plans, sections, and elevations of ducts, drawn to scale and coordinating the installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, the detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
  9. Floor Plans: Indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.
- C. Qualification Data: For Installer.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For fire alarm system to include in emergency, operation, and maintenance manuals. Comply with NFPA 72, Appendix A, recommendations for Owner's manual. Include abbreviated operating instructions for mounting at the FACP.
- F. Submittals to Authorities Having Jurisdiction: In addition to distribution requirements for submittals specified in Division 1 Section "Submittals," make an identical submittal to authorities having jurisdiction. To facilitate review, include copies of annotated Contract Drawings as needed to depict component locations. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Architect for review.
- G. Documentation:
1. Approval and Acceptance: Provide the "Record of Completion" form according to NFPA 72 to Owner, Architect, and authorities having jurisdiction.
  2. Record of Completion Documents: Provide the "Permanent Records" according to NFPA 72 to Owner, Architect, and authorities having jurisdiction. Format of the written sequence of operation shall be the optional input/output matrix.
    - a. Hard copies on paper to Owner, Architect, and authorities having jurisdiction.
    - b. Electronic media may be provided to Architect.

## 1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

- B. Installer Qualifications: Work of this Section be performed by a UL-listed company.
- C. Installer Qualifications: Personnel certified by NICET as Fire Alarm Level II.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

## **1.8 COORDINATION**

- A. The fire alarm system is being replaced under a separate contract. Coordinate with contractor of other contract.

## **1.9 EXTRA MATERIALS**

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Smoke, Fire, and Flame Detectors: Quantity equal to 10 percent of amount of each type installed, but not less than 1 unit of each type.
  - 2. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but not less than 1 unit of each type.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. SimplexGrinnell LP; a Tyco International Company.

### **2.2 EXISTING FIRE ALARM SYSTEM**

- A. Compatibility with Existing Equipment: Fire alarm system and components shall operate as an extension of an existing system.

### **2.3 FACP**

- A. Modify existing panel for the additional devices and functions. Add power supplies and modify programming as required.

## 2.4 MANUAL FIRE ALARM BOXES

- A. Description: UL 38 listed; finished in red with molded, raised-letter operating instructions in contrasting color. Station shall show visible indication of operation. Mounted on recessed outlet box; if indicated as surface mounted, provide manufacturer's surface back box.
1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type. With integral addressable module, arranged to communicate manual-station status (normal, alarm, or trouble) to the FACP.
  2. Station Reset: Key- or wrench-operated switch.
  3. Indoor Protective Shield: Factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
  4. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure, hinged at the top to permit lifting for access to initiate an alarm.

## 2.5 SYSTEM SMOKE DETECTORS

- A. General Description:
1. UL 268 listed, operating at 24-V dc, nominal.
  2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
  3. Multipurpose type, containing the following:
    - a. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
  4. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection of building wiring.
  5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
  6. Integral Visual-Indicating Light: LED type. Indicating detector has operated and power-on status.
  7. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.
    - a. Provide multiple levels of detection sensitivity for each sensor.
- B. Photoelectric Smoke Detectors:
1. Sensor: LED or infrared light source with matching silicon-cell receiver.
  2. Detector Sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) smoke obscuration when tested according to UL 268A.
- C. Ionization Smoke Detector:

1. Sensor: Responsive to both visible and invisible products of combustion. Self-compensating for changes in environmental conditions.
2. Detector Sensitivity: Between 0.5 and 1.7 percent/foot (0.0016 and 0.0056 percent/mm) smoke obscuration when tested according to UL 268A.

D. Duct Smoke Detectors:

1. Photoelectric Smoke Detectors:
  - a. Sensor: LED or infrared light source with matching silicon-cell receiver.
  - b. Detector Sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) smoke obscuration when tested according to UL 268A.
2. Ionization Smoke Detectors:
  - a. Sensor: Responsive to both visible and invisible products of combustion. Self-compensating for changes in environmental conditions.
  - b. Detector Sensitivity: Between 0.5 and 1.7 percent/foot (0.0016 and 0.0056 percent/mm) smoke obscuration when tested according to UL 268A.
3. UL 268A listed, operating at 24-V dc, nominal.
4. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
5. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. The fixed base shall be designed for mounting directly to the air duct. Provide terminals in the fixed base for connection to building wiring.
  - a. Weatherproof Duct Housing Enclosure: UL listed for use with the supplied detector. The enclosure shall comply with NEMA 250 requirements for Type 4X.
6. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
7. Integral Visual-Indicating Light: LED type. Indicating detector has operated and power-on status. Provide remote status and alarm indicator and test station where indicated.
8. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.
9. Each sensor shall have multiple levels of detection sensitivity.
10. Sampling Tubes: Design and dimensions as recommended by manufacturer for the specific duct size, air velocity, and installation conditions where applied.
11. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

## 2.6 HEAT DETECTORS

- A. General: UL 521 listed.

- B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or rate-of-rise of temperature that exceeds 15 deg F (8 deg C) per minute, unless otherwise indicated.
  - 1. Mounting: Plug-in base, interchangeable with smoke-detector bases.
  - 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.

## 2.7 NOTIFICATION APPLIANCES

- A. Description: Equipped for mounting as indicated and with screw terminals for system connections.
  - 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly.
- B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn.
- C. Visible Alarm Devices: Xenon strobe lights listed under UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.
  - 1. Rated Light Output: As required to meet NFPA requirements for specific location.
  - 2. Strobe Leads: Factory connected to screw terminals.
  - 3. Synchronization: Strobe lights are synchronized.

## 2.8 ADDRESSABLE INTERFACE DEVICE

- A. Description: Microelectronic monitor module listed for use in providing a system address for listed alarm-initiating devices for wired applications with normally open contacts.
- B. Integral Relay: Capable of providing a direct signal to external device to be controlled.

## 2.9 GUARDS FOR PHYSICAL PROTECTION

- A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
  - 1. Factory fabricated and furnished by manufacturer of the device.
  - 2. Finish: Paint of color to match the protected device.

## 2.10 WIRE AND CABLE

- A. Wire and cable for fire alarm systems shall be UL listed and labeled as complying with NFPA 70, Article 760.
- B. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG.
- C. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
  - 1. Low-Voltage Circuits: No. 14 AWG, minimum.
  - 2. Line-Voltage Circuits: No. 12 AWG, minimum.

## PART 3 - EXECUTION

### 3.1 EQUIPMENT INSTALLATION

- A. Smoke or Heat Detector Spacing:
  - 1. Smooth ceiling spacing shall not exceed **30 feet (9 m)**.
  - 2. Spacing of heat detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas, shall be determined according to Appendix A in NFPA 72.
  - 3. Spacing of heat detectors shall be determined based on guidelines and recommendations in NFPA 72.
- B. HVAC: Locate detectors not closer than **3 feet (1 m)** from air-supply diffuser or return-air opening.
- C. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of the duct.
- D. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.
- E. Audible Alarm-Indicating Devices: Install not less than **6 inches (150 mm)** below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
- F. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least **6 inches (150 mm)** below the ceiling.
- G. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- H. FACP: Surface mount with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor.
- I. Annunciator: Install with top of panel not more than **72 inches (1830 mm)** above the finished floor.

### **3.2 WIRING INSTALLATION**

- A. Wiring Method: Install wiring in metal raceway according to Division 16 Section "Raceways and Boxes."
  - 1. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.
- B. Wiring Method:
  - 1. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
- C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- E. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.

### **3.3 IDENTIFICATION**

- A. Identify system components, wiring, cabling, and terminals according to Division 16 Section "Electrical Identification."
- B. Install instructions frame in a location visible from the FACP.
- C. Paint power-supply disconnect switch red and label "FIRE ALARM."

### **3.4 GROUNDING**

- A. Ground the FACP and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to the FACP.

### **3.5 FIELD QUALITY CONTROL**

- A. **Manufacturer's Field Service:** Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
  - 1. Before requesting final approval of the installation, submit a written statement using the form for Record of Completion shown in NFPA 72.
  - 2. Perform each electrical test and visual and mechanical inspection listed in NFPA 72. Certify compliance with test parameters. All tests shall be conducted under the direct supervision of a NICET technician certified under the Fire Alarm Systems program at Level III.
  - 3. **Visual Inspection:** Conduct a visual inspection before any testing. Use as-built drawings and system documentation for the inspection. Identify improperly located, damaged, or nonfunctional equipment, and correct before beginning tests.
  - 4. **Testing:** Follow procedure and record results complying with requirements in NFPA 72.
    - a. Detectors that are outside their marked sensitivity range shall be replaced.
  - 5. **Test and Inspection Records:** Prepare according to NFPA 72, including demonstration of sequences of operation by using the matrix-style form in Appendix A in NFPA 70.

### **3.6 ADJUSTING**

- A. **Occupancy Adjustments:** When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.
- B. **Follow-Up Tests and Inspections:** After date of Substantial Completion, test the fire alarm system complying with testing and visual inspection requirements in NFPA 72. Perform tests and inspections listed for three monthly, and one quarterly, periods.

END OF SECTION 16860

## **SECTION 16050 - BASIC ELECTRICAL MATERIALS AND METHODS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Supporting devices for electrical components.
  - 2. Access Panels
  - 3. Electrical demolition.
  - 4. Cutting and patching for electrical construction.
  - 5. Temporary Power and Communication
  - 6. Permits and Fees

#### **1.3 SUBMITTALS**

- A. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- B. Submittal Procedures: Submittal procedures are specified in Division 1.
  - 1. Prepare submittals in three-ring "hard cover" binders with project name and volume on the binding. Include tabs identified by the specification section and in numerical order. Include plastic sleeves to hold drawings that exceed 8-1/2" x 11".
  - 2. Include cover sheet with the following information: date, project name, address, and title; Installer's name, address and phone number; Project manager, and Engineering firm names and phone numbers.
- C. Project Record Documents: Project Record Documents are specified in Division 1.
  - 1. Redline changes or information recognized to be of importance to the Owner. Include wiring changes, panelboard changes, etc.
  - 2. Dimension underground wiring and other concealed electrical features.
  - 3. Redline actual equipment electrical characteristics on equipment schedules.
- D. Digital Operation and Maintenance Manual on CD-ROM

1. Intuitive CD-ROM instructional manual for information to care, adjust, maintain and operate equipment. Include contract documents, shop drawings, product data.
  - a. Software: Adobe Acrobat.
  - b. Format: PDF.
  - c. Index: Hypertext alphabetical index.
  - d. Auto Starting: Windows 9X with any directions to continue observable on the screen.

#### **1.4 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.
- C. Comply with Owner Standards.
  1. State of Utah, Division of Facilities Construction and Management "Design Criteria".
  2. Southern Utah University "Design Standards"
- D. Installer Qualifications: All workmen doing electrical work shall be duly licensed with the required supervision in the State or Locality as legally required.
  1. Site Review: All electricians must carry their electrician's license with them and show it upon request.

#### **1.5 COORDINATION**

- A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
- B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.
- C. Coordinate electrical equipment installation with other building components.
  1. Verify all dimensions be field measurements.
  2. Minimize costs to resolve equipment and other conflicts by successfully concluding preinstallation conferences. Include the following:
    - a. Review Division 15 shop drawings. Compare equipment electrical specifications with equipment schedule. Prevent Div 15 equipment encroaching on clearances required by NEC. Request clarification of conflicts prior to installation.

- b. Determine whether lighting fixtures and other electrical items conflict with the location of structural members and mechanical or other equipment.
  - c. Coordinate connecting electrical service to components furnished in other sections of the specification or by the User. Verify electrical requirements including voltage, full load amps, and minimum wire ampacity prior to installing or purchasing the associated electrical equipment and wiring.
- D. Coordinate electrical service connections to components of Owner's facilities.
- E. Temporary Power and Communication are specified in Division 1 Section "Construction Facilities and Temporary Controls".
- 1. Comply with requirements for temporary electric and communication services with the proper Owner's representative.
  - 2. Comply with Article 305 of the NEC.
- F. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces. Access doors and panels are specified in Division 8 Section "Access Doors."
- G. Coordinate with Authorities Having Jurisdiction including: city, county, state, university, federal and other governmental authorities.
- 1. Obtain all permits (including excavation permits) prior to beginning construction.
  - 2. Request inspections required by Authorities Having Jurisdiction in a timely manner and in order to comply with sequencing requirements.

## **PART 2 - PRODUCTS**

### **2.1 SUPPORTING DEVICES**

- A. Material: Cold-formed steel, with corrosion-resistant coating acceptable to authorities having jurisdiction.
- B. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel.
- C. Slotted-Steel Channel Supports: Flange edges turned toward web, and 9/16-inch- (14-mm-) diameter slotted holes at a maximum of 2 inches (50 mm) o.c., in webs.
- D. Slotted-Steel Channel Supports: Comply with Division 5 Section "Metal Fabrications" for slotted channel framing.
  - 1. Channel Thickness: Selected to suit structural loading.
  - 2. Fittings and Accessories: Products of the same manufacturer as channel supports.
- E. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring-steel clamps or click-type hangers.

- F. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.
- G. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Plugs have number and size of conductor gripping holes as required to suit individual risers. Body constructed of malleable-iron casting with hot-dip galvanized finish.
- H. Expansion Anchors: Carbon-steel wedge or sleeve type.
- I. Toggle Bolts: All-steel springhead type.
- J. Powder-Driven Threaded Studs: Heat-treated steel.

### **PART 3 - EXECUTION**

#### **3.1 ELECTRICAL EQUIPMENT INSTALLATION**

- A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom.
- B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.
- C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.
- D. Right of Way: Give to raceways and piping systems installed at a required slope.
- E. Existing Utilities: Locate and identify existing underground utilities in excavation areas or in demolition areas. Maintain services to areas outside demolition limits or excavated areas. When services must be interrupted, install temporary services for affected areas.
- F. Manufacturer's Instructions: Comply with manufacturer's installation instructions and recommendations, to the extent that those instructions and recommendations are more explicit or stringent than requirements indicated in the Contract Documents.
- G. Record drawings and Shop Drawings: Mark up drawings daily during construction with changes or deletions in the scope of the project.

#### **3.2 ELECTRICAL SUPPORTING DEVICE APPLICATION**

- A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components.

- B. Dry Locations: Steel materials.
- C. Support Clamps for PVC Raceways: Click-type clamp system.
- D. Selection of Supports: Comply with manufacturer's written instructions.
- E. Strength of Supports: Adequate to carry present and future loads, times a safety factor of at least four; minimum of **200-lb (90-kg)** design load.

### 3.3 SUPPORT INSTALLATION

- A. Install support devices to securely and permanently fasten and support electrical components.
  - 1. Comply with NFPA 70. In addition, install supports within 12" of couplings, fittings, and boxes, with a minimum of two supports per 10 foot length of raceway. Install supports at each change of direction. Similarly support cables in cable trays or raceways as indicated; except, provide J-hooks to support cables.
  - 2. Support suspended conduit and cables independently from all other electrical or mechanical systems by attaching directly from building structure, unless prior approval in writing has been obtained from the Architect after engineering calculations have been submitted.
  - 3. Coordinate installation of supports so as not to interfere with the removal of ceiling tiles, the service of mechanical equipment, etc.
  - 4. Install bracing parallel to trusses, beams, joists, bridging, etc.
- B. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.
- C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.
- D. Support parallel runs of cables together on trapeze or bracket type hangers, either vertically or horizontally.
- E. Size supports for multiple raceway and cable installations so capacity can be increased by a 25 percent minimum in the future.
- F. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.
- G. Install **1/4-inch- (6-mm-)** diameter or larger threaded steel hanger rods, unless otherwise indicated.
- H. Spring-steel fasteners specifically designed for supporting single conduits or tubing may be used instead of malleable-iron hangers for 1-1/2-inch (38-mm) and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to slotted channel and angle supports.

- I. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.
- J. Simultaneously install vertical conductor supports with conductors.
- K. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers. If supported directly from the building structure, attach box to framing on opposite sides of the box. If bar hangers are used, attach bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than **24 inches (610 mm)** from the box.
- L. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.
- M. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.
  1. Install wrapped or coated RMC sleeves with 3 feet extending on each side through penetrations of foundations or concrete walls by RNC.
- N. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:
  1. Wood: Fasten with wood screws or screw-type nails.
  2. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.
  3. New Concrete: Concrete inserts with machine screws and bolts.
  4. Existing Concrete: Expansion bolts. Drill holes in concrete so holes do not cut main reinforcing bars. Fill and seal holes drilled in concrete and not used.
    - a. Obtain prior approval from project structural engineer prior to drilling prestressed or post-tension concrete slabs and beams.
  5. Instead of expansion bolts, threaded studs driven by a powder charge and provided with lock washers may be used in existing concrete.
  6. Steel: Welded threaded studs or spring-tension clamps on steel.
    - a. Field Welding: Comply with AWS D1.1.
  7. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
  8. Light Steel: Sheet-metal screws.
  9. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load. Do not support electrical equipment or conduits with toggle bolts, moly-bolts, or screws in sheetrock or plaster. Do not support electrical equipment or conduit from tie wires.
  10. Do not use wooden plugs in concrete or masonry units for fastening conduits, tubing, boxes, cabinets, etc.

- O. Permanently mark multiplying factor on meter face where current transformers are used.

### **3.4 TEMPORARY ELECTRIC AND COMMUNICATION SERVICES**

- A. Provide electric service, metering, main disconnect and distribution. Connect to Owner's temporary service location.
  - 1. Where connecting to the institution's electric service, report initial meter reading and obtain written permission prior to energizing temporary facilities.
  - 2. As soon as permanent power and metering is available, disconnect the temporary power supply and remove from the construction site.
- B. Provide temporary wiring and light fixtures for temporary lighting.
- C. Protect receptacles with 20 amp GFI circuit breakers.
- D. Provide temporary wiring for communication services. Connect to Owner's temporary service location.
  - 1. Where connecting to the institution's communication service, obtain written permission prior to connecting to temporary facilities.

### **3.5 ACCESS DOORS**

- A. Install access panels where required by accessibility requirements of NEC for electrical installations such as junction boxes, ballasts, and other electrical equipment requiring access.

### **3.6 FIRESTOPPING**

- A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestopping."

### **3.7 DEMOLITION**

- A. Protect existing electrical equipment and installations indicated to remain. If damaged or disturbed in the course of the Work, remove damaged portions and install new products of equal capacity, quality, and functionality.
  - 1. Relocate existing electrical devices, conduit or equipment that for any reason obstructs construction. Include any equipment having electrical connections that requires disconnecting and reconnection at the same or another location throughout the course of construction.
  - 2. Maintain in working condition all electrical equipment and apparatus in areas not remodeled.

3. Temporary Partitions or Dust Barriers: Prevent the spread of dust and dirt to adjacent areas.
- B. Accessible Work: Remove exposed electrical equipment and installations, indicated to be demolished, in their entirety.
  1. Include exposed equipment and installations made obsolete by new work.
- C. Abandoned Work: Cut and remove buried raceway and wiring, indicated to be abandoned in place, 2 inches (50 mm) below the surface of adjacent construction. Cap raceways and patch surface to match existing finish.
- D. Remove and legally dispose of demolished material from Project site.
- E. Remove, store, clean, reinstall, reconnect, and make operational components indicated for relocation.
- F. Remove conductors from raceway to the first active outlet or branch panels for vacated or unused circuits.

### **3.8 CUTTING AND PATCHING**

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.
  1. Core drilling: X-Ray post-tension slabs prior to core drilling to assure that post-tension cables are not damaged.
- B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

### **3.9 FIELD QUALITY CONTROL**

- A. Inspect installed components for damage and faulty work, including the following:
  1. Supporting devices for electrical components.
  2. Electrical demolition.
  3. Touchup painting.
- B. Test all electrical work to ensure that they test free of mechanical and electrical defects.
  1. Comply with testing requirements of authorities having jurisdiction.
  2. Comply with Owner's standards for testing in documents listed in "Quality Assurance".

### **3.10 CLEANING AND PROTECTION**

- A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.
  - 1. Remove labels that are not permanent labels.
  - 2. Wipe surfaces of electrical equipment. Remove excess lubrication and other substances.
  - 3. Clean exposed exterior and interior hard-surface finishes to a dust-free condition, free of stains, films and similar foreign substances.
- B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION 16050

## **SECTION 16060 - GROUNDING AND BONDING**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

#### **1.3 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - 1. Comply with UL 467.

### **PART 2 - PRODUCTS**

#### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Grounding Conductors, Cables, Connectors, and Rods:
    - a. Apache Grounding/Erico Inc.
    - b. Boggs, Inc.
    - c. Chance/Hubbell.
    - d. Copperweld Corp.
    - e. Dossert Corp.
    - f. Erico Inc.; Electrical Products Group.
    - g. Framatome Connectors/Burndy Electrical.
    - h. Galvan Industries, Inc.
    - i. Harger Lightning Protection, Inc.
    - j. Hastings Fiber Glass Products, Inc.
    - k. Heary Brothers Lightning Protection Co.
    - l. Ideal Industries, Inc.
    - m. ILSCO.
    - n. Kearney/Cooper Power Systems.
    - o. Korn: C. C. Korn Co.; Division of Robroy Industries.
    - p. Lightning Master Corp.

- q. Lyncole XIT Grounding.
- r. O-Z/Gedney Co.; a business of the EGS Electrical Group.
- s. Raco, Inc.; Division of Hubbell.
- t. Robbins Lightning, Inc.
- u. Salisbury: W. H. Salisbury & Co.
- v. Superior Grounding Systems, Inc.
- w. Thomas & Betts, Electrical.
- x. VFC, Inc.

## 2.2 GROUNDING CONDUCTORS

- A. For insulated conductors, comply with Division 16 Section "Conductors and Cables."
- B. Material: copper.
- C. Equipment Grounding Conductors: Insulated with green-colored insulation.
- D. Copper Bonding Conductors: As follows:
  - 1. Bonding Conductor: as noted on the drawings, stranded copper conductor. Comply with NEC minimum requirements.
  - 2. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches (42 mm) wide and 1/16 inch (1.5 mm) thick.

## 2.3 CONNECTOR PRODUCTS

- A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.
- B. Bolted Connectors: Bolted-pressure-type connectors, or compression type.

## PART 3 - EXECUTION

### 3.1 APPLICATION

- A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
- B. In raceways, use insulated equipment grounding conductors.
- C. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.

### 3.2 EQUIPMENT GROUNDING CONDUCTORS

- A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.

- B. Install equipment grounding conductors in all feeders and branch wiring.
- C. Air-Duct Equipment Circuits: Install an equipment-grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.

### 3.3 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

### 3.4 CONNECTIONS

- A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
  - 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
  - 2. Make connections with clean, bare metal at points of contact.
  - 3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- B. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
- C. Non-contact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.
- D. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.
- E. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

### **3.5 SEPARATELY DERIVED SYSTEMS**

- A. Comply with NFPA 70, Article 250, for types, sizes, and quantities of grounding electrode conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
- B. Do not ground system neutral conductor under any circumstances after it has been grounded at the service entrance disconnect except for separately derived systems. Interconnect or bond all grounding systems to the main system ground. Do not use neutral conductors for grounding equipment. Do not bond the neutral bus to distribution cabinets, except for separately derived systems.

### **3.6 FIELD QUALITY CONTROL**

- A. Testing: Perform the following field quality-control testing:
  - 1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
  - 2. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 16060

## **SECTION 16075 - ELECTRICAL IDENTIFICATION**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70, OSHA standards, and authorities having jurisdiction.

#### **1.3 QUALITY ASSURANCE**

- A. Comply with ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with ANSI A13.1 and NFPA 70 for color-coding.

### **PART 2 - PRODUCTS**

#### **2.1 RACEWAY AND CABLE LABELS**

- A. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide (0.08 mm thick by 25 to 51 mm wide).

#### **2.2 NAMEPLATES AND SIGNS**

- A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.
- B. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
  - 1. Engraved legend with black letters on white face.
  - 2. Punched or drilled for mechanical fasteners.
- C. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

## 2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
  - 1. Minimum Width: 3/16 inch (5 mm).
  - 2. Tensile Strength: 50 lb (22.3 kg) minimum.
  - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
  - 4. Color: According to color-coding.
  
- B. Paint: Formulated for the type of surface and intended use.
  - 1. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.
  - 2. Primer for Concrete Masonry Units: Heavy-duty-resin block filler.
  - 3. Primer for Concrete: Clear, alkali-resistant, binder-type sealer.
  - 4. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
  
- B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.
  
- C. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.
  
- D. Self-Adhesive Identification Products: Clean surfaces before applying.
  
- E. Install painted identification according to manufacturer's written instructions and as follows:
  - 1. Clean surfaces of dust, loose material, and oily films before painting.
  - 2. Prime surfaces using type of primer specified for surface.
  - 3. Apply one intermediate and one finish coat of enamel.
  
- F. Paint fire alarm junction boxes red.
  
- G. Circuit Identification Labels on Boxes: Install labels externally for all installed boxes prior to installation of conductors.
  - 1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
  - 2. Concealed Boxes: Plasticized card-stock tags.

3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
- H. Circuit Identification Labels on Plates for Emergency Circuits: Install labels externally for all installed wiring device plates indicating panel and circuit number.
  1. Clear preprinted adhesive labels.
- I. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
- J. Color-Coding of Secondary Phase Conductors: Color code switch legs, travelers and other wiring for branch circuits other than those listed below. Permanently post color code at each branch panelboard. Use the following colors for service, feeder and branch-circuit phase conductors:
  1. 208/120-V Conductors:
    - a. Phase A: Black.
    - b. Phase B: Red.
    - c. Phase C: Blue.
    - d. Neutral: White.
    - e. Ground: Green.
    - f. Insulated Ground: Green with white stripe.
  2. 480/277-V Conductors:
    - a. Phase A: Brown.
    - b. Phase B: Orange.
    - c. Phase C: Yellow.
    - d. Neutral: Gray.
    - e. Ground: Green.
  3. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 6 AWG:
    - a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1-inch- (25-mm-) wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.
- K. Power-Circuit Identification: Metal tags or aluminum, wraparound marker bands for cables, feeders, and power circuits in vaults, pull and junction boxes, manholes, and switchboard rooms.
  1. Legend: 1/4-inch- (6.4-mm-) steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
  2. Tag Fasteners: Nylon cable ties.
  3. Band Fasteners: Integral ears.
- L. Apply identification to conductors as follows:
  1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.

2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
- M. Apply warning, caution, and instruction signs as follows:
1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
  2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum **3/8-inch- (9-mm-)** high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.
  3. Install caution signs for enclosures Over 600 V: Indicate system voltage on black, preprinted on orange field.
- N. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with **1/2-inch- (13-mm-)** high lettering on **1-1/2-inch- (38-mm-)** high label; where two lines of text are required, use labels **2 inches (50 mm)** high. Use white lettering on black field. Apply labels for each unit of the following categories of equipment using mechanical fasteners:
1. Interior and exterior of panelboards, electrical cabinets, and enclosures.
    - a. Distribution Panelboards: Identify Distribution Panelboard designation and circuit serving distribution panelboard; label main and distribution overcurrent protection showing load served and location (identify room numbers).
    - b. Branch Panelboards: Identify distribution panel and circuit serving panelboard.
    - c. Main Overcurrent Protection: Identify main device and service disconnects.
  2. Access doors and panels for concealed electrical items.
  3. Emergency system boxes and enclosures.
  4. Disconnect switches.
  5. Enclosed circuit breakers.
  6. Motor starters.
  7. Transformers.
- O. For panelboards, provide framed, typed circuit schedules with explicit description and identification of items controlled by each individual breaker.

END OF SECTION 16075

## **SECTION 16120 - CONDUCTORS AND CABLES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600 V and less.

#### **1.3 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

### **PART 2 - PRODUCTS**

#### **2.1 MANUFACTURERS**

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

#### **2.2 CONDUCTORS AND CABLES**

- A. Manufacturers:
  - 1. Copper Wire and Cables:
    - a. American Insulated Wire Corp.; a Leviton Company.
    - b. General Cable Corporation.
    - c. Senator Wire & Cable Company.
    - d. Southwire Company.
- B. Refer to Part 3 "Conductor and Insulation Applications" Article for insulation type, cable construction, and ratings.

- C. Conductor Material: Copper, minimum size #12 for phase conductors and #14 for control conductors complying with NEMA WC 7; stranded conductor.
- D. Conductor Insulation Types: Type THWN-2 and XHHW complying with NEMA WC 7.
- E. Multiconductor Cable: Not allowed.

## **2.3 CONNECTORS AND SPLICES**

- A. Manufacturers:
  - 1. AFC Cable Systems, Inc.
  - 2. AMP Incorporated/Tyco International.
  - 3. Burndy.
  - 4. Hubbell/Anderson.
  - 5. IlSCO.
  - 6. O-Z/Gedney; EGS Electrical Group LLC.
  - 7. 3M Company; Electrical Products Division.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

## **PART 3 - EXECUTION**

### **3.1 CONDUCTOR AND INSULATION APPLICATIONS**

- A. Feeders: Type THWN-2, single conductors in raceway.
- B. Branch Circuits: Type THWN-2, single conductors in raceway.
- C. Fire Alarm Circuits:
  - 1. Type THWN-2 in raceway for fire alarm power circuits, for horn circuits, and for strobe circuits.
  - 2. Power-limited, fire-protective, signaling circuit cable in raceway for initiating loop circuits.
- D. Emergency circuits: Install in separate raceways from all other wiring, except where they connect to the same equipment for two-source operation.
- E. Control Circuits: Type THWN-2, in raceway.
- F. Fixture Conductors: Install conductors in lighting fixtures with insulation ratings as recommended by the manufacturer's written instructions or a minimum 90 degrees C., whichever is higher.

### **3.2 INSTALLATION**

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

- B. Multi-wire branch circuits: install no more than three circuits in a raceway, unless specifically shown otherwise.
- C. Install #10 conductors for branch circuits for which the conductor length from panelboard to furthest outlet is more than 100' for 120 volt or more than 140' for 277 volt circuits. Install #8 conductors in for branch circuits for which the conductor length from panelboard to furthest outlet is more than 200' for 120 volt or more than 250' for 277 volt circuits. Increase raceway size to 1" diameter for #8 conductor size
- D. Neutral Conductors for Branch Circuits: Provide a dedicated neutral conductor that is one size larger than the phase conductor for all multi-wire branch circuits that share a neutral conductor.
- E. GFI circuit breakers or feed-thru outlets to outlets served: provide separate neutrals.
- F. Panelboards, switchboards, MCCs, switchgear: Do not route conductors through a section which terminate in another section, except for interconnecting control conductors.
- G. Remove existing conductors from raceway before pulling in new wires and cables.
- H. Parallel conductors: Where parallel conductors are installed in parallel raceways, install in each raceway conductors of phase, neutral and/or ground as specified. Carefully cut parallel conductors to identical length for each phase leg. Do not parallel conductors less than #1/0.
- I. 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.
- J. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- K. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- L. Do not install wiring through any part of a transformer vault or elevator equipment room and shaft that is does not serve equipment in the respective room. Also, coordinate that piping or other items foreign to the transformer vault, elevator equipment room or shaft is not installed in these spaces.
- M. Support cables according to Division 16 Section "Basic Electrical Materials and Methods."
- N. Seal around cables penetrating fire-rated elements according to Division 7 Section "Through-Penetration Firestop Systems."
- O. Identify and color-code conductors and cables according to Division 16 Section "Electrical Identification."

### 3.3 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Conductor splices: Minimize conductor splices. Do not install in conduit bodies.
- C. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- D. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches (300 mm) of slack.
- E. Furniture connections: connect systems furniture to power supply circuits per manufacturer's written instructions.
- F. Panelboard connections: do not splice conductors in panelboards.
- G. Service Connections: Provide lugs, cable, and all other materials necessary to complete connections to the transformer or service lateral for the building.
  - 1. Measure voltage at main disconnect and adjust taps if necessary to obtain the proper value.

### 3.4 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing:
  - 1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.
  - 2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.
- B. Test Reports: Prepare a written report to record the following:
  - 1. Test procedures used.
  - 2. Test results that comply with requirements.
  - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 16120

## **SECTION 16130 - RACEWAYS AND BOXES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. Related Sections include the following:
  - 1. Division 16 Section "Basic Electrical Materials and Methods" for supports, anchors, and identification products.

#### **1.3 DEFINITIONS**

- A. EMT: Electrical metallic tubing.
- B. FMC: Flexible metal conduit.
- C. LFMC: Liquidtight flexible metal conduit.
- D. RNC: Rigid nonmetallic conduit.

#### **1.4 SUBMITTALS**

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

#### **1.5 QUALITY ASSURANCE**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

#### **1.6 COORDINATION**

- A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets, and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

## **PART 2 - PRODUCTS**

### **2.1 MANUFACTURERS**

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

### **2.2 METAL CONDUIT AND TUBING**

- A. Manufacturer:
  - 1. AFC Cable Systems, Inc.
  - 2. Alfex Inc.
  - 3. Anamet Electrical, Inc.; Anaconda Metal Hose.
  - 4. Electri-Flex Co.
  - 5. Grinnell Co./Tyco International; Allied Tube and Conduit Div.
  - 6. LTV Steel Tubular Products Company.
  - 7. Manhattan/CDT/Cole-Flex.
  - 8. O-Z Gedney; Unit of General Signal.
  - 9. Wheatland Tube Co.
- B. Rigid Steel Conduit: ANSI C80.1.
- C. Plastic-Coated Steel Conduit and Fittings: NEMA RN 1.
- D. EMT and Fittings: ANSI C80.3.
  - 1. Fittings: Steel Set-screw or compression type. Do not use die-cast fittings.
- E. FMC: Zinc-coated steel.
- F. LFMC: Flexible steel conduit with PVC jacket.
- G. Fittings: NEMA FB 1; compatible with conduit and tubing materials. Do not use die-cast fittings.

### **2.3 METAL WIREWAYS**

- A. Manufacturer:

1. Hoffman.
  2. Square D.
- B. Material and Construction: Sheet metal sized and shaped as indicated, NEMA 1 or 3R as required by location.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.
- E. Wireway Covers: Hinged type.
- F. Finish: Manufacturer's standard enamel finish.

## **2.4 BOXES, ENCLOSURES, AND CABINETS**

- A. Manufacturer:
1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
  2. Emerson/General Signal; Appleton Electric Company.
  3. Erickson Electrical Equipment Co.
  4. Hoffman.
  5. Hubbell, Inc.; Killark Electric Manufacturing Co.
  6. O-Z/Gedney; Unit of General Signal.
  7. RACO; Division of Hubbell, Inc.
  8. Robroy Industries, Inc.; Enclosure Division.
  9. Scott Fetzer Co.; Adalet-PLM Division.
  10. Spring City Electrical Manufacturing Co.
  11. Thomas & Betts Corporation.
  12. Walker Systems, Inc.; Wiremold Company (The).
  13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, Type FD, with gasketed cover.
- D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- E. Cast-Metal Pull and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.
- F. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

- G. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.

## 2.5 EXPANSION FITTINGS:

- A. Manufacturer:
  - 1. O-Z Gedney; Unit of General Signal.
- B. Expansion Fittings: Malleable Iron, hot dipped galvanized, weatherproof suitable for raceway and applications
  - 1. Coordinate expansion requirements with Architect.

## PART 3 - EXECUTION

### 3.1 RACEWAY APPLICATION

- A. Outdoors:
  - 1. Exposed: Rigid steel.
  - 2. Concealed: Rigid steel.
  - 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  - 4. Boxes and Enclosures: NEMA 250, Type 3R.
- B. Indoors:
  - 1. Exposed:
    - a. Above 6' from finished floor: EMT or Rigid Steel.
    - b. Below 6' from finished floor, or subject to mechanical damage: Rigid Steel.
  - 2. Concealed: EMT, or Rigid Steel.
  - 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
  - 4. Damp or Wet Locations: Rigid steel conduit.
  - 5. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
    - a. Damp or Wet Locations: NEMA 250, Type 4, stainless steel.
- C. Minimum Raceway Size:
  - 1. Metallic Conduits: 3/4-inch trade size (DN 21) except 1/2" C trade size (DN 16) for low voltage automatic temperature control or motor control wiring.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid Metal Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated. Engage a minimum of five full threads.
2. PVC Externally Coated or wrapped Rigid Steel Conduits: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduits.
3. EMT: set screw or compression for dry interior locations; compression for damp or wet locations; compression with tape for installations in concrete slabs above grade.
4. Building Expansion joints: use expansion fittings with 36" of wrapped metal raceways on either side of joint.

### 3.2 INSTALLATION

- A. Layout of electrical boxes: Do not scale electrical drawings.
1. Verify final locations with field measurements and with the requirements of the actual equipment to be connected as determined from shop drawings.
  2. Refer to mounting height detail sheet for typical elevations.
  3. Mounting heights indicated in the symbol schedules are to the center of the outlet.
  4. Mechanical and equipment rooms. Coordinate location of lighting and power outlets with duct and equipment locations. Do not install outlets behind equipment or where otherwise inaccessible. Position lighting, regardless of where shown on drawings, to provide proper illumination.
  5. Mount outlet boxes for switches and receptacles with the long axis of the device vertical unless otherwise indicated.
  6. Set boxes with plaster-rings flush with finished surface.
  7. Install boxes on opposite sides of wall with a stud and a minimum 10" between them.
  8. Locate box covers or device plates so they will not span different types of building finishes either vertically or horizontally.
- B. Outlet Boxes:
1. Frame construction: 4"X4"X1-1/2" with suitable plaster-ring, except:
    - a. 2-1/8" deep for boxes with 3 conduit entrances or for communication outlets
    - b. 4-11/16" boxes for boxes with 4 or more conduits.
  2. Masonry or concrete construction: 1g or multiple gang by 3-1/2" deep.
  3. Fixture Outlets: minimum 4" outlet box with 3/8" fixture stud supported adequately for minimum of 200 lbs.
  4. Do not use gangable boxes.
- C. Keep raceways at least 12 inches (300 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- D. Complete raceway installation before starting conductor installation.
- E. Support raceways as specified in Division 16 Section "Basic Electrical Materials and Methods."

- F. Install temporary closures to prevent foreign matter from entering raceways.
- G. Stub-ups: Embed coupling flush with finished floor. If to remain a spare, the flush plug is to remain in the coupling.
- H. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and keep straight legs of offsets parallel, unless otherwise indicated. Make bends in parallel or banked runs from same centerline to make bends parallel.
- I. Raceways below grade: Install RNC or wrapped/coated Rigid Steel minimum 24" below grade, unless specifically noted otherwise. Where noted encase in concrete.
- J. Conceal conduit and EMT within finished walls, ceilings, and floors, except at surface mounted panels and apparatus or unless otherwise indicated. Install surface raceways only where indicated or where directed by Architect.
  - 1. Install concealed raceways with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.
  - 2. Install surface raceways in rooms where surface mounted panels are indicated or for exposed equipment in mechanical, electrical, or communication rooms.
- K. Raceways Penetrating foundation walls: Install rigid conduit through the foundation wall or 3' each side.
- L. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.
  - 1. Run parallel or banked raceways together on common supports.
  - 2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- M. Raceway coordination: Do not install raceways in or through the following areas that do not serve equipment in those areas:
  - 1. Elevator equipment rooms.
  - 2. Electrical vaults.
- N. Join raceways with fittings designed and approved for that purpose and make joints tight.
  - 1. Use insulating bushings to protect conductors.
- O. Tighten set screws of threadless fittings with suitable tools.
- P. Cap open ends of empty conduit to keep out debris until the project is completed.
- Q. Terminations:

1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. For RMC and IMC, use two locknuts, one inside and one outside box and a bushing. For EMT, use insulated throats or plastic bushings (except for grounding bushings where required).
  2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
  3. Service Conduits or conduits installed in concentric/eccentric knock-outs or reducing washers: terminate raceway with grounding bushings.
- R. 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. Plug empty raceways at both ends.
- S. Install seals for conduit penetrations of slabs on grade and exterior walls below grade. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.
- T. Roof Penetrations: Install flashings for conduit penetrations of roofs under the direct supervision of the roofing installer.
- U. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  2. Where conduits pass through airtight spaces or plenums to prevent air leakage.
  3. Where conduits pass from hazardous areas to nonhazardous.
  4. Where otherwise required by NFPA 70.
- V. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used **6 inches (150 mm)** above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.
- W. Raceway Cleaning: Prevent accumulation of water, dirt or concrete in raceways. Where water or foreign matter have entered raceways, thoroughly clean or replace conduits where such accumulation cannot be removed by methods approved by this Engineer.
- X. Flexible Connections: Use maximum of **72 inches (1830 mm)** of flexible conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate ground conductor across flexible connections.

- Y. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

### **3.3 PROTECTION**

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

### **3.4 CLEANING**

- A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

END OF SECTION 16130

## **SECTION 16140 - WIRING DEVICES**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Single and duplex receptacles, ground-fault circuit interrupters, and isolated-ground receptacles.
  - 2. Single- and double-pole snap switches and dimmer switches.
  - 3. Device wall plates.

#### **1.3 DEFINITIONS**

- A. GFCI: Ground-fault circuit interrupter.

#### **1.4 SUBMITTALS**

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

#### **1.5 QUALITY ASSURANCE**

- A. Source Limitations: Obtain each type of wiring device through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

### **PART 2 - PRODUCTS**

#### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Wiring Devices:

- a. Bryant Electric, Inc./Hubbell Subsidiary.
- b. Eagle Electric Manufacturing Co., Inc.
- c. Hubbell Incorporated; Wiring Device-Kellems.
- d. Leviton Mfg. Company Inc.
- e. Pass & Seymour/Legrand; Wiring Devices Div.

## 2.2 RECEPTACLES

- A. Straight-Blade-Type Receptacles: Comply with NEMA WD 1, NEMA WD 6, DSCC W-C-596G, and UL 498.
  1. Thermoplastic face.
  2. Thermoset base.
  3. Back and side wired.
  4. Rating: 20 A minimum
- B. GFCI Receptacles: Straight blade, feed-through type, Heavy-Duty grade, with integral NEMA WD 6, Configuration 5-20R duplex receptacle; complying with UL 498 and UL 943. Design units for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter.

## 2.3 SWITCHES

- A. Single- and Double-Pole Switches: Comply with DSCC W-C-896F and UL 20.
  1. Rating: Minimum 20A.
  2. Thermoplastic face.
  3. Thermoset base.
  4. Back and side wired.
  5. Pilot Light as referenced on the drawings.

## 2.4 WALL PLATES

- A. Single and combination types to match corresponding wiring devices.
  1. Plate-Securing Screws: Metal with head color to match plate finish, except screwless devices for locations where only dimmers are shown.
  2. Material for Finished Spaces: 0.035-inch- (1-mm-) thick, satin-finished stainless steel.
  3. Material for Unfinished Spaces: Galvanized steel.
  4. Material for Wet Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. Install devices and assemblies level, plumb, and square with building lines.

- B. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- C. Wallplates and coverplates: install wallplates and coverplates for all outlets, including blank outlets.
- D. GFI Devices: Install separate GFCI devices, except where installed under the same multi-gang plate.
- E. Remove wall plates and protect devices and assemblies during painting.
- F. Install cord and plug sets for appliances, mechanical equipment, and other equipment per manufacturer's written instructions.

### **3.2 IDENTIFICATION**

- A. Comply with Division 16 Section "Electrical Identification."

### **3.3 CONNECTIONS**

- A. Ground equipment according to Division 16 Section "Grounding and Bonding."
- B. Connect wiring according to Division 16 Section "Conductors and Cables."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### **3.4 FIELD QUALITY CONTROL**

- A. Perform the following field tests and inspections and prepare test reports:
  - 1. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.
  - 2. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
- B. Remove malfunctioning units, replace with new units, and retest as specified above.

END OF SECTION 16140

## **SECTION 16410 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:
  - 1. Feeder and branch-circuit protection.
  - 2. Motor and equipment disconnecting means.
- B. Related Sections include the following:
  - 1. Division 16 Section "Fuses" for fusible devices.

#### **1.3 DEFINITIONS**

- A. GFCI: Ground-fault circuit interrupter.
- B. RMS: Root mean square.
- C. SPDT: Single pole, double throw.
- D. MCP: Motor Circuit Protectors (Adjustable instantaneous trip circuit breakers).

#### **1.4 SUBMITTALS**

- A. Product Data: For each type of switch, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each switch and circuit breaker.
  - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations and layout of installed devices, equipment features, and ratings. Include the following:
    - a. Enclosure types and details for types other than NEMA 250, Type 1.
    - b. Current and voltage ratings.
    - c. Short-circuit current rating.

- d. UL listing for series rating of installed devices.
  - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
- C. Maintenance Data: For enclosed switches and circuit breakers and for components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:
1. Routine maintenance requirements for components.
  2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
  3. Time-current curves, including selectable ranges for each type of circuit breaker.

## 1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NEMA AB 1 and NEMA KS 1.
- C. Comply with NFPA 70.

## 1.6 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
  1. Ambient Temperature: Not less than **minus 22 deg F (minus 30 deg C)** and not exceeding **104 deg F (40 deg C)**.
  2. Altitude: Not exceeding **6600 feet (2000 m)**.

## 1.7 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Fusible Switches:
  - a. Eaton Corp.; Cutler-Hammer Products.
  - b. General Electric Co.; Electrical Distribution & Control Division.
  - c. Siemens Energy & Automation, Inc.
  - d. Square D Co.
2. Molded-Case Circuit Breakers:
  - a. Eaton Corp.; Cutler-Hammer Products.
  - b. General Electric Co.; Electrical Distribution & Control Division.
  - c. Siemens Energy & Automation, Inc.
  - d. Square D Co.

## **2.2 ENCLOSED SWITCHES**

- A. Enclosed, Nonfusible Switch: NEMA KS 1, Type HD, with lockable handle.
- B. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, built-in fuse pullers arranged to facilitate fuse removal, lockable handle with two padlocks, and interlocked with cover in closed position.
  1. Rejection clips where rejection fuses are specified.

## **2.3 ENCLOSED CIRCUIT BREAKERS**

- A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
  1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
    - a. Instantaneous trip.
    - b. Long- and short-time pickup levels.
    - c. Long- and short-time time adjustments.
    - d. Ground-fault pickup level, time delay, and I<sup>2</sup>t response.
  4. GFCI Circuit Breakers: Single- and two-pole configurations with 5 -mA trip sensitivity, unless noted otherwise on the drawings.
  5. Molded-Case Switch: Molded-case circuit breaker without trip units.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
  1. Lugs: Mechanical style suitable for number, size, trip ratings, and material of conductors.
  2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

3. Auxiliary Switch: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

## **2.4 ENCLOSURES**

- A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
  1. Outdoor Locations: NEMA 250, Type 3R.
  2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

## **2.5 FACTORY FINISHES**

- A. Finish: Manufacturer's standard gray paint applied to factory-assembled and -tested enclosures before shipping.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.
  1. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.2 INSTALLATION**

- A. Equipment Disconnects
  1. Maximum elevation: 48".
  2. Locate lockable disconnect near each motor complying with clearance requirements.
  3. Multiple speed motors: provide switch in all motor leads.

### **3.3 IDENTIFICATION**

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."
- B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.
- C. Fusible Switch Labels: Label each enclosure with "REPLACE WITH CURRENT LIMITING FUSES ONLY. CATALOG NUMBER: (FUSE CAT. NO.)."

### **3.4 CONNECTIONS**

- A. Install equipment grounding connections for switches and circuit breakers with ground continuity to main electrical ground bus.
- B. Install power wiring. Install wiring between switches and circuit breakers, and control and indication devices.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### **3.5 FIELD QUALITY CONTROL**

- A. Prepare for acceptance tests as follows:
  - 1. Test insulation resistance for each enclosed switch, circuit breaker, component, and control circuit.
  - 2. Test continuity of each line- and load-side circuit.
- B. Testing: After installing enclosed switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
  - 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

### **3.6 ADJUSTING**

- A. Set field-adjustable switches and circuit-breaker trip ranges.

### **3.7 CLEANING**

- A. On completion of installation, inspect interior and exterior of enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16410

## **SECTION 16420 - ENCLOSED CONTROLLERS**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes ac general-purpose controllers rated 600 V and less that are supplied as enclosed units.
- B. Related Sections include the following:
  - 1. Division 16 Section "Fuses" for fuses in fusible switches.

#### **1.3 SUBMITTALS**

- A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each enclosed controller.
  - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
    - a. Enclosure types and details.
    - b. Nameplate legends.
    - c. Short-circuit current rating of integrated unit.
    - d. UL listing for series rating of overcurrent protective devices in combination controllers.
    - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.
  - 2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
- C. Maintenance Data: For enclosed controllers and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:
  - 1. Routine maintenance requirements for enclosed controllers and all installed components.
  - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

- D. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

#### **1.4 QUALITY ASSURANCE**

- A. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.

#### **1.5 DELIVERY, STORAGE, AND HANDLING**

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subjected to weather, cover enclosed controllers to protect from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

#### **1.6 COORDINATION**

- A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."
- C. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.
- D. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

### **PART 2 - PRODUCTS**

#### **2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Manual and Magnetic Enclosed Controllers:
    - a. Eaton Corp.; Cutler-Hammer Products.
    - b. General Electrical Distribution & Control.
    - c. Rockwell Automation Allen-Bradley Co.; Industrial Control Group.
    - d. Siemens/Furnas Controls.
    - e. Square D Co.

## **2.2 MANUAL ENCLOSED CONTROLLERS**

- A. Description: NEMA ICS 2, general purpose, Class A, with toggle action and overload element.

## **2.3 MAGNETIC ENCLOSED CONTROLLERS**

- A. Description: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.
- B. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
- C. Combination Controller: Factory-assembled combination controller and disconnect switch with safety interlock to prevent the door from opening when the unit is in operation.
  - 1. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a nationally recognized testing laboratory.
- D. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 20 tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

## **2.4 ENCLOSURES**

- A. Description: Flush- or surface-mounted cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
  - 1. Outdoor Locations: NEMA 250, Type 3R.
  - 2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

## **2.5 ACCESSORIES**

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
  - 1. Pilot Lights: off indicating red lamp; on indicating green lamp; overload light: either separate light or both red and green lights illuminated. LED, 50,000 hours.
- C. Auxiliary Contacts: Equip controllers with 2 N/O, 2 N/C auxiliary contacts.
- D. Control Relays: Auxiliary and adjustable time-delay relays.
- E. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.

## **2.6 FACTORY FINISHES**

- A. Finish: Manufacturer's standard Grey paint applied to factory-assembled and -tested enclosed controllers before shipping.

## **PART 3 - EXECUTION**

### **3.1 EXAMINATION**

- A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances, and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. Location: Locate controllers within sight of motors controlled, unless otherwise indicated.

### **3.2 APPLICATIONS**

- A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.
- B. Select horsepower rating of controllers to suit motor controlled.

### **3.3 INSTALLATION**

- A. See Division 16 Section "Basic Electrical Materials and Methods" for general installation requirements.

- B. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 16 Section "Basic Electrical Materials and Methods."
- C. Comply with mounting and anchoring requirements specified in Division 16 Section "Seismic Controls for Electrical Work."
- D. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 16 Section "Fuses."

### **3.4 IDENTIFICATION**

- A. Identify enclosed controller components and control wiring according to Division 16 Section "Electrical Identification."

### **3.5 CONTROL WIRING INSTALLATION**

- A. Install wiring between enclosed controllers according to Division 16 Section "Conductors and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
  - 1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
  - 2. Connect selector switches with enclosed controller circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors. Provide relays and associated wiring required for sequence of operation.

### **3.6 CONNECTIONS**

- A. Conduit installation requirements are specified in other Division 16 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.
- B. Ground equipment.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

### **3.7 FIELD QUALITY CONTROL**

- A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed controller bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.
3. Document that overload sizes or settings have been determined based upon actual motor nameplate information.

B. Testing: Perform the following field quality-control testing:

1. Perform each electrical test and visual and mechanical inspection indicated in NETA ATS, Sections 7.5, 7.6, and 7.16.
2. Certify compliance with test parameters.
3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

### **3.8 ADJUSTING**

- A. Set field-adjustable switches and circuit-breaker trip ranges.

### **3.9 CLEANING**

- A. Clean enclosed controllers internally, on completion of installation, according to manufacturer's written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 16420